CRANFIELD UNIVERSITY

GURKAN YESILYURT

EFFECTS OF LEADERSHIP AND MORALE ON THE OUTCOME OF THE BATTLE

CRANFIELD DEFENCE AND SECURITY

LEADERSHIP AND MANAGEMENT

PhD

Academic Year: 2021 - 2024

Supervisor: Dr. Iftikhar Zaidi

Associate Supervisor: Dr.Irfan Ansari

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Supervisor:  Dr. Iftikhar Zaidi

Associate Supervisor: Dr. Irfan Ansari

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This thesis is submitted in partial fulfilment of the requirements for the degree of Enter degree

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ABSTRACT

In this research the factors affecting the outcome of the battle will be examined from the perspective of leadership and morale.

Keywords:

Click here to enter any additional keywords (not contained within the thesis title)

ACKNOWLEDGEMENTS

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LIST OF EQUATIONS

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LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| IT | Information Technology |
|  |  |
|  |  |
|  |  |
|  |  |

# INTRODUCTION

## Introduction

Human history is full of strife, struggles, fights, and ultimately wars that take place on a grand scale. What the reasons for these struggles are and which side's justifications are more satisfactory constitute the field of historical science. However, with the patterns of effects on the outcome are formed over years and they become the subject of both management science, military art, and operational research.

Military theorists and scientists have produced many works on the factors affecting the outcome of wars. Some of these works are based on personal experience like Sun Tzu, some others are based on both experience and philosophy like Clausewitz, while others based on quantification with mathematical formulas like Lancaster, Dupuy, and others. While much have been said on the physical elements of the factors like force ratios, most of these studies excludes the qualitative characteristics or take them constant because of their qualitative nature.

Although the importance of leadership and morale is generally emphasized by all authors, it has not been treated within a rigorous, and systematic study. So, in this research, the factors affecting the outcome of the battle will be examined from the perspective of leadership and morale.

## Background

The first written organized thoughts on the subject belongs to Sun Tzu. He names five fundamental factors to evaluate the war. These factors, which Sun Tzu associates with the winning of the battle are moral influence, weather, terrain, command, and doctrine (Sun Tzu, n.d., p. 63-65). With these estimation factors laid down as principles, he prescribes some force ratio rules in the “art of using troops” part of his famous Art of War and says, “when ten to the enemy’s one, surround him”, “when five times his strength, attack him”, “if double his strength, divide him” (Sun Tzu, n.d., p. 79-80).

Clausewitz ’s approach to subject is comprehensive and covers qualitative nature of the subject as well. He conditions overcoming enemy with matching the efforts against his “power of resistance” which he says product of two inseparable factors, namely “total means at his disposal” and “strength of his will” (Clausewitz, 1832, p. 77). He recognizes the fighting as a trial of moral and physical forces through the medium of physical force and asserts that psychological forces exert a decisive influence on the elements involved in war (Clausewitz, 1832, p. 127). He specifies that, with deciding; time, place, and the force of the engagement, strategy, not force ratio, has “considerable influence” on engagement’s outcome. These reservations in mind, he explains “superiority of numbers” as most common element in victory with an important condition which is “if purpose, circumstances, and the fighting value of the troops is disregarded”. But he further argues that if superiority reach the point where it is overwhelming, superiority of numbers will be the most important factor in the outcome of an engagement (Clausewitz, 1832, pp. 194–195).

In the 1900s, the subject attracted the attention of engineers like Lancaster. At this stage, mathematical formulas were used to explain the importance of the subject.

Lancaster contributed to the literature with two important concepts. First one is the **differential explanation of the casualties** (the number of men knocked out per unit time will be directly proportional to the numerical strength of the opposing force, efficiency of weapons and unit value). Second one is **N-square law** as “the fighting strength of a force is proportional to the square of its numerical strength multiplied by the fighting value of individual units (Lanchester, 1916, pp. 39–66).

With the rapid development of technology, the subject has become the subject of military history and operational research. Depuy, former USA Army Officer, have examined the subject with the help of well-designed mathematical models.

His efforts started with calculating the lethality of weapons with the name “Operational Lethality Indices (OLI)” in 1963. He and his colleagues then integrated these OLI values to Combat Variables to get “Combat Power Potentials” of the sides in 1969 and named this model as He named this approach as Quantified Judgement Model (QJM). Where Power Potentials for the friendly force divided by the enemy force was greater than 1.0, he postulated that this meant that friendly side should have been successful (Dupuy, 1979, pp. 19–50).

In order to test this theory, he also quantified the “actual results” of the battle, again with giving numerical values to mission accomplishment, holding ground, and comparing the casualties. He named this as Result Model. He tested whether the QJM correctly estimated the outcome of the battle or not (N. T. Dupuy, 1979, p. 42).

Conscious of the inconsistences in the system he developed, he further refined his system and reported the results in a totally new book named “Understanding the war: History and theory of Combat” in 1987.

In this book, he based all his analysis to the Clausewitz’s “Law of Numbers”. Clausewitz asserts that “if we strip the engagement of all variables arising from its purpose and circumstances, and disregard the fighting value of the troops, we are left with the bare concept of the engagement in which the only distinguishing factor is the number of the troops”(Clausewitz, 1832, p. 194). From this phrase he re-formulated his combat power of 1979. This time combat power is calculated by multiplying OLI factor (instead of number of troops he uses OLI factors) and environmental factors and quality of the troops (N. T. Dupuy, 1987, p. 30).

Most controversial point of his system was his approximation of troop quality by equating it to the actual battle results ratio divided by the theoretical combat power ratio. From 1960s to 1990s for almost three decades, Dupuy and his colleagues made comprehensive contributions to the subject, although his formula of assessing the “quality of the troops” (factors other than weapon effectiveness and environmental variables) is assessed to be “erroneous” in research which includes an interview with himself also (Ciano, 1988, p. 31).

By far the latest systematic treatment came from Biddle. His research methodology combines recent historiography with formal doctrinal theory, case method, statistical analysis, and simulation experimentation. He argued that material factors alone cannot explain capability and added force employment, which is a nonmaterial variable to his analysis. He defines modern system of force employment as “the doctrine and tactics by which armies use their materiel in the field” (Biddle, 2006, p. 2).

Modern system of force employment might be summarized as offensive and defensive operations and tactics. He discusses advantages and disadvantageous of offensive tactics such as breakthrough and exploit operations versus limited aim operations and bite and hold tactics under the effects of offensive tactics like cover and conceal, dispersion, combined arms, and independent small unit operations. If armies conduct these kinds of offensive operations with the requirements of these tactics, he argues, then these armies are conforming with the modern system of force employment. The same argument is made also for defensive operations and tactics (Biddle, 2006, pp. 28–51).

His key finding might be summarized as the effects of preponderance in the numbers and technology is mediated by “modern system of force employment”. He concludes that technology and preponderance’s effects are radically different as a function of force employment, it can be decisive or almost immaterial as a function of the implementation of the modern system force employment. The one who implements “force employment” better, will exploit advantageous of numerical superiority in numbers and technology (Biddle, 2006, pp. 60–77).

Other than Biddle, there are other works emphasizing and utilizing non-material factors on the outcome of the battle. One of them is UK Defence Doctrine which categorizes “fighting power” into three sections, namely conceptual, physical, and moral components(UK Ministry of Defence, 2014, p. 25).

One of them is a Rand Report which provided a detailed explanation of “will to fight” and a model designed to support assessment of forces (Connable et al., n.d., p. 10). They accept that morale, cohesion, and discipline is associated with the “will to fight” but they argue “morale” especially is ill-defined. Their model provides US army military planners an assessment tool for the “will to fight” dimension of the units.

## Aim and Objectives

### Aim:

This research will aim to **explore** effects of non-material factors on the outcome of the battle alongside other combat power elements.

### Objectives:

To **explain** how far combat power elements varies the outcome of the battle.

To **explore** the nature and the degree of the effects of leadership and morale on the outcome of the battle.

## Scope

There are so many non-material factors that affect the outcome of the battle. This research will mainly focus on leadership and morale effects. Material factors that influence the outcome of the battle will be explained in general to put the research into context. It is not intended to identify all elements affecting the course of the events in the battle.

## Problem Analysis

The problem spotted in this field is over generalization and of the first contributors and overstrain of the topic by the latest ones. Literature reflects the individualistic experiences of the first contributors (Sun Tzu, Clausewitz) and mathematically overstrained explanations of others (Dupuy).

Sun Tzu forecasts victor by comparing five fundamental factors (i.e moral influence, weather, terrain, command, and doctrine) (Sun Tzu, n.d., p. 66). Although still valid all these factors today, current complexity of the battle in compare with the approximately 4th B.C. warfare, the time when “The Art of War” is crafted, requires more comprehensive analysis. Clausewitz, laid down philosophical foundations of the military art, comprehensively approached all disciplines of the warfare, appreciate the importance of the all the intangible factors of the battle, although his concepts need to be tested with the current level of scientific methodological approaches.

When we come to the latest contributors like Lancaster and Dupuy, the detected main problem is enforcing an overarching model to explain all kinds of battles mainly with mathematical models, which seems to be impossible when we consider the nature of the warfare which is mainly laid down by Clausewitz, who states that “uncertainties and lack factors always plays an important role to the extent of which makes the battle almost a gamble”(Clausewitz, 1832, p. 85).

Having said so almost all contributors in this field agreed on material factors alone cannot explain the result in military conflict. Sun Tzu’s three out of five fundamental factors to be victorious (includes moral, command, and doctrine elements) relates with non-material factors(Sun Tzu, n.d., p. 63). Clausewitz puts morale factor “among the most important in war” (Clausewitz, 1832, p. 184). Biddle’s conclusion is far more assertive and states “Material alone correlates poorly with observed capability” (Biddle, 2006, p. 27). UK Defence Doctrine also emphasizes none of fighting power elements should claim precedence and each mutually supports and informs the other (UK Ministry of Defence, 2014, p. 25).

So, there is a consensus among researchers on the importance of the non-material factors in the battles. What is missing in the literature is robust academic research on these factors, especially leader’s role and morale, because of their qualitative nature.

New data analysis tools to conduct “content analysis method” on the text materials presents powerful exploitation opportunities for new insights which in turn will facilitate the examination of these subjects.

## Research Value

This research is expected to provide contribution to literature new knowledge by analysing the leadership and morale in the battle environment and exploring the nature of their effects in deductive approach.

The reasons of adopting deductive approach will be explained in the first phase of the research with analysing the current gap within the existing literature.

This research will also test the two basic assumptions of the Clausewitz on the effect of numerical preponderance on the victory. First assumption is “Superior numbers may actually be contributing very little, depending on the circumstances”, and the second one is “Superiority, when reaches to the point where it is overwhelming, is the most important factor in the outcome of an engagement”(Clausewitz, 1832, p. 194).

This research will also complement four decades of effort by Dupuy from late 1950s to 1990, although he named “intangible factors” (leadership, training and morale, logistics, time and space, momentum, intelligence, technology, initiative, and combat effectiveness) to the outcome of the battle (N. T. Dupuy, 1979, pp. 37–39), inclusion of these factors to analysis is either incomplete or lacked the rigorous methodology.

This research is expected to add value to leadership studies in the battlefield environment. Off intangible factors stated by Dupuy, time and space, intelligence, surprise, and initiative factors are also referred to be related with leadership. And most importantly the strategy, which has “considerable influence” on the outcome of the battle (Clausewitz, 1832, p. 194) is devised by the leaders, in turn will be treated as the by-product of the leaders. All these factors will be analysed to appraise to what degree leadership matters on the battlefield.

## Positioning

This research will be basic research, “with a purpose to know the way some phenomenon or process works” (Guillermina, n.d., pp. 52–53). The phenomenon is leadership and morale in the complex process of battle.

Ontological assumption is shaped by the particularities of the battle environment and the drivers of it. Reality in this field lies within the human being’s perception. In essence it is the people who follows the leader, and it is the mood of people which triggers action in the battle. In line with this understanding, epistemological assumption, the way to frame the knowledge within this reality, is assessed to be battle databases and the views of expert personnel in this field which are mainly articulated by military history books, soldiers who expressed their experiences with the memoirs, states, who provides official accounts of the events.

So, exploring the nature of these two phenomena requires to examine them with both positivist and social constructivist approaches. Positivist approaches has yielded valuable results so far for the material side of the topic, while producing unsatisfactory results for non-material factors. That’s why this research will adopt mainly constructivist approach.

## Research Questions

### Research Question 1:

What kind of effects leadership and morale have on the outcome of the battle?

### Research Question 2:

How much the outcome of the battle effected with inclusion of leadership and morale as factors alongside with other material factors?

## Hypothesis / Thesis

### Hypothesis:

Hypothesis to be tested with initial quantitative research is an existing theory form Clausewitz: (his famous “On War” will be used as “working theory” for this research).

“If superiority of numbers reaches to the point where it is overwhelming, it will be the most important factor in the outcome of an engagement, so long as it is great enough to counterbalance all other contributing circumstances” (Clausewitz, 1832, pp. 194–195).

### Thesis:

Initial thesis of this research is leadership and morale affect considerably the outcome of the battle.

All qualitative research will be conducted to collect evidence to test this thesis.

## Concepts and Variable

Concepts for the first phase (quantitative research) of the research are combat variables, material factors (numbers of personnel, weapon, and others), non-material factors (leadership, training, experience, morale, logistics). Each of these factors stated in parenthesis will be used as independent variables.

For the second phase of the research, although not as measurable as the quantitative research (Bryman, 2012, p. 388), the reference concepts will be leadership and morale in the battle context. These are also the intervening variables for the research since they have moderating effect (calibrating the effects of the independent variables on dependent).

Outcome of the battle is an ambiguous concept that will be used as dependent variable to appease the determinant’s importance.

## Methodology

In line with the positioning of the research as stated in 1.7 Positioning section, methodology of the research will be “explanatory sequential design” (Creswell, 2003, p. 213), with quantitative methodology preceding the qualitative one in supporting role.

Statistical methods will be used to identify the correlations between independent and dependent variables and variance coefficients on the outcome of the battle with the use of current battle databases. Then relationship between leadership and morale on the battle result will then be explored with qualitative methodology, mainly with “content analysis” method. These two methodologies will allow to gain the knowledge how and to what degree leadership and morale affects the battle, which literature currently lacks.

Theoretical framework of the research is depicted on the Figure-1

Diagram

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Figure 1‑1 Theoretical framework of the research

### Research Steps:

How it will be studied?

1st step: Literature review study will be conducted to identify the factors (variables) effecting the outcome of the battle.

2nd step:

Quantitative analysis will be conducted to explore the relationship between the factors effecting the outcome of the battle. In case correlation detected between the factors and the result of the battle than the relationship will be modelled with regression models.

Each factor’s contribution to variance will be analysed with Multiple Regression Analysis. This analysis is best suited since there exists multiple predictors which affect the result (James et al., n.d., p. 71). To enable this analysis, data will be used from already in-place databases.

Graphical demonstration for material factors is presented in the Figure-2.

Text

Description automatically generated

Figure 1‑2 Material Factor Analysis

3rd step:

For the leadership and morale factors, “content analysis” method will be conducted. Current level in content analysis allows to measure how important a word is to a document. It will be done in the steps summarized below:

* Named entities will be annotated.
  + This step includes locating and classifying key terms of the morale and the leadership into pre-defined categories. Examples are given below:
    - “Military spirit” term (named as the most important moral elements in war (Clausewitz, 1832, p. 189) will be classified in morale category,
    - “Intellectual powers and courage” of the commander (named as “soldiers first requirement” (Clausewitz, 1832, p. 101) will be classified in the leadership category.
  + Literature will be reviewed comprehensively to cover all possible important features associated with the effectiveness of these two variables (leadership and morale) to better represent the named entities.
* Named entity recognition (NER):
  + Once named entities annotated manually, recognition of all these entities from raw text will be conducted by Natural Language Processing (NLP).
  + Raw texts might be official battle reports, academic products, or memoirs of soldiers. In the methodology chapter it will be expressed which raw texts will be used as input to the model. It will be beneficial to use raw texts of the battles of which regression analysis is made.
* Relation Extraction (RE) models will be trained with the language representation techniques. New features will be created to build downstream deep learning models to find relations between the outcomes and leadership and morale factors.

Graphical demonstration for material factors is presented in the Figure-3.

Timeline

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Figure 1‑3 Non-material Factor Analysis

4th step:

Results of the “Content Analysis” will be integrated into the quantitative research results to conclude the nature of the relationship between leadership and morale and the outcome of the battle.

## Research Ethics

This research’s focus will be on leadership and morale on the warfare. Leadership qualities and morale effects will be solicited from universally accepted literature. It is expected that maximum objectivity will be attained in this term.

In order to provide maximum objectivity for the selection of the battles however there are some limitations when the effects of the material factors analysed. Main limitation is the availability of the datasets. There are two widely used dataset for the battles, which are Correlates of War (Sarkees & Frank Wayman, 2010) and USA Army’s CDB Dataset(USA Historical Evaluation and Research Organization, 1990). COW Dataset includes wars rather than battles. Since this research’s unit of analysis is battle, usability of this dataset will be limited to only analysing the effects of the material features. CDB90 dataset is centred on the battles. However, it has also drawbacks. The battles analysed in this dataset is mainly from USA, German, and Israeli experiences. The second main limit of this dataset is reliability. After reflecting the errors of it Biddle concludes that “real errors thus doubtless remain in the CDB90 data, in frequency that is difficult to assess but could well be significant”(Biddle, 2006, p. 153).

The effect of this risk related with the databases is assessed to be limited for this research, since the focus will not be on the material factors of warfare.

In analysing leadership and morale factors, text analysis will be used. For that purpose, Relation Extraction Model will be created. This model will be a simple software application through which a raw text will be inserted as input. Selection of raw texts will be arranged in a transparent, fair, and objective way that the model will yield the empirically sound results.

There is no intellectual property or conflict of interest issue related with this research.

## Limitations

The biggest limitation of this research is not coming from the nature of the subject, which is leadership and morale, but coming from the nature of the environment, which is battle. The factor of “chance”, which Clausewitz terms it as the most abundant thing in the battle(Clausewitz, 1832, p. 85), has a potential to prevent crystal clear understanding of the reasons of the outcome. Conscious of this fact, the focus will be on the patterns of leadership and morale in the battlefield.

This research is not aimed at quantifying the battle nor aimed at developing a theory to explain it. In line with Clausewitz’s conceptualization, who argues that “absolute, so called mathematical, factors never find a firm basis in military calculations” (Clausewitz, 1832, p. 86) this research will not calculate the winner based on mathematical formulas but will try to find the patterns of the winner side leadership and morale factors and their effects on the outcome of the battle.

The battles will be selected only from ones fought between state actors.

Since the factors might be better analysed for the battles which has a historical recording mechanism already in-place, only the battles fought after Napoleonic era will be analysed.

Although leader role might be best observed in the irregular warfare, it will be limited to the person who are given the role as commander, and hence leaders. Leader role in irregular warfare is the topic of other study.

The analysis will be made with the in-place databases. The details of the databases can be seen in the methodology part. This research has no intention to create a new battle database.

## Layout of the Research

In this chapter (Chapter one) the general context has been set up. Questions has been so far responded with regard to what will be studied, why this research is being conducted, and how it will be conducted. Aim, objectives, questions, value, and limitations of the research has been articulated.

In Chapter two current literature will be summarized to explain what kind of approaches and models are being used so far.

In Chapter three theoretical framework will be presented to explain the factors effecting the outcome of the battle (variables) and their relationships, data collection and analysis methods.

In Chapter four how the research was carried out will be explained.

In Chapter five findings of research will be presented.

# LITERATURE REVIEW

## Lanchester’s Principle of Concentration and the N-Square Law:

### The Principle of Concentration:

Lanchester states that “one of the great questions at the root of all strategy is that of ‘concentration’; concentration of all whole resources of belligerent on a single purpose or object, and concentration of the main strength of his forces, at one point in the field of operations”. He mentions two dimensions of the concentration namely material and moral concentration, while treating former as a subject of scientifically rather than strategic principle. In order to understand the importance of the concentration in material sense, he suggests focusing on the underlying principles and controlling factors of concentration. These factors are summarized below.

#### The Conditions of Ancient Warfare (p.40-41):

He states that in ancient times no matter how much strength strategy brings to the theatre of operations, ultimately men will find only men to wield its weapon. Under the old conditions it was not possible by any strategic plan or tactical manoeuvre to bring other than approximately equal numbers of men into the actual fighting line. Under the present-day conditions all this changed. With modern long-range weapons the concentration of superior numbers gives an immediate superiority in the active combatant ranks. Here he implies that concentration in old times rather difficult to achieve although it was not impossible. That’s why he argues that concentration in ancient times cannot be a constant quantity. In the ancient condition where man is opposed to man, and **assuming the combatants to be of equal fighting value** and **conditions are equal**, “duels” will make up the fight and there will be equal numbers killed.

Since he focuses on the reduction of strengths, he implicitly says that numerically larger side will win the battle, with the conditions of the equal fighting value and conditions in the ancient battle conditions.

#### The Conditions of Modern Warfare (p.40-41):

In the modern conditions, with the assumptions of equal fighting value and conditions, each man will in a given time score, on an average, a certain number of hits that are effective, so, **the number of men knocked out per unit time will be directly proportional to the numerical strength of the opposing force**. This is known as Linear Law of Lanchester. He provides mathematical expression of this in differential equations which is given in Figure 2-1. (p.42)

|  |  |
| --- | --- |
|  | |
| b and r | Numerical strength of blue and red |
| t | Time |
| ∂b/∂t  (∂r/∂t) | Change of rate in blue (red) force as a function of time, derivative of the casualty curve. |
| c and k | constants, (c=k if the fighting values of the individual units of the force are equal) |

Figure 2‑1 Differential Equations of Lanchester

These differential equations show the rate of change of casualties as a function of time (He takes derivative of the curve to get exact number of casualties at any given time, not an average).

With equal conditions and equal fighting values and with these equations, he provides the reduction of strengths of the two forces in different conditions. In one of these conditions, he uses the example of Blue force 1000 strong encountering Red force 1000 strong separately (in the first phase Blue force encounters with the half of Red force, and in the second phase with the other half). In the first phase Blue force wipes out Red force with only 134 losses. In the second phase, “Blue” force remains 866 strong encounters 500 “Red” force. And gains an easy victory.

With the same logic, “Red” force which is inferior to the Blue in relation 1:√2, a Red force 1000 strong encountering a Blue force 1400 strong, if they meet in single pitched battle Blue dominates, but if the Reds by superior strategy divides the Blue and encounters them separately this time battle will be drawn.

In the case of equal forces, this time battle prolonged indefinitely.

With these three examples, he concludes that divided forces might be overwhelmed even if the sum of the divided forces is greater than other force.

#### Fighting Units not of Equal Strength (p.47):

After analyzing these force ratios, he further asserts that “the direct numerical comparison of the forces engaging in conflict is almost universal”. He further goes and asserts that “counting the pieces as of value, and to deny the more extended application of mathematical theory, is illogical and unintelligent.”

When he treats forces of unequally trained or of different morale or different weapon efficiency, he refers training and morale as cannot be accounted for in an equation, while he includes the effectiveness of the weapon systems. With this addition, he refers,

He asserts that “any difference in the efficiency of weapons may be presented by a disparity in the constants c and k in equations”.

With a Blue force of 500 that use rifle and lose 100 men would eventually be equal force of Red with 1000 man that use breech-loader gun with 200 casualties. Here we have different constants and Lanchester shows this again with mathematical equation.

|  |  |
| --- | --- |
|  | |
| b and r | Numerical strength of blue and red |
| t | Time |
| ∂b/∂t  (∂r/∂t) | Change of rate in blue (red) force as a function of time, derivative of the casualty curve. |
| M (and N) | Efficiency or value of an individual unit of the Blue (Red) force. |
| c and k | constants |

Figure 2‑2 Rate of reductions with efficiency of the weapons included.

He elaborates these equations with the condition of equality to get his famous n-square law.

|  |
| --- |
| This equation may be rewritten as  This equation may be rewritten as |

Figure 2‑3 N-Square Law

o He explains this formulation as “fighting strengths of the two forces are equal when the square of the numerical strength multiplied by the fighting value of the individual units are equal.

• Outcome of this investigation: the n-square law and its proof (p.48-50)

o Within this law he defines the fighting strength of a force: it is proportional to the square of its numerical strength multiplied by the fighting value of its individual units.

o Thus, (referring to fig. 5b) he made conclusion of divided forces: sum of squares of two portions of the divided forces are for all values equal to the square of the other (not divided) force.

o Simple proof of this law arising from equations 1 and 2: Let the numerical values of the blue and red represented by b and r, then in a small interval of time the change in b and r is represented by db and dr of such relative magnitude that db/dr=r/b or

o If we draw the squares on b and r and represent the increments db and dr as small finite increments, we see at once that the change of area of b² is 2b db, and change of area of r² is 2r dr which according to foregoing (1), are equal.

o Therefore, the difference between the two squares is constant. q represents the numerical value of the remainder of the blue force after annihilation of the red.

b²-r² = constant ------> b²-r²=q² ---------> b²=q²+r²

o Example of this is an army of 50K giving battle in turn to two armies of 40K and 30K respectively, equally well armed; then the strengths are equal, since 50K²=40K²+30K². But if divided force fight in one part then the army of 50K will be overwhelmed.

• Example involving weapons of different effective value:

o He gave an example with this assumption: 1 man employing machine-gun can punish a target to the same extent in a given time as 16 riflemen. He analyzes number of men armed with machine-gun necessary to replace a battalion (1000 men strong) in the field?

o From n-square law: N r² = M b² - 16\*r²=1\*1000²-r²=√1000²/16 = 1000/4=250 or one quarter the number of the opposing force (p.50).

o According to him this example exhibits at once the utility and weakness of the method. Basic assumption is that the fire of each force is definitely concentrated on the opposing force. Thus, the enemy will concentrate on the 1 machine-gun operator the fire that would otherwise be distributed over four riflemen. And so, on an average he will only last for one quarter the time, and at 16 times the efficiency during his short life he will only be able to do the work of 4 riflemen in lieu of 16 (p.51).

o When, on the other hand, the circumstances are such to preclude the possibility of such concentration the value of the individual machine-gun operator becomes 16 riflemen. The same applies when he is opposed by shrapnel fire or any other weapon which is directed at a position rather than individual. So, he concludes that one might pay attention to these variations when assessing the theory (p.51). According to him these variations are less common in naval then in military warfare; the individual unit -the ship- is always the gunner’s mark. He points out that aircraft is more similar to navy ship (p.51).

• The Hypothesis Varied-modifying initial hypothesis to harmonise with the conditions of long-range fire (p.51-52):

o Assumption: fire concentrated on a certain area known to be held by the enemy, and take this area to be independent of the numerical value of the forces, then, with notation as before, we have;

-db/dt = b\*Nr\*constant

-dr/dt = r\*Mb\*constant ----->M db/dt = N dr/dt --->or the rate of loss is independent of the numbers engaged, and is directly as the efficiency of the weapons.

o Under these conditions the fighting strength of the forces is directly proportional to their numerical strength; there is no value in concentration, qua concentration, and the advantage of rapid fire is relatively great. This is more likely to ancient warfare.

• An Unexpected Deduction (p.52):

o Better for numerically superior force to come to close quarters,

o Blue force of 100 men with machine-gun vs red force of 1000 men with rifle

o 1st assumption: both forces are spread over a front of given length at long range.

o Red force loses 16 men to the blue force loss of 1 man. Red lose.

o If red come closer enough for each individual have mark, red would lose half to come closer, but would win, by n-square law: 600²\*1>100²\*16

• Examples from history (p.53):

o Principle: on the field of battle “concentration” matter of the most vital importance.

o Controlling factors both in strategy and tactic.

o Attacking of opposing force before concentration gained: defeat of Napoleon in Italy campaign.

CHAPTER VI: The N-Square Law in its Application

• The N-Square Law in its Application to a Heterogeneous Force (p.54-55):

o chapter V summary: Fighting strength of a force, so far as it depends upon its numerical strength, is best represented by the square of the number of units.

o Where individual fighting strengths of the component units (land, navy or air) may be different, it has been shown that if a numerical fighting value can be assigned to these units, the fighting strength of the whole force is as the square of the number multiplied by their individual strength. Nr²=Mb²

o Where the component units differ among themselves, as in the case of a fleet that is not homogeneous, the measure of the total of fighting strength of a force will be the square of the sum of the square roots of the strengths of its individual units.

• Graphical Representation (p.55):

o The strengths of a number of separate armies of forces successively mobilized and brought into action are represented by the lines a,b,c,d,e, and aggregate fighting strength of these armies are given by the lengths of the lines A,B,C,D,E, each being the hypotenuse of a right-angle triangle, as indicated.

o Thus, two armies a and b, if acting separately (in point of time), have only the fighting strength of a single force or army represented numerically by the line B.

• N-square law in naval warfare (p.57-58):

o N-square law applies to military operations;

 on land: there may be special conditions to the hypothesis whereby its usage maybe masked.

 naval warfare: however, the conditions strictly conform to basic assumptions. Thus, when battle fleet meets battle fleet, there is no advantage to the defender analogous to that secured by the entrenchment of infantry.

o In a naval battle every shot fired is aimed at one enemy’s ship; there is no firing on the mass.

o Old conditions (1000-yard effective range): advantage could be taken of concentration within limits. 18th century tactics makes it apparent that with any ordinary disparity of numbers (probably in no case exceeding 2 to 1) the effect of concentration must have been not far from that indicated by theory.

o With a battle-fleet action at the present day the conditions are still more favorable to the weight of numbers, since with the modern battle range-some 4 to 5 miles- there is virtually no limit to the degree of concentration of fire.

o Further than this, there is in modern naval warfare practically no chance of coming to close quarters in ship-to-ship combats, as in old days.

o Thus, the conditions are to-day almost ideal from the point of theoretical treatment. Numerical superiority of ships of individually equal strength will mean definitely that the inferior fleet at the outset has to face the full fire of the superior.

o The same observations will probably be found to apply to aerial warfare when air fleets engage in conflicts, more especially so in view of the fact that aeroplane in three dimensions of space instead of being limited to two, as in the case with the battleship. This will mean that even with weapons of moderate range the degree of fire concentration possible will be very great.

• Individual value of Ships or Units (p.59):

o Deciding the value of individual units is difficult.

o Fighting value of ship depends not only to armament but also to protective armor. Question of fleet strength can never be reduced quite a matter of simple arithmetic.

o May be gauged by the weight of its “broadside” or more accurately, taking into account the speed with which the different guns can be served, by the weight of shot that can be thrown per minute.

o Another basis may to compare energy per minute for broadside fire, which represents, the horsepower of the ship as a fighting machine.

o Similar means of comparison for aeroplane, though it may be that the downward fire capacity will be regarded as of vital importance.

• Applications of the n-square Law (p.59-61):

o The n-square law tells us at once the price or penalty that must be paid if elementary principles are outraged by the division of battle fleet into two or more isolated detachments.

o If battle fleet separated into 2 equal parts, increase would require to be fixed at approximately %40 percent – that is to say, in relation of 1 to √2; more generally the solution is given by a right-angled triangle.

• British Naval Tactics in 1805 (p.62):

o Not form in a line-of-battle parallel to the combined fleet

o Break the line, envelop rear, overpower with groups of ships, isolate enemy and cut off.

o First tactics according to Lancaster, advantages of fire concentration.

o Van cannot help rear

• Nelson’s Memorandum and Tactical Scheme (p.63, 64):

o British formed 2 main columns.

o One of the main columns was to cut the enemy’s line about the centre,

o Other to break through about 12 ships from the rear,

o Smaller column being ordered to engage the rear of the enemy’s van 3 or 4 ships ahead of the centre, and to frustrate, every effort the van might make to help centre or rear.

• Nelson’s Tactical Scheme Analysed (p.65-66):

o Nelson planned to envelop the half of -23 ships- combined fleet with 32 ships. This, according to n² law would give him superiority of fighting strength of almost exactly 2 to 1 .

o Strength of British in arbitrary n² units:32²+8²=1088

o Combined fleet: 23²+23² = 1058

o British advantage:30, remaining British ship: √30=5.5 ships

o If they had engaged in older times tactics:

o strength of combined fleets 46²=2116

o strength of British fleets: 40²=1600, Balance in favor of combined fleet would be 526, in ship terms √516= 23.

o Thus, we are led to appreciate the commanding importance of a correct tactical scheme. If old-time method of attack had been adopted, British could not avert defeat.

o First: Definite statement of cutting the enemy into two equal parts – according to n-square law the exact proportion corresponding to the reduction of his total effective strength to a minimum

o Second: the selection of a proportion, nearest whole number equivalent to the √2 ratio of theory, required to give a fighting strength equal to tackling the two halves of the enemy on level terms, and the detachment of the remainder, the column of 8 sail, to weaken and impede the leading half of the enemy’s fleet to guarantee the success of the main idea.

## Numbers, Predictions and War:

Dupuy’s approach to detect the values of the intangible variables of the battle is assessed to be heuristic, a kind of hasty response to fill this gap, a short-term approximation to complete the QJM.

Force Strength (S): The sum of the values of the weapons of a force (Operational Lethality Indices (OLI) – modified to reflect environmental variables. OLI factors were base of his research where he analysed the relationship between the weapons and the number of casualties. He added Operational Environmental Factors (OE) to the formula to better reflect the battlefield realities like effects of weather, terrain, season, mobility, and vulnerability factors. Force strength is calculated by multiplication of weapon effectiveness and environmental conditions.

Combat Power Potential (P): This value is calculated by applying (multiplying) all identifiable operational variables to the Force Strength (S) value. These variables are mobility factor, leadership, training and experience, morale, and logistic factors. Where applicable he gave mathematical weights to these variables. As an example, he gave values for the morale of the belligerents (excellent morale: 1.0, Panic: 0,2 and etc). Where he found solid proof, he multiplied these values with the Force Strength.

## Analysis of the Factors that Have Influenced Outcomes of the Battles and Wars: A Data Base of Battles and Engagements

This analysis conducted by Dupuy and colleagues under the auspices of US Army Concept Analysis Agency. They define their report as below:

“A comprehensive analysis in six volumes of the factors that have significantly influenced the outcomes of 600 major battles of modern history, commencing with the Netherlands' War of Independence and the Thirty Year' War, and continuing through the 1973 Arab-Israeli War. Volume I include the summary and introductory materials. Volumes II-VI present matrices and narrative summaries for the engagements, which are grouped chronologically by wars and campaigns factors affecting outcome in historical engagements, surprise in warfare, combat forms and resolution in historical engagements, advance rates, and frontages in historical engagements within wars. The matrices summarize all important elements of data and qualitative information concerning each engagement, plus a historical assessment of the factors that were important to the course of the engagement and its outcome. Following each group of matrices are narrative summaries of engagements listed in the matrices. These narratives succinctly describe the background, course, and outcome of each engagement, include a brief assessment of its significance, and list the sources consulted with respect to the presentation for each. Bibliographies are listing the major sources consulted during the research for each.”(T. N. Dupuy et al., 1984, sec. Report Documentation Page)

In summary, the review of the HERO reports and the subsequent random assessments resulted In a conclusion that the report and the assessments will provide a valuable starting point for orginizitions desiring to investigate the relationship between history, Its "numbers," ana analysis or prediction of battle Intricacies. However, as HERO points out in their own introduction (IOL II), the work needs rigorous review, some gar require filling, and other time periods and battle coverage would help in providing(T. N. Dupuy et al., 1984, pp. 2–3).

a more comprehensive work.

## Section Heading (use Heading 2)

### Subsection Heading (use Heading 3)

### Unit of Analysis

Unit of analysis for this research is “battle” with the identification of Clausewitz, who defines it as “the struggle by the main force” (Clausewitz, 1832, p. 248). In his terms war consists of “engagements” with all kinds of purposes. Of these engagements that fought to attain main objective is termed as “battle”.

Databases:

* One of these database is provided by “The Correlates of War Project” which was founded in 1963 by J.David Singer, a political scientist at the University of Michigan. This project consists of war data (inter-state, intra-state, extra-state, non-state war data) for the period between 1816-2007. Inter-state war data part will be utilized (Sarkees & Frank Wayman, 2010).
* Other database is U.S. Concepts Analysis Agency’s updated version of the historical combat data set which covers 660 battles for the periods between 1600-1982 (Historical Evaluation and Research Organization, 1988).

# CHAPTER TITLE (USE HEADING 1)

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APPENDICES

Whilst Heading 1 to Heading 6 can be used to number headings in the main body of the thesis, Heading styles 7–9 have been modified specifically for lettered appendix headings with Heading 7 having the ‘Appendix’ prefix as shown below.

Appendix Title (Use Heading 7)

Appendix Section (Use Heading 8)

Appendix Subsection (Use Heading 9)

Creating captions in Appendices

If you have chosen to include chapter numbers in your captions then follow the instructions given here to apply the same format to the captions in your appendices. This section explains how to caption the figures and tables in your Appendices, assuming that Heading 7 is numbered “Appendix A” and that the Figures and Tables are going to be labelled ‘Figure A-1’, ‘Figure A-2’, ‘Table B-1’ etc.

You will have to create new, separate labels that look like the ‘Figure’ and ‘Table’ labels you used in the main body of your thesis.

1. Select the **References** tab on the Ribbon then click on **Insert Caption**
2. Click **New Label**. Type **Figure\_Apx** then click **OK**
3. You now have two labels for figures, called **Figure** and **Figure\_Apx**  
   Repeat for table captions.
4. In the **Caption** box, type your caption text
5. Click **Numbering**. Tick **Include chapter numbering** and choose **Heading 7** from the drop-down list of styles and click **OK** twice
6. Your caption should look something like this:

**Figure\_Apx A‑1 This is the caption text for a Figure in the Appendix**

1. Delete the extraneous ‘\_Apx’ from the caption label so it reads:  
   **Figure A‑1 This is the caption text for a Figure in the Appendix**  
   **TIP:** Instead of deleting each ‘\_Apx’ individually use **Find & Replace** to modify all the labels at once.

Creating Lists of Figures and Tables for Appendices

This template already includes a List of Figures and a List of Tables, however you will have to create two new lists for the ‘Figure\_Apx’ and the ‘Table\_Apx’ labels.

1. Place the insertion point on a blank row after the existing List of Figures
2. Select the **Insert Table of Figures** command on the **References** tab of the Ribbon
3. Set the **Caption Label** box to ‘**Figure\_Apx**’ and click **OK**  
   **Note:** Word will put a single blank line between the original and new lists preventing it from appearing as one seamless list. However if you select the blank paragraph between the tables you can hide it by opening the Font dialog box from the Home tab and selecting **Hidden**.
4. Click after the List of Tables and repeat for the Caption Label ‘Table\_Apx’