New Perspectives on Ancient Warfare

Edited by

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BRILL

LEIDEN • BOSTON
2010

Cover illustration: Detail of an Assyian relief depicting the siege of Lachish by King Sennacherib in 701 BCE. British Museum. Photo: G. Fagan, with permission.

This book is printed on acid-free paper.

Library of Congress Cataloging-in-Publication Data

New perspectives on ancient warfare / edited by Garrett G. Fagan, Matthew Trundle.
p. cm. -- (History of warfare, ISSN 1385-7827)
Includes bibliographical references and index.
ISBN 978-90-04-18598-2 (hardback : alk. paper) 1. Military art and science--History--To 500. 2. Military history, Ancient. I. Fagan, Garrett G., 1963- II. Trundle, Matthew, 1965- III. Title. IV. Series.

U29.N48 2010
355.0209'01--dc22

2010015188

ISSN 1385-7827
ISBN 978 90 04 18598 2

PRINTED IN THE NETHERLANDS

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WEAPONS, TECHNOLOGICAL DETERMINISM, AND ANCIENT WARFARE*

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Introduction

John Keegan pointed out that the discipline of military history comprises many different fields. Generals and generalship, weapons and weapon systems, naval history and technology, institutions and armies, strategic doctrines and political science are all part of Keegan's list.[1] The focus of the discipline, however, has fluctuated between these fields in the last century, according to the changing interests and outlooks of the period. In the specific field of ancient military history, the study of weapons and weapon systems has been particularly relevant, focusing on typological analysis, comparative works and detailed accounts of the military performance of dozens of different weapons and their tactics. This interest in the tools has been sometimes pushed to its limits, turning them into decisive factors that eventually explain the whole nature and circumstances of war. The idea that the weapon is the decisive item that could by itself win battles, or make a significant difference to their outcomes, entails a certain simplification of the complex reality of warfare. This simplification is what is commonly labeled 'technological determinism.'

Broadly speaking, technological determinism implies that military tactics and techniques are determined by technological change: the introduction of a new weapon generates an automatic adaptation of tactics. The main criterion to establish the connection between weapons and tactics is superiority: the qualities of the new item, felt to be superior

* I am deeply grateful to Hans van Wees, Kurt A. Raaflaub, Greg Anderson, Philip de Souza and Vincent Gabrielsen for reading an earlier draft of this paper and providing valuable suggestions and comments. I also thank José Ignacio de la Torre for the many quotations and examples about the Roman army he shared with me. They all contributed to improve the ideas and approaches contained in this paper. All remaining errors are, of course, my own.

[1] J. Keegan, *The Face of Battle. A Study of Agincourt, Waterloo and the Somme* (London: Pimlico, 2004), 27–36.

to older ones, first prompt a technological substitution and then a tactical adaptation. This swift military change, in turn, is finally supposed to be the main cause of political, social and economic transformation. Thus, technology becomes the engine of historical change.

Determinism operates at several levels. We can differentiate a basic, 'battlefield' level, which maintains that there is a direct connection between weapons and tactics. Certain weapons are supposed to determine the choice of specific tactics, and thus victory itself. As a result, better weapons and tactics help to win battles, and victory in turn explains the diffusion of technological innovations and the seemingly automatic replacement of older artifacts by new ones, as if technological change were driven by the principle of progress.[2] A second level of the deterministic approach to warfare, the 'political' level, entails that, in view of the crucial role played by weapons in the outcome of war, all decisions, interests, and policies of ancient communities were determined by military factors. As a result, the military becomes a central and all-pervasive concern in ancient political agendas.[3] We can finally differentiate a third, 'structural' level, which maintains that military technological transformations, following the previous two steps, produce and explain broader socio-political change. According to this view, military technology is the trigger that fires the gun of historical evolution.[4]

Ancient history has sometimes tended to overestimate the impact of military affairs. Arguments and approaches focusing on weapons and war have regularly figured in studies about the ancient world. Due to the irresistible attraction of technology, the role of weapons on the general dynamics of warfare has sometimes been overrated, as if they were the

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[2] For references on this point, see infra nn. 32, 54, 55 and 56.

[3] For instance, Republican Rome: W. V. Harris, *War and Imperialism in the Roman Republic, 327–70 BCE* (Oxford: Clarendon Press, 1979); J. A. North, "The Development of Roman Imperialism," *JRS* 71 (1981): 1–9; A. H. Bernstein, "The Strategy of a Warrior-State: Rome and the Wars against Carthage, 264–201 BCE," in *The Making of Strategy. Rulers, States and War*, ed. W. Murray et al. (Cambridge: Cambridge Univ. Press, 1994), 56–84. Classical Athens: J. de Romilly, "Guerre et Paix entre Cités," in *Problèmes de la Guerre en Grèce Ancienne*, dir. J. P. Vernant (Paris: Mouton, 1968), 207–20; D. Kagan, "Athenian Strategy in the Peloponnesian War," in Murray, *Strategy* (this note), 24–55. For a recent and critical discussion on this subject, see S. Hornblower, "Warfare in Ancient Literature: The Paradox of War," in *CHGRW*, 1.22–53.

[4] For example, see A. Ferrill, *The Fall of the Roman Empire: the Military Explanation* (London: Thames and Hudson, 1986), 164: "Many historians have argued…that the fall of Rome was not primarily a military phenomenon. In fact, it was exactly that. After 410 the emperor in the West could no longer project military power to the frontiers"; G. Parker, "Introduction: The Western Way of War," in *CHW*, 8 (cf. 11): "Military activity and state formation in the West therefore became inextricably linked: states made war

only cause for a wide range of military and historical matters. Determinism aims to explain the transformations of warfare from the point of view of technological innovation, simplifying the otherwise complex dynamics of war into a single element. However, despite its claims for consistency and homogeneity, it is not a theoretical model by itself. In fact it can be better understood as a motley collection of 'deterministic views,' minor assertions and unverified assumptions about the nature of military transformation and the role of weapons on and off the battlefield.

This approach has fallen in a growing discredit in the last years. Recent studies on ancient warfare increasingly emphasize the impact of ideological and human factors on combat, and deterministic arguments have been consistently identified and rejected whenever the subject has been consciously tackled.[5] My intention here is to present a general discussion

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but war also made states." The theory of the 'hoplite revolution' maintains that the introduction of the Argive shield and the phalanx in Greece led to the formalization of the *polis* as a communal institution; see P. Cartledge, "Hoplites and Heroes: Sparta's Contribution to the Technique of Ancient Warfare," *JHS* 97 (1977): 11–23; J. Salmon, "Political Hoplites?" *JHS* 97 (1977): 84–101; J. M. Bryant, "Military Technology and Socio-cultural Change in the Ancient Greek City," *Sociological Review* 38.3 (1990): 484–516; M. H. Jameson, "The Political and Socio-economic Structure of the Greek Polis," *Stud. Ital.* 85 (1992): 153–160; S. Mitchell, "Hoplite Warfare in Ancient Greece," in *Battle in Antiquity*, ed. A. B. Lloyd (London: Duckworth, 1996), 87–107; V. D. Hanson, *The Other Greeks: The Family Farm and the Agrarian Roots of Western Civilization* (Berkeley: Univ. of California Press, 1999); A. Schwartz, "The Early Hoplite Phalanx: Order or Disarray?" *Classica et Mediaevalia* 53 (2002): 31–64; T. Everson, *Warfare in Ancient Greece: Arms and Armour from the Heroes of Homer to Alexander the Great* (Stroud: Sutton, 2004), 69–73, 120–24. Similarly, a widespread reconstruction of the origins of the Roman state parallels the Greek 'hoplite revolution,' with the introduction of the Greek equipment and tactics leading to the formalization of the Roman citizen state: T. J. Cornell, *The Beginnings of Rome: Italy and Rome from the Bronze Age to the Punic Wars (c. 1000–264 BCE)* (London: Routledge, 1995), 173–97; A. Goldsworthy, *Roman Warfare* (London: Phoenix, 2007), 33–35. The decline of the Mycenean palaces and other cultures in the Eastern Mediterranean at the end of the Bronze Age has also been explained according to military arguments: R. Drews, *The End of the Bronze Age: Changes in Warfare and the Catastrophe ca. 1200 BCE* (Princeton: Princeton Univ. Press, 1993); Everson, *Warfare* (this note), 35–36. Drews argues that both the beginning of chariot warfare in 17th-century BCE Mesopotamia and the introduction of infantry tactics at the end of the Bronze Age were military revolutions that gave a specific tactic a complete superiority for a long period: R. Drews, *The Coming of the Greeks: Indo-European Conquest in the Aegean and the Near East* (Princeton: Princeton Univ. Press, 1989), 74–120; Drews, *End* (this note), 104–34. For a recent and detailed discussion on the connection between war and state, see V. Gabrielsen, "Warfare and the State," in *CHGRW*, 1.1248–72.

[5] For recent studies on ancient warfare from non-deterministic approaches, see among several others J. Carman and A. Harding, ed. *Ancient Warfare: Archaeological Perspectives* (Stroud: Sutton, 1999); J. Rich, "Fear, Greed and Glory: The Causes of

on 'technological determinism' and offer alternative ways to explain technological and tactical change in warfare. I will put to the test the assumptions that, first, some kinds of weapons and tactics are objectively 'superior' to others, and that, secondly, societies are always trying to create or import such superior weapons and tactics, which will therefore be adopted wherever possible. For that purpose, I shall only center on the first level of determinism, i.e. on the basic connection between weapons, tactics and combat, and on the elusive nature of military technology in the ancient world. My conclusions are intended to be applicable to ancient warfare in general, but I shall focus on Greek and Roman cases, due not only to the unbalanced state of our sources, but also to the limitations of my own specialization.

'A hoplite is slave to his weapons': Ancient Approaches to Technology[6]

As a starting point, I will survey the ancient sources in order to assess how the ancient peoples approached military technology. My aim is to

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Roman War-making in the Middle Republic," in *War and Society in the Roman World*, ed. J. W. Rich and G. Shipley (London: Routledge, 1993), 38–62; idem, "The Origins of the Second Punic War," in *SPW*, 1–37; idem, "Warfare and External Relations in the Middle Roman Republic," in *War, Peace and World Orders in European History*, ed. A. V. Hartmann and B. Heuser (London: Routledge, 2001), 62–71; P. Sabin, "The Mechanics of Battle in the Second Punic War," in *SPW*, 59–79; idem, "The Face of Roman Battle," *JRS* 90 (2000): 1–17; idem, "Battle. A: Land battles," in *CHGRW*, 1.399–433; J. E. Lendon, *Soldiers and Ghosts: A History of Battle in Classical Antiquity* (New Haven: Yale Univ. Press, 2005); H. van Wees, ed. *War and Violence in Ancient Greece* (London: Duckworth, 2000); idem, *Greek Warfare. Myths and Realities* (London: Duckworth, 2004). For the rejection of deterministic approaches to ancient warfare and history: J. W. Eadie, "The Development of Roman Mailed Cavalry," *JRS* 57.1/2 (1967): 161–173; W.K. Pritchett, *The Greek State at War, vol. 4* (Berkeley: Univ. of California Press, 1985), 31; H. van Wees, "The Homeric Way of War II," *G&R* 41.2 (1994): 137; J. Rich, "Origins" (this note): 15; idem, "Warfare" (this note): 63; V. D. Hanson, "Genesis of Infantry, 600–350 BCE," in *CHW*, 15; Lendon, *Soldiers* (this note), 156–161; J.A. Lynn, *Battle: A History of Combat and Culture* (Boulder: Westview, 2004). A significant example of this new perspective is the rejection of the 'hoplite reform' theory and its strongly deterministic model: R. Sealey, *A History of the Greek City-States, ca. 700–338 BCE* (Berkeley: Univ. of California Press, 1976), 57; F. Frost, "The Athenian Military before Cleisthenes," *Historia* 33 (1984): 293; I. Morris, *Burial and Ancient Society. The Rise of the Greek City-State* (Cambridge: Cambridge Univ. Press, 1987), 198; K. A. Raaflaub, "Homer to Solon: the Rise of the *Polis*. The Written Sources," in *The Ancient Greek City-State*, ed. M. H. Hansen. Historisk-Filosofiske Meddelelser. 67 (Copenhagen: Munksgaard, 1993), 80; idem, "Soldiers, Citizens and the Evolution of the Early Greek *Polis*," in *The Development of the Polis in Archaic Greece*, ed. L. G. Mitchell and P. J. Rhodes (London: Routledge, 1997), 53.

[6] Eur. *HF* 190: *anēr hoplitēs doulos esti tōn hoplōn*.

establish whether there was any sort of 'ancient determinism' that could act as a foundation for its modern counterpart, although my survey will be naturally limited. Ancient writers resorted at times to weapons, tactics or military arguments in their interpretations of past and present realities. Ancient communities were highly militarized, in the sense that great percentages of their male population were regularly involved in military activities. Warfare was thus deeply rooted in communal ideology and imagery, in public spaces, traditions and literature, and the military factor was probably among the very first that came to mind when trying to explain historical events.[7] However, this does not mean that there was a sort of 'ancient determinism' that paralleled the modern version. Modern determinism cannot claim to rest on ancient foundations, because, as we shall see, the ancients' approach to military technology in particular and warfare in general differed substantially from our own.

To begin with, general assertions of the superiority of particular weapons and tactics were not very common in the ancient world. Only in certain circumstances would a single weapon be said by ancient writers to be superior to others.[8] Likewise, ancient sources only rarely emphasize the role of certain weapons in securing victory in combat, and when they do, common weapons like spears or swords are not

[7] Size of the Roman army in the Middle and Late Republic: Rich, "Warfare" (n. 5): 65; P. A. Brunt, *Italian Manpower, 225 BCE-AD 14* (Oxford: Clarendon Press, 1971). Classical Greek cities: van Wees, *Greek Warfare* (n. 5), 46. For recent and detailed discussions on the role of warfare in Greek civilization: G. Shipley, "Introduction: The Limits of War," in *War and Society in the Greek World*, ed. J. Rich and G. Shipley (London: Routledge, 1995), 1–24; van Wees, *Greek Warfare* (n. 5); Hornblower, "Warfare" (n. 3); M. Whitby, "Reconstructing Ancient Warfare," in *CHGRW*, 1.54–81.

[8] For instance, Aeschylus claims that the Greek spear won the day against the Persian bows and arrows in the Persian Wars (*Pers.* 239–42, 278, 729, 817, 926). This literary metaphor is not strictly deterministic, but it does reflect a concern with the decisiveness of war in preserving the freedom of Greece. Herodotus thought that Greek weapons were superior to the Persians' lighter equipment. Persian bows and short spears made them "easy to overcome" (*eupetees cheirōthēnai*; 5.49.17), while it was their lack of heavy armor (*anoploi*) that explained their annihilation (*diephtheironto*) by the Spartans at Plataea (9.62.11–15), because they "fought, as it were, naked (*gymnetes*) against men fully armed (*hoplites*)" (9.63.10). Tactically, Herodotus also emphasized the Greeks' good order (*kata taxis te kai kata ethnea kekosmēmenoi*) at Thermopylae as a factor in their initial success (7.212). Polybius remarked on the great qualities of the Celtiberian sword or *gladius* (6.23.4), which proved to be superior to other types (frg. 179), while Asclepiodotus pointed out that the Macedonian type of shield was the best (*aristē*; *Tact.* 5.1.1–2) for the phalanx. Both Polybius (3.114) and Livy (22.46) praised the better qualities of the Roman equipment.

usually mentioned.[9] These explanations emphasizing the impact of weapons remain a clear minority in our sources, limited to specific examples of certain battles where the technological factor was thought to be clearly relevant.[10] As we shall see below, ancient writers were far more inclined to look for moral factors to explain victory, and weapons were relegated to a secondary role. Hence, it seems that military arguments could be significant for the ancients when trying to explain general situations, processes or periods, both at the 'political' and the 'structural' levels.[11] But they rarely used them to clarify the specific circumstances of combat.

As a result, war was for ancient peoples more likely to produce global, structural transformations. For example, the Athenian orator Demosthenes remarked in one of his most famed speeches (9.47ss.) that nothing in his time had changed more than war: "while practically all the arts have made a great advance (*pollēn epidosin*) and we are living today in a very different world from the old one, I consider that nothing has been more revolutionized and improved than the art of war (*ouden hegoumai pleon ē ta tou polemou kekinēsthai ka'pidedōkenai*)." Leaving aside the specific political intentions of his longer discussion on war, Demosthenes' comment certainly implies a concern for military matters, and an awareness of their dramatic role in contemporary events. Athens had gone through several political transformations in the previous two hundred years, experiencing changing regimes and several revolutions from tyranny to democracy. Nevertheless, the politician chose to focus on the transformations of war to describe the new situation to his fellow Athenians. This implies not only that the military factor could be used to explain certain events or periods, but also that it was a

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[9] As Sabin claims in "Mechanics" (n. 5): 74: "Differences in equipment are mentioned surprisingly rarely by our sources when accounting for the outcome of individual engagements." This perhaps leads to a greater emphasis on uncommon factors, like elephants (Arr. *Anab*. 5.25.1; Diod. 19.15, 39, 20.113; Plut. *Vit. Dem*. 28) or chariots (Liv. 10.28; Arr. *Anab*. 5.14–18; Plut. *Vit. Tim*. 27; Diod. 20.12).

[10] For example, at the battle of Mantineia (418 BCE): according to Thucydides (5.65–72), the unbalanced protection offered by the shield forced the soldiers to seek refuge in their right-hand comrades' shield, which in the long run produced a general drift of the army. All the subsequent events in the battle were explained through this particular detail, which almost drove the Spartans to defeat.

[11] For instance, the Roman empire as a result of its military strength: Joseph *BJ* 3.71; Veg. *Mil*. 1.1.1–2. Aristotle explained the introduction of the Spartan constitution and Lycurgus' reforms through the argument of the Messenian Wars; he even pointed out that political crisis and transformations "happen especially during war (*kai malista en tois polemois touto ginetai*)" (*Pol*. 1306 b36–1307 a2).

convenient argument that could overshadow other factors and play a leading role in general historical explanations.[12]

A second argument to reject the notion of 'ancient determinism' is the absence of an ancient concept of 'progress' that could parallel our own. This issue is crucial, since the concept of progress makes up the foundation of modern determinism: technological change is commonly interpreted as if the multiple and complex lines of mechanical innovation would lead to a specific end, and every step taken would be better than the previous.[13] Although in the passage mentioned above Demosthenes seems to describe the evolution of warfare as a sort of military 'progress,' it is far from clear whether this detail of political speech can really be interpreted as an example of ancient determinism. In fact, the very existence of an ancient concept of 'progress' is still in question, since the notion of progress raises several problems when applied to the ancient world. In broad terms, it takes for granted not only a context of technological development on the physical level, but also "a speculative view of the future as well as the past" on the intellectual level. In the ancient world reflections on the past were quite common, but speculations about the future were rare. Furthermore, progress implies a 'direction,' which in turn implies a value judgment, a subjective and optimistic interpretation of historical change. Ancient societies lacking detailed historical records hardly conceived of the idea of progress. Constrained by tradition and custom, the ancient world had limited room for innovation, and its relatively unscientific knowledge of the past reduced the possibilities of a systematic comparison with the present. As a result, "progress did not readily develop a generalized meaning."[14]

Moreover, the typically primitive reflections on change and historical evolution were marked by two main features. First, they were to a great extent dominated by myth, legend or any other type of religious or cultural explanation. In Greece, for instance, the scientific approach to

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[12] See E. L. Wheeler, "Battle. A: Land battles," in *CHGRW*, 1.191.

[13] C. Meier warns of the need to have "a precise knowledge and an explicit exposition of the modern concept of progress" before any approach to the ancient ideas of progress is made, in *The Greek Discovery of Politics* (Cambridge: Harvard Univ. Press, 1990), 186. Both notions are, then, closely connected.

[14] For an interpretation of Demosthenes' speech: van Wees, *Greek Warfare* (n. 5), 115–17. For a discussion on the existence of an ancient concept of progress, see E. R. Dodds, "The Ancient Concept of Progress," in *The Ancient Concept of Progress and Other Essays on Greek Literature and Belief*, ed. E. R. Dodds (Oxford: Clarendon Press, 1973), 1; Meier, *Greek Discovery* (n. 13), 186. Both quotations in this paragraph are from Dodds, "Ancient Concept" (this note): 2.

historical change developed by philosophers and intellectuals had to deal with strong and deeply rooted myths like that of the Five Races or the Eternal Recurrence, anti-progressive stories that hampered any sort of rational discussion. Secondly, they tended mainly to be pessimistic. The history of mankind was viewed as a process of continuous degeneration, a permanent reminder that the past had always been better, that men had lost wonderful skills, and that heroes were a thing of the distant past. In fact mythical thinking as a whole, as both Homer and Hesiod show, was pessimistic, describing an ideal past which bore no comparison with the decadent present. As a result, it was difficult for the ancient world to develop a real notion of progress. Even in the restricted sphere of technology, innovation was usually connected to moral failure or regression. Plutarch, for example, described the eloquent reaction ascribed to the Spartan king Archidamus the first time he saw a catapult projectile brought from Sicily (Plut. *Mor*. 191e; *Apoth. Lac*. 219a): "By Heracles, it is the end of manly virtue (*andros areta*)!" he cried. As is still the case in our own world, technology was felt to be a perverse substitute for humans.[15]

There were naturally several affirmations of progress as a positive force, especially in the Graeco-Roman world.[16] However, most of them were only partially affirmations of progress in the modern sense, and

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[15] Mythical thinking as pessimistic: Dodds, "Ancient Concept" (n. 14): 3–4. Technological innovation as moral failure: Dodds, "Ancient Concept," (n. 14): 2, 19, 20; S. Cuomo, *Technology and Culture in Greek and Roman Antiquity* (Cambridge: Cambridge Univ. Press, 2007).

[16] Thucydides claimed that "it is a rule that, just as in crafts, the new always prevails (*aiei ta epigignomena kratein*)" (1.71.3). Aristotle praised the great advances in sciences like medicine (*Pol*. 1268b31–1269a8), and even expected societies to improve from the provision of bare necessities to the advantages of properly established civilization (*Pol*. 1329b25–31); regarding the military, he considered the ancient claim that the best proof of a city's courage was the absence of walls to be an "outdated opinion" (*lian archaiōs hypolambanousin*, *Pol*. 1330b32–35), and encouraged the building of "the securest fortifications" to face "the inventions that have now been made in the direction of precision with missiles and artillery for sieges" (*Pol*. 1331a 1–2). Over a century earlier, Xenophanes had recognized the need for human effort to improve knowledge: "Not from the beginning did the gods reveal everything to mankind," he said, "but in course of time by research (*zētountes*) men discover improvements (*epheuriskousin ameinon*)" (frg. 18 Diels-Krantz). A generation later, Aeschylus drew a sketch of human achievements in Prometheus' speech (Aesch. *PV* 442–506), turning this mythical figure into a symbol of man's continuous effort and spirit. Fifth-century Athenian intellectual life emphasized the importance of the concept of *technē*, and a new confidence in human skills to face future challenges can be seen in historical and medical writings like those of Thucydides and Hippocrates. Sophocles' 'Ode to Man' in the *Antigone* (332–372) praised man's achievement of civilization and cultural development as the result of his own

can be better understood as "perceptions of improvement."[17] Ancient literature on military affairs was in general much more concerned with moral or religious issues than with science or technology: rather than describing technical knowledge from an objective point of view, what mattered was to provide a solution to the controversy about which side was right[18]. As Dodds points out, "there is no attempt to mark the stages of evolution, no recognition of the decisive influence of the food-producing techniques, no reference to the origins of communal life. Technology takes a very minor place."[19]

Specific tools or devices were seldom the focus of intellectual reflection. Regarding military equipment, ancient writers rarely tried to understand or explain their use, function or impact. Most of the time, military change entailed the introduction of new technology and a mechanical adoption of new weapons, without further inquiries on the nature of these changes. This is, for example, the case of Livy's discussion on the evolution of the early Roman army.[20] Naturally, we can find some

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efforts. Archimedes contributed to establish the protocols for scientific research, and expected his theoretical findings to be expanded in the future (*Method*, p. 430 Heiberg). Polybius described the advances in signaling technology and remarked on the likelihood of further improvements (10.43–47). Later, Posidonius, Vitruvius, Manilius, Pliny, Seneca, and several other intellectuals of imperial Rome confessed their confidence in progress and their optimistic view of human skills and capacities for innovation. See Dodds, "Ancient Concept" (n. 14): 4–11, 16, 18, 19, 22–23, and Meier, *Greek Discovery* (n. 13), 194–204. In the military field, Lendon recognizes that "ancient people were perfectly capable of thinking of military progress much as we do, with new, better military methods replacing obsolete old ones," in *Soldiers* (n. 5), 9.

[17] Meier, *Greek Discovery* (n. 13), 204. Regarding the examples described in the previous note, Xenophanes, for instance, does not imply a belief in endless progress in his fragment, while Aeschylus' remark is only concerned with intellectual—not technological—development. See Dodds, "Ancient Concept" (n. 14): 5.

[18] For example, the victory of the Greeks over the Persians was interpreted early in the fifth century from a moral perspective: the Greeks, fighting for freedom, had superior goals and motivations. For further details, see C.G. Starr, "Why Did the Greeks Defeat the Persians?" *La parola del passato* 17 (1962): 321–32. For Polybius, the causes of the Second Punic War were also connected to moral factors, like the humiliation of Carthage in the first war and the Carthaginian desire for revenge. Anger against Rome was also for him the cause of other wars like those with Antiochus and Perseus. See Rich, "Mechanics" (n. 5), for a detailed discussion on this point. Catherine Gilliver argues that the notion of morality was extremely important and a real concern for Romans when waging war, in "The Roman Army and Morality in War," in *Battle in Antiquity*, ed. A. B. Lloyd (London: Duckworth, 1996), 219–38.

[19] Dodds, "Ancient Concept" (n. 14): 5.

[20] Liv. 8.8.3: "The Romans in the past used round shields (*clipei*), but after they began to be paid for military service (*stipendiarii facti sunt*) they adopted oblong ones (*scuta pro clipeis fecere*) in their place; and what had originally been a phalanx on the Macedonian model (*phalanges similes Macedonicis*) later came to be a battle-line (*structa acies*) drawn up by maniples, with those in the rear arranged in more units."

general descriptions of weaponry in ancient literature.[21] But unlike us ancient authors were not interested "in developmental matters or in discovery stories."[22] As a result, they settled the question of technological innovation by attributing the different weapons to certain individuals or peoples.[23] It was Pliny who offered the most elaborate account of individual inventions. His text is in fact a summary of the personalization of military technology:

> The Africans were the first to use clubs (called 'staves') when they battled the Egyptians. Shields were invented, if not by Chalcus son of Athamas, then by Proetus and Aerisius while they were campaigning against each other. Midias of Messene invented the breastplate. The helmet, sword and spear were inventions of the Spartans, and greaves and crests for the helmets came from the Carians. Some say Jupiter's son Scythes invented the bow and arrow, though others attribute the latter to Perseus' son Perses. Lances were developed by the Aetolians, the spear with a throwing strip by Aetolus, Mars' son, the light skirmishing spears by Tyrrenus, likewise the heavy javelin, and the battle-axe by Penthesilea the Amazon. Pisaeus is credited with hunting spears and the version of missile throwers called the scorpion, while the Cretans invented the catapult and the Phoenicians the ballista and the sling.[24]

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[21] Hellenistic tacticians like Asclepiodotus and Onasander, for instance, detailed the characteristics of Macedonian equipment and tactics, while Polybius (6.22–23) and Josephus (*BJ* 3.93–97) focused on Roman equipment. Both Xenophon (*Eq. mag.* 12.1–12) and Ammianus (24.6.8, 25.1.12–13) extensively discussed the arms and armor of the cavalry of their ages, and even Herodotus described the bizarre and heterogeneous armaments of the Persians (Hdt. 7.61–81). Vegetius also enumerated the weapons of the primitive Romans (1.20), and Polybius again carefully studied the organization and operation of the Macedonian phalanx (18.29–30). However, apart from Polybius' and Xenophon's accounts, most of these passages were simply literary digressions written out of antiquarian, erudite, or ethnographical curiosity, but not properly technical comments on the physical characteristics and functional possibilities of weapons.

[22] Cuomo, *Technology* (n. 15): 51.

[23] Marius was credited with the reform of the Roman cohorts, the standardization of the legion's equipment and training, and the introduction of the bending *pilum* (Plut. *Vit. Mar.* 9.1, 13.1, 25.1–2). Iphikrates was also thought to have reformed the peltasts' spear, lengthening it by half (Diod. 15.44; Nep. *Iphicr.* 1.3–4). Other famous innovations were also attributed to specific scientists or generals, like the Macedonian phalanx and the sarissa to Philip (Diod. 16.3.2), the battering ram to one Pephrasmenos from Tyre—later improved by Geras of Chalcedon—(Vitr. *De arch.* 10.13.1–2), or the Greek fire to Kallinikos, "an engineer from Syrian Heliopolis" (Theophanes, *Chron.* 354.14). Examples of collective inventions included the catapult, discovered in Syracuse at the time of the tyrant Dionysius (Diod. 14.42–43), and the trireme, introduced by the Corinthians but popularized by a certain Ameinokles (Thuc. 1.13).

[24] Plin. *HN* 7.200–201. The passage is longer though, and Pliny discusses therein the attribution of other military elements, like the war trumpet to a certain Pisaeus, the

It is remarkable how Pliny needed to attribute some of the most common weapons, like shields or spears, to individual 'inventors,' even to the point of including purely mythological figures in his list. Nevertheless, it is also significant how some of these items were connected to certain peoples for clear ethnographic reasons, like the attribution of the bow and arrow to an eponym of the Scythians, or the javelins to the Aetolians.

However, ancient writers did not recognize all those technological innovations as "forming a continuous ladder of ascent, and still less they conceive such a ladder as extending into the present and the future." As a result, new weapons were considered as isolated dots on the map of mechanical discoveries, unconnected and unrelated to each other. This clearly undermined any opportunity to elaborate a consistent notion of progress, and led to partial and momentary affirmations of local development. It has been suggested that those partial descriptions of progress were in fact connected to certain contexts of cultural and technical expansion, like fifth-century Greece. As a result, certain literary pieces like Prometheus' speech can be explained through the "triumphant experience of progress enjoyed by Aeschylus and his generation."[25]

Nevertheless, these cases of general technological and intellectual dynamism were rather infrequent in the ancient world, and they were not enough to sustain a coherent and general notion of progress. Moreover, even these periods of dynamism witnessed contemporary reactions of opposition, when the forces of tradition and conservatism tried to raise suspicion against cultural change. Moral and religious considerations emerged once again, as anti-progressive intellectuals warned about the dangers of technological development for the established ways of social and cultural life.[26] Only a generation after Aeschylus, Euripides presented progress as a manifestation of divine providence in a speech

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testudo to Artemon of Clazomenae, the ram to Epius during the Trojan War, horse-riding to Bellerophon, the reins and saddles to Pelethronius, and cavalry tactics to the Tessalian people of the Centaurs. He also attributes the two-horse chariot to the Phrygians, and the four-horse type to Erichthonius; Palamedes "invented" (*invenit*) military formation, the password, tokens for recognition, and sentinels, Sinon signaling from watchtowers, and finally Lycaon and Theseus discovered truces and treaties (7.201–2).

[25] Quotations in the paragraph: Dodds, "Ancient Concept" (n. 14): 2–3 and 6. Literary descriptions of technology connected to contexts of technical expansion: Dodds, "Ancient Concept" (n. 14): 6–12; Meier, *Greek Discovery* (n. 13), 186.

[26] For recent bibliography on the subject, see Cuomo, *Technology* (n. 15), 8 and note 4.

by Theseus (*Suppl.* 195–218): the Athenian hero praises not human effort or ingenuity, but "the god who brought us to live by rule from chaos and from brutishness." In the next century, Plato's theory of Forms represented a more fundamental opposition to the idea of progress, since for him all kind of improvement consisted not in an endless race towards superior forms of intellectual and technological findings, but in the approximation to a pre-existing model. Thus, there was no such thing as 'invention,' and the focus was not on the future but on the past. Taking this idea one step further, in the *Laws* (678–9) Plato imagined his ideal society as a sort of 'primitive community,' trying to reproduce in it the same simplicity, the same absence of wealth, and the same lack of complex technology that could be found in earlier human groups. The resulting picture is contrary to the notion of linear progress, and recovers the old myth of the Eternal Return. In his *Protagoras*, again, the myth of Prometheus (320d–321d) reveals the divine origin of human skills and techniques, emphasizing the defenselessness of the human condition without the support of the gods.

Even Aristotelian optimism about human improvement was soon betrayed by his own pupils, Theophrastus and Dicaearchus, who followed Plato in his idealization of primitivism as a simpler and happier way of life. The idealization of a more stable past and the nostalgia for a simpler existence found literary expression in Theocritus, Onesicritus, Vergil, and finally in Horace, who expressed his rejection of progress in a new version of the Five Races myth (*Carm.* 3.6.46). Both Vergil (*Ecl.* 4.4, *Aen.* 6.791) and Seneca (*Q Nat.* 3.27–30) believed that the destruction of the human race was close, and that a new Golden Age would arise from the ashes of civilization.[27] Even in the military field, the past was a source of innovation: according to Diodorus (16.3.2), Philip II got the idea of an infantry force armed with long pikes from Homer.[28] As Lendon points out, it was the past, and not the future, that really inspired cultural and military transformation in the ancient world.[29]

Thus, serious obstacles arose against the idea of progress, not only because intellectual evolution could paradoxically lead to anti-progressive

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[27] Following Dodds, "Ancient Concept" (n. 14), 16–17, 20–21.

[28] "Philip devised the compact order and the equipment of the phalanx (*tèn tês phálangos pyknótēta kaì kataskeuén*), imitating the close order fighting with overlapping shields of the warriors at Troy (*mimnesámenos tòn en Troía tôn heróōn synaspismón*), and was the first to organize the Macedonian phalanx."

[29] Lendon, *Soldiers* (n. 5), 11–13, 36–38, 156–61. See also Dodds, "Ancient Concept," (n. 14): 14–15.

doctrine, but also because the feeling spread that technology could not produce further innovations: the poet Choerilus of Samos pointed out that "everything has been assigned (*panta dedastai*) and the *technai* have reached their limits (*echousi de peirata*)" (Frg. 1 Kinkel).[30] Lucretius claimed that "everything remains always the same (*eadem sunt omnia semper*)" (3.945), and the emperor Marcus Aurelius shared this view several centuries later: "our successors will see nothing new (*ouden neōteron opsontai*)," he wrote; "in a sense, the man who has lived for forty years, if he has any intelligence at all, has seen all that has been and all that will be (*panta ta gegonota kai ta esomena heōrake*), since all is one kind (*kata to homoeides*)" (11.1). Regarding military development, Frontinus expressed a similar conviction (*Str.* 3 *pr.*): "I leave aside siege works and engines," he wrote in his military treatise, "human invention having been exhausted in this realm long ago. I see no basis for further improvement (*nullam video ultra artium materiam*)."

In their discussion about intellectual and technological development, ancient societies represent the controversy between innovation and tradition, research and conservatism. Some ancient writers understood quite well that the real limit for progress was human nature itself, and that moral principles were always a match for technological innovation. As happens now with modern scholarship, weapons, tactics and military explanations had an extraordinary appeal and played a considerable role in historical explanations, but unlike in our modern world, ancient thought could not develop a real notion of progress.[31] As a result, their theoretical approach to military technology, albeit capable at times of substituting complex causality for simple determinism, was more superficial. Ancient technology did not pervade all the spheres of life, as modern technology does, and perhaps for that reason it played a minor role in historical explanation. As a result, ancient determinism manifested itself usually at the political and structural levels, and much less at the battlefield level. Of course, military technology was at times thought to represent a threat to human values, skills and functions. That was

[30] Regarding simple weapons, this is not far from true indeed. According to van Creveld, "by 600 BCE, at the very latest, the most important weapons which in their endless combinations were destined to dominate warfare during the next two millennia had been invented and were in widespread use," in M. van Creveld, *Technology and War. From 2000 BCE to the present* (New York: The Free Press, 1991), 14.

[31] See Dodds, "Ancient Concept" (n. 14): 24–25, and Meier, *Greek Discovery* (n. 13), 193–195.

certainly the main concern of ancient writers. Yet even then, those intellectuals preferred to focus on warfare and its impact on human life, rather than on the weapons themselves. Thus, it is fairly safe to conclude that the ancients did not share our deterministic approach to technology, and therefore that there is no ancient basis for modern deterministic approaches to the ancient world. In fact, it is our identification of history with progress and our concept of human development that needs to be explained.

Technology and Superiority: The Myth of Determinism

As pointed out above, modern scholarship on the ancient world has tended at times to emphasize the impact of technology on warfare and the leading role played by weapons in military victory. According to this view, superior equipment could be thought to perform decisively in combat, and could explain why and how a battle was won. In this line, Holley maintains that "even the most cursory survey of military history substantiates the premise that superior weapons give their users an advantage favouring victory."[32]

However, do better weapons really win battles? The answer to this question has sometimes been affirmative, but a detailed analysis of the two elements that compose it, 'better weapons' and 'winning battles,' is

[32] Impact of technology in war: van Creveld, *Technology* (n. 30), 1, 12. Examples of superiority: iron-working peoples against non-iron-working peoples: van Creveld, *Technology* (n. 30), 14–15. Greeks over the Persians: A. B. Lloyd, "Philip II and Alexander the Great: The Moulding of Macedon's Army," in *Battle in Antiquity*, ed. A. B. Lloyd (London: Duckworth, 1996), 192–3; S. Hornblower, "Greeks and Persians: West against East," in *War, Peace and World Orders in European History*, eds. A. V. Hartmann and B. Heuser (London: Routledge, 2001), 53. Superiority of Greek mercenaries abroad: see infra, n. 37. Romans over other Mediterranean peoples: Bernstein, "Strategy" (n. 3); Sabin, "Mechanics" (n. 5): 74; idem, "Face" (n. 5): 3. The superiority of the Greek hoplite equipment in general is an old dictum in modern scholarship: A. Snodgrass, *Early Greek Armours and Weapons from the End of the Bronze Age to 600* BCE (Edinburgh: Edinburgh Univ. Press, 1964), 180; M. I. Finley, *Early Greece. The Bronze and Archaic Ages* (London: Chatto and Windus, 1970), 101; Salmon, "Political Hoplites?" (n. 4): 84 n. 1; O. Murray, *Early Greece* (Brighton: Harvester, 1980), 120; A. J. Holladay, "Hoplites and Heresies," *JHS* 102 (1982): 99–100; Jameson, "Political" (n. 4): 158; Bryant, "Military Technology" (n. 4): 488, 498; Schwartz, "Early Hoplite Phalanx" (n. 4): *passim*; P. Hunt, "Military Forces," in *CHGRW*, 1.117. Considering the history of the Roman army as a whole reinforces the tendency to regard the 1000 years of Roman victories and expansion as military superiority; see, for example, Lendon, *Soldiers* (n. 5), 168–71. Quotation: I. B. Holley, *Ideas and Weapons* (Washington: Office of Air Force History, 1971), 175.

often absent. The historical-technological argument usually emphasizes technological over historical factors, and resorts most commonly to explanations about the mechanical development of historical events. A common feature of technological determinism is "the absence of rigorous definition of weapons, combined with a tendency to stress that specific pieces of technology were active ingredients in shaping military outcomes. In some cases … the machines become quite central." Consequently, determinism is the result of a lack of accurate definitions of the many elements involved in warfare, especially the weapons. "Loose definitions," says George Raudzens, "encourage tendencies toward technological determinism."[33]

A complete survey of the complexities and problems surrounding the definition of ancient military realities would certainly fall beyond the limits of this study, and I will not attempt it here. Nevertheless, it would be useful to differentiate between the many devices we recognize as 'technology,' especially between 'tools' and 'machines.' Technically speaking, simple weapons like spears or swords could be best labeled as 'tools,' implements intended to be an extension of human muscular strength and functions; these tools interact in complex systems of artifacts and practices that we usually label 'weapon systems,' like the Greek phalanx or the Roman legion. Machines, in contrast—catapults, towers, battering rams—are complex devices with moving parts that translate muscular into mechanical energy. For obvious reasons, machinery has always attracted greater attention than tools, and it has been the object of theoretical inquiry since antiquity. However, the vast majority of ancient fighting was in practice carried out using simple weapons, while machines played a minor role. This is a relevant distinction when dealing with ancient military technology, for machines and tools were in fact engineered, produced, and spread through different ways and channels.[34]

Determinism implies that superior technology, either in the form of tools or machines, has a direct impact on the outcome of ancient battles. As Bryant puts it, "proficiency in the travails of combat is everywhere

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[33] Both quotations in the paragraph, in G. Raudzens, "War-Winning Weapons: The Measurement of Technological Determinism in Military History," *JMH* 54 (1990): 405.

[34] Machines as complex devices: J. Keegan, *A History of Warfare* (London: Pimlico, 2004; originally published, 1993), 119; van Creveld, *Technology* (n. 30), 11. For a recent discussion on the spread of the catapult and other machines, see Cuomo, *Technology* (n. 15), 46–59. For the connection between weapons and simple tools, see Xen. *Hell.* 3.3.7.

basically a function of superiority in weaponry and physical skills."[35] However, two questions must be asked: what exactly is 'superior technology,' and how can the 'direct impact' be measured? Raudzens points out that "the impact of weapons on the outcome of battles is not nearly so obvious, though at times it is strongly implied." Superior technologies, thus, are supposed, either consciously or unconsciously, to play a decisive role in combat, because new artifacts are thought to perform much more effectively than older ones.[36] However, since a certain degree of technological balance is usually assumed in intra-ethnic wars—Romans fighting Romans, Greeks fighting Greeks, and so on—superiority is more commonly emphasized in inter-ethnic wars.[37]

This approach leads to two problems. First, both 'superiority' and 'effectiveness' entail a comparison that is not always possible. The notion of superiority demands not only elements but also criteria and terms for comparison —'superior' in what, over what and according to what? Most of the time the information or analysis required is not available. Secondly,

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[35] Quotation: Bryant, "Military Technology" (n. 4): 488. As a result, determinism encourages a logical and rational interpretation of war: "In the conventional approach of military historians," says John Carman, "war-making decisions and actions are explained as either designed to perform a particular (often strategic or tactical) function successfully, or as a failure to identify correctly an opportunity or a threat," in "Beyond the Western Way of War: Ancient Battlefields in Comparative Perspective," in *Ancient Warfare. Archaeological Perspectives*, ed. J. Carman and A. Harding (Stroud: Sutton, 1999), 39.

[36] Quotation: Raudzens, "War-Winning Weapons" (n. 33), 404. New and more effective artifacts: the Argive shield, for instance, is a common example of a technological innovation with dramatic effects on the battlefield. Its plain superiority is sometimes emphasized, e.g. Jameson, "Political" (n. 4): 158; Everson, *Warfare* (n. 4), 120, while it was supposed to have been a decisive factor in battles like Hysiae (669 BCE). See A. Andrewes, *The Greek Tyrants* (London: Hutchinson, 1974); Cartledge, "Hoplites and Heroes" (n. 4): 25; Salmon, "Political Hoplites?" (n. 4): 92–93; V. Parker, "The Dates of the Messenian Wars," *Chiron* 21 (1991): 44–46. M. M. Markle emphasized the crucial role of the sarissa, that "changed the nature of the infantry phalanx," in "The Macedonian Sarissa, Spear and Related Armor," *AJArch*. 81.3 (1977): 331.

[37] Lynn, "Battle" (n. 5): xviii–xix. Examples of inter-ethnic wars: the equipment of the Roman legionary against the traditional Greek hoplite panoply in their second-century wars: Sabin, "Face" (n. 5): 3; V. D. Hanson, "From Phalanx to Legion, 350-250 BCE," in *CHW*, 44. The Greek panoply against the lighter equipment of the Persians throughout the Classical period: Hornblower, "Greeks and Persians" (n. 32), 53. Greek mercenaries in service abroad during the archaic period: Holladay, "Hoplites and Heresies" (n. 32): 100; A. Snodgrass, "Interaction by Design: The Greek City-State," in *Peer Polity Interaction and Socio-political Change*, ed. C. Renfrew and J. F. Cherry (Cambridge: Cambridge Univ. Press, 1986), 51–52; P. Baker, "Les Mercenaires," in *Armées et Sociétés de la Grèce Classique. Aspects sociaux et politiques de la guerre aux Ve et IVe s. av. J. C.*, ed. F. Prost (Paris: Errance, 1999), 240; Hunt, "Military Forces" (n. 32): 109.

'effectiveness' is not a simple variable, but can be assessed according to different criteria: speed, length or distance, range, weight, damage. For any given piece of technology, these criteria are not always clear-cut: shields, for example, considerably improve the protection of a soldier, but they are heavy and cumbersome artifacts that can eventually become a nuisance for their bearers.[38] Thus, a weapon can be superior in one respect, but clearly inferior in another.

Despite these problems, 'superiority' and 'effectiveness' are closely related concepts in deterministic terms. Effectiveness is commonly estimated according to the killing potential of a given weapon, that is, according to the assumption that improved artifacts produce more casualties. As a result, some weapons are superior to others because they kill more people than the rest. Fundamental to this preconception is the Clausewitzian idea of annihilation as the objective of war. Clausewitz explicitly stated that "the direct annihilation of the enemy's forces must always be the dominant consideration," because "the destruction of the enemy forces is the overriding principle of war." This 'annihilation policy' has at times been connected to different cultures of different periods, like Late Bronze Age Egyptians, Hittites and Assyrians, Alexander's semi-professional army or the late Republican Roman legions. At earlier stages, a pattern of violent attacks and 'massacres' have been detected in European Mesolithic and Neolithic communities, where the entire population seems to have been slaughtered and thrown into ditches. According to Thucydides (7.87.6), some forty thousand Athenians were massacred in the Sicilian Expedition in a clear example of this terrible policy: "The Athenians were beaten in all areas and altogether; all that they suffered was great; they were annihilated, as the saying goes, with total annihilation (*nikēthentes … panōlethría to legomenon*), their army, their fleet, everything was annihilated (*kai pezos kai nees kai ouden hoti ouk apōleto*), and few out of many returned home (*oligoi apo pollon ep' oikou apenostēsan*)." Hanson provides another example from classical Greece, presenting it as an example of the destructive potential of hoplite warfare: the almost complete destruction of a whole community, Boeotian Thespiai, in a chain of disastrous military actions during the

[38] On the Argive shield see, for example, V. D. Hanson, *The Western Way of War. Infantry Battle in Classical Greece* (Oxford: Oxford Univ. Press, 1990), 65–71; Goldsworthy, *Roman Warfare* (n. 4), 134–35. On the Roman *scutum* see Wheeler, "Battle" (n. 12): 196.

fifth century. Thus, the need for technological superiority is built into the very foundations of war-making.[39]

This point is extremely dubious, though. The material potential of ancient technology for killing, and the very existence of this 'annihilation principle' as the final goal of ancient warfare should be revised. On the one hand, ancient weapons were not really effective artifacts for mass destruction. Recent studies on Greek and Roman mortality rates in combat show that casualties were rather low in general terms.[40] Ancient 'tools' were not accurate implements for fast, effective and complete annihilation. Killing required a rather long time, and handling simple weapons for long periods was extremely exhausting, hampering a systematic destruction of the enemy. Hanson describes the extraordinary effort of Hannibal's army to annihilate the Roman legions at Cannae, and the enormous difficulty in finishing off thousands of still armed and desperate men. For this reason, "Hannibal's men must have sought to inflict a quick, crippling wound and then to move on to the next victim, confident that the wounded could be easily polished off the next day." As a result, time, and not technology, was often the real agent of death.[41]

True, Hellenistic warfare escalated into disproportionate massacres, as casualties rose to many thousands per battle, and even in the classical period massacres can be found on several battlefields.[42] Hence, the work

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[39] Quotation from Clausewitz: C. von Clausewitz, *On War* (Oxford: Oxford Univ. Press, 2008), 1.1.3. Effectiveness and higher casualties: G. Raudzens, "Firepower Limitations in Modern Military History," *Journal of the Society for Army Historical Research* 67.271 (1989): 134. Late Bronze Age Egyptians, Hittites and Assyrians: Hanson, "Genesis" (n. 5): 16. Alexander's army: Lloyd, "Philip" (n. 32): 187–94; Hanson, "Phalanx" (n. 37): 37. Late Republican Roman legions: Goldsworthy, *Roman Warfare* (n. 4), 24–25, 103–4; J. P. Roth, "War," in *CHGRW*, 1.397. European Mesolithic and Neolithic communities: S. Vencl, "Stone Age Warfare," in *Ancient Warfare. Archaeological Perspectives*, ed. J. Carman and A. Harding (Stroud: Sutton, 1999), 57–72. Thespiai: V. D. Hanson, "Hoplite Obliteration: The Case of the Town of Thespiai," in *Ancient Warfare. Archaeological Perspectives*, ed. J. Carman and A. Harding (Stroud: Sutton, 1999), 203–17. See also the massacre of an Argive army by the Spartans in a battle inside the walls connecting Corinth and Lechaion in 392, and notice Xenophon's striking account of the circumstances of the slaughter (*Hell*. 4.4.12).

[40] Casualties in Greek combat: P. Krentz, "Casualties in Hoplite Battles," *GRBS* 26 (1985): 13–29; Wheeler, "Battle" (n. 12): 212–13. Casualties in Roman combat: Brunt, *Italian Manpower* (n. 7); Sabin, "Mechanics" (n. 5); idem, "Battle" (n. 5): 413–16; Rich, "Warfare" (n. 5); Roth, "War" (n. 39): 394–98.

[41] Killing at Cannae: V. D. Hanson, "Cannae," in *Experience of War. An Anthology of Articles from MHQ (the Quarterly Journal of Military History)*, ed. R. Cowley (London: Norton, 1992), 44–45. Quotation: ibid., 48. See also A. Goldsworthy, *Cannae. Hannibal's Greatest Victory* (London: Phoenix, 2007), 150–56.

[42] Casualties in Hellenistic battles: V.D. Hanson, *The Wars of the Ancient Greeks*. Cassell History of Warfare (London: Cassell, 1999), 201; Sabin, "Battle" (n. 5): 413–16.

could be naturally accomplished even with those 'tools.' However, the contrast between the reduced mortality of classical battles and the insane slaughter of later periods emphasizes the fact that the characteristics and limitations of ancient weaponry do not suffice to explain the casualty rates, and that the destructive power of an army depends in practice on myriad factors. Furthermore, increasing enemy casualties was not necessarily a guarantee for immediate victory either in battle or in war: despite suffering great losses at the beginning of the Hannibalic war, Rome kept on fighting for fifteen more years and eventually won the war. Late fifth-century Athens provides another example: the dramatic losses produced by the plague in 429–427 and the extermination of the whole Athenian army in the Sicilian Expedition in 415–413 did not prevent the city from fighting for twenty seven years in the Peloponnesian War. Inflicting greater losses was not always, I would say, the aim of a battle, but simply a way to prevail over the enemy. In ancient warfare, physical or material predominance was not always sought, but a moral reward was often preferred. Honor and profit were powerful objectives by themselves, and they could both be satisfied without disproportionate bloodshed.[43]

Inflicting higher casualties, thus, was not a sufficient criterion for technological effectiveness. Weapons and weapon systems had advantages and disadvantages that made it difficult to assess their performance on a regular and objective basis. Late Roman cataphracts, for

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For Cannae, where more than 50,000 Roman legionaries were killed, see Hanson, "Cannae" (n. 41); Goldsworthy, *Cannae* (n. 41). For a recent discussion on the casualty rates in the battles of the Second Punic War, see Sabin, "Mechanics" (n. 5): 66–68.

[43] Honor as a structural element of war: D. Kagan, *On the Origins of War and the Preservation of Peace* (New York: Anchor Books, 1996), 8–10; van Wees, *Greek Warfare* (n. 5), 22–26. Discussing the aftermath of Cannae, Adrian Goldsworthy suggests that "war, as Hannibal had been raised to conceive of it and practise it, did not require the annihilation of the enemy, which was anyway seldom possible. Instead, it required a demonstration that it was no longer in his interest to continue fighting. Once persuaded of this, a state or people conceded defeat and sought peace," in *Cannae* (n. 41), 168. The speech of the Corinthians before the Peloponnesian allies on the eve of the war against Athens offers a confirmation of this point: "it behooves brave men, when wronged, to go from peace to war, but to abandon war and resume peace again when a favourable opportunity offers" (Thuc. 1.120.3). They later recognize that they will put an end to the war "as soon as we have avenged our wrongs upon the Athenians" (Thuc. 1.121.1). Clausewitz himself recognizes that complete annihilation, what he calls 'disarming the enemy', is just the object of war 'in the abstract', and that it frequently cannot be accomplished; in fact, "it is possible to increase the likelihood of success without defeating the enemy's forces", and "in war many roads lead to success, and they do not all involve the opponent's outright defeat"; see Clausewitz, "On War" (n. 39), 1.2.

example, designed as crack force to charge through infantry lines, were defenseless if thrown from their horses, and vulnerable in hand-to-hand fighting due to their lack of shield; they were only capable of performing one tactic—frontal charge at full speed—and this only under ideal conditions: "on level ground, in fairly moderate temperatures, and against an unimaginative opponent." The chariots were impressive weapons designed for frontal attacks in order to disperse the enemy infantry, but their performance relied on surprise, speed and favorable conditions, and they remained extremely breakable and difficult to control at top speed. The Greek hoplite, although well suited to close combat, was a slow soldier who performed less effectively on rough terrain and could be easily outmaneuvered by cavalry or light-armed troops.[44] Weapons were in fact a continuous problem for the commander, who had to provide the logistics required for their use: cavalry needed horses that had to be fed; swords and spears frequently broke, and specialized craftsmen and increasing amounts of raw materials were needed to repair or replace them. An army like Antiochus' at Magnesia—with some 70,000 men, cavalry, mounted archers, dromedaries, light infantry, elephants and scythed chariots (Liv. 37.40)—common from the fourth century onwards, clearly illustrates these logistical problems.[45]

Thus, technological effectiveness is not always a matter of casualty rates; in fact, "are there clear examples of the realization of weapons expectations? …Weapons impact analysis has not received more than marginal attention from scholars." The limitations of ancient weapons should lead to new considerations regarding their social and psychological impact upon their bearers. The deterministic approach focuses permanently on weapons, while the human side of warfare is often pushed into a secondary position: "the emphasis is on the hardware, and the human dimension of weapons impact is, as a rule, not treated. We know a great deal about when and how weapons were made, how many were produced and what they looked like, a bit about where they were

[44] Quotation: Eadie, "Development" (n. 5): 165, 172–73. Chariots: R. F. Glover, "Some Curiosities of Ancient Warfare," *G&R* 19.55 (1950): 5–6; Sabin, "Battle" (n. 5), 417–18. Greek hoplite: Hanson, *Western* (n. 38); idem, "Genesis" (n. 5).

[45] On logistics, see generally D. W. Engels, *Alexander the Great and the Logistics of the Macedonian Army* (Berkeley: Univ. of California Press, 1980) and J. W. I. Lee, *A Greek Army on the March. Soldiers and Survival in Xenophon's* Anabasis (Cambridge: Cambridge Univ. Press, 2007). On logistics in archaic and classical Greece, see P. Krentz, "War," in *CHGRW*, 1.150–4. For Hellenistic and early Roman times, see Roth, "War" (n. 39): 380–88.

used, a little about how much they cost, and plenty about their performance capabilities at least in theory and on the testing ranges. Only occasionally are there comments about their actual impact on soldiers in battle."[46] As a result, determinism eliminates the human being from the equation of historical change in favor of arguments based on technology, which are much more compelling and attractive.

Ancient sources, in contrast, strongly stressed the human factor as decisive for winning battles: as the anecdote of Archidamus and the catapult show, moral qualities were thought to be the real causes of victory or defeat.[47] The emphasis on men as the decisive elements in warfare has a long history in ancient literature, especially in Greek literature, where citizen soldiers are depicted as the real 'wall' of the city (Alc. frg. 112.10; Thuc. 7.77.7). Courage, readiness for duty and sacrifice are greatly celebrated both in Homer and in lyric poetry,[48] because a man who fights is "a common good for the whole city and the community (*xunon esthlon touto polēi te panti te dēmō*)" (Tyrtaeus frg. 12.15). The human factor reveals itself as crucial in every field of warfare: Alexander's success in sieges, for example, owed a great deal to internal strife and treason, and the considerable effort devoted by Aeneas Tacticus in his work to the prevention of treason during a siege (10, 18–20) shows that suspicions were well grounded. Philopoemen's military reforms focused more on the preparation and training of troops than on the introduction of new weapons, for the failure of the Achaean army was for him a moral, not a technological, problem. Greek literature emphasized the role of the general in the final success of any campaign, rating his personal qualities and charisma over the material conditions of the army. These are all examples of the crucial role of human nature in warfare as perceived by the ancients.[49]

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[46] Quotations: Raudzens, "War-winning weapons," (n. 33): 403; idem, "Firepower" (n. 39): 130–31.

[47] For Archidamus and the catapult, see Plut. *Mor*. 191e; *Apoth. Lac*. 219a. Moral factors in ancient sources: P. Beston, "Hellenistic Military Leadership," in *War and Violence in Ancient Greece*, ed. H. van Wees (London: Duckworth, 2000): 315; Cuomo, *Technology* (n. 15), 42–43.

[48] Homer: *Il.* 2.235, 5.529, 7.96, 6.112, 8.174, 11.287, 15.487, 561, 564, 661, 734, 16.209, 270, 17.111, 185, 264, 20.169, 21.571–2. Lyric poetry: Tyrtaeus frg. 5.4–6, frg. 10.17–18, frg. 11.2–4, frg. 12, frg. 13; Callinus frg.1.1.

[49] Internal strife and sieges: B. Gille, *Les Mécaniciens Grecs. La Naissance de la Technologie* (Paris: Seuil, 1980), 52; Y. Garlan, *La Guerre dans l'Antiquité* (Paris: Nathan, 1972), 125–26; B. S. Strauss, "Battle. B: Naval Battles and Sieges," in *CHGRW*, 1.244–6. Philopoemen's military reforms: Beston, "Hellenistic Leadership" (n. 47): 319–20, 325.

Men, the real agents of war, are dramatically shaken in combat, and their morale, stamina or confidence in victory can be seriously affected by multiple factors. Fear, stress, tiredness, hunger or thirst, all threaten to turn the most experienced units into a panicked and useless mob. Raudzens points out that "most soldiers in most recorded battles surrender or run off after losing less than one third of their comrades"; this means that psychological imperatives prevailed over tactics and command in a considerable part of historical warfare.[50] Weapons play a crucial role in this psychological sphere, because they have a considerable effect on the soldiers' morale and will: all over the ancient world, warriors from different cultures attempted to intimidate their enemies with their appearance, like the Homeric heroes or the Gauls; even the Roman legionaries attempted to frighten the enemy with their panoplies.[51] Perhaps common weapons like spears or swords were not particularly terrifying, but intimidation was not caused by individual pieces but by the whole equipment, and other, more sophisticated, elements played a greater role: Diodorus, for instance, describes the extraordinary impact of the first catapults on men's morale, and confesses that "this piece of artillery caused in fact great consternation" (14.50.4). Chariots had a similar effect (Diod. 17.53; Front. *Str*. 2.3.17), and Vegetius says that they provoked "great fear" (*magnum terrorem*) the first time they were used in combat (3.24.1). Elephants caused considerable impact as well,

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The role of the general in combat: ibid., 321, 322, 325, 326, 328. Bear in mind the catastrophic effects that a commander's death in combat has on his troops: Sabin, "Mechanics" (n. 5): 74; E. L. Wheeler, "The General as Hoplite," in *Hoplites. The Classical Greek Battle Experience*, ed. V. D. Hanson (London: Routledge, 1991), 121–72; Hanson, *Western* (n. 38), 107–16. For a discussion on the crucial role of Alexander's leadership, see Lloyd, "Philip" (n. 32): 177–78.

[50] Raudzens, "Firepower" (n. 39): 152–3. For experienced units turning into a panicked mob: Keegan, *Face of Battle* (n. 1), 172–77. For psychological factors in combat: Sabin, "Mechanics" (n. 5), 71–77; C. J. Rogers, "The Efficacy of the English Longbow: A Reply to Kelly deVries," *War in History* 5.2 (1998): 235.

[51] References on the outfit of the Homeric heroes: van Wees, "Homeric Way of War II" (n. 5): 131–37. For the terrible appearance of the Gauls: Liv. 5.35.4, 37.4, 37.8; Polyb. 2.29.6–9; Plut. *Vit. Mar*. 15, 21. For further details on Gauls, see L. Rawlings, "Celts, Spaniards, and Samnites: Warriors in a Soldiers' War," in *SPW*, 87. Roman legionaries: "The effect of these [a set of long feathers] being placed on the helmet, combined with the rest of the armor, is to give the man the appearance of being twice his real height, and to give him a noble aspect calculated to strike terror into the enemy" (Polyb. 6.23). See also Rawlings, "Celts" (this note): 88. Adornment of shields in the Hellenistic armies as a way to impress and frighten the enemy: B. Bar Kochva, *The Seleucid Army. Organization and tactics in the great campaigns* (Cambridge: Cambridge Univ. Press, 1976), 56, and notes 10–12.

because their size and spectacular performance in combat almost counteracted their uncontrollable character. Ancient sources emphasize the terrible sight of elephants, and the deadly effects of their trunks and tusks. Military formations, like the phalanx and the legion, also had a famous terrifying power over their enemies.[52]

The impact of weapons in the development and outcome of a battle, thus, is not a direct and logical connection in terms of casualties or hits, but a complex equation involving many variables. Thus, if the alleged 'superiority' or 'effectiveness' of a weapon is measured in terms of performance in combat, we have to find the value of all those variables; to consider a single aspect is not enough reason to regard a piece of technology as superior. The specific use of the weapon in practice—the accuracy of the 'tool' for its established task—should also be taken into account. However, this is no easy feat: the task can be different according to different users, and it is commonly the results of a gradual interaction with the weapon.[53] Thus, the 'most accurate task' is not always self-evident, but mistakes and errors of judgment or assessment can assign specific pieces to wrong functions. However, this ranges beyond the limits of technology, and moves into the fields of strategy and tactics.

Superior Tactics: Formations against Formations

According to determinism, tactics must be systematically connected with specific weapons, and a belief in tactical superiority parallels technological superiority: a 'superior' weapon is thought to perform a given tactical function more efficiently than 'inferior' ones. The Argive shield is an example of this view, sometimes identified with the hoplite phalanx to the point that an isolated hoplite is considered useless.[54] As a result, deterministic approaches tend to emphasize the superiority of some

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[52] Chariots: Diod. 17.53; Front. *Str*. 2.3.17. Elephants: R. F. Glover, "The Tactical Handling of the Elephant," *G&R* 17.49 (1948): 1, 3–4; Sabin, "Battle" (n. 5): 419–21. Ancient sources on elephants: Diod. 17.88; Plut. *Pyrrh*. 21.7; Polyb. 1.74.3, 77.2, 3.53.8; Liv. 33.9.7; App. *Hisp*. 46; Veg. 3.24.5–6. Greek phalanx: Hanson, *Western* (n. 38), 96–104; idem, "Genesis" (n. 5): 19; idem, "Phalanx" (n. 37): 33, 40. Macedonian phalanx: N. G. L. Hammond, "Training in the Use of the Sarissa and Its Effect in Battle, 359–333 BCE," *Antichthon* 14 (1980): 59. Legion: Hanson, "Phalanx" (n. 37): 43.

[53] See van Creveld, *Technology* (n. 30), 15.

[54] Argive shield and hoplite phalanx: H. L. Lorimer, "The Hoplite Phalanx with Special Reference to the Poems of Archilochus and Tyrtaeus," *BSA* 42 (1947): 76–138; M. Détienne, "La Phalange, Problèmes et Controverses," in *Problèmes de la Guerre en*

tactics over others.[55] Hence, being regarded as superior, these tactics are supposed to have spread, simply copied, from one place to another in a sort of mechanical transfer of knowledge.[56]

However, the assessment of these 'superior qualities' of weapons and tactics is absolutely subjective, and modern scholars can disagree on this point. For instance, Greek hoplites are usually considered heavy, slow

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Grèce Ancienne, dir. J. P. Vernant (Paris: Mouton, 1968), 119–42; Cartledge, "Hoplites and Heroes" (n. 4): 13; idem, "La Nascita degli Opliti e l'Organizzazione Militare," in *I Greci: Storia, Cultura, Arte, Societá. vol. II.I, Formazione*, ed. S. Settis (Torino: Einaudi, 1996), 692; R. Osborne, *Greece in the Making, 1200–479 BCE* (London: Routledge, 1996), 177–78; Everson, *Warfare* (n. 4), 120–22; Lendon, *Soldiers* (n. 5), 182; Goldsworthy, *Roman Warfare* (n. 4), 33. Isolated hoplites: Lorimer, "Hoplite Phalanx" (this note): 128; idem, *Homer and the Monuments* (London: Macmillan, 1950), 462; T. B. L. Webster, *From Mycenae to Homer* (London: Methuen, 1958), 214–15; W. G. Forrest, *The Emergence of Greek Democracy. The Character of Greek Politics, 800–400 BCE* (London: World Univ. Library, 1966), 90; Andrewes, *Greek Tyrants* (n. 36), 32; Bryant, "Military Technology" (n. 4): 498; Mitchell, "Hoplite Warfare" (n. 4), 89; Osborne, *Greece* (this note), 175–76; Schwartz, "Early Hoplite Phalanx" (n. 4): 33, 39–40; Goldsworthy, *Roman Warfare* (n. 4), 33–34. For a critical discussion on this subject, see L. Rawlings, "Alternative Agonies. Hoplite Martial and Combat Experiences Beyond the Phalanx," in *War and Violence in Ancient Greece*, ed. H. van Wees (London: Duckworth, 2000), 233–59. The sarissa is thought to be useless outside the phalanx as well: Markle, "Macedonian Sarissa" (n. 36): 331; Hammond, "Training" (n. 52): 53. The Bronze Age chariot has been so tightly linked to chariot warfare and charge tactics that the functions described in Homer have been branded as literary fantasy or even ignorance of a lost practice; for a recent discussion on this point, see van Wees, *Greek Warfare* (n. 5), 159 and note 17.

[55] Lendon recognizes the existence of this pattern in scholarship in *Soldiers* (n. 5), 11, a pattern emphasizing, for example, the superiority of chariot charges over infantry on flat terrain (Drews, *Coming of the Greeks* [n. 4]; van Creveld, *Technology* [n. 30], 13), of the Greek phalanx over light-armed infantry (Hornblower, "Greeks and Persians" [n. 32], 53; Hanson, "Genesis" [n. 5]: 23, 25), of the Macedonian phalanx over the hoplite phalanx (Hanson, "Phalanx" [n. 37]: 33), of the Roman legion over the Macedonian phalanx (Rich, "Warfare" [n. 5]: 64; Hanson, "Phalanx" [n. 37]: 41–42; idem, "The Roman Way of War, 250 BC–AD 300," in *CHW*, 49–51), and so on. In *End of Bronze Age* (n. 4), 97–225, Robert Drews argued that the downfall of the Bronze Age cultures in the Aegean was the result of the introduction of a new type of infantry that gave 'barbarian' peoples a military advantage over the chariot-riding kingdoms. Recent and more cautious approaches, e.g. Lendon, *Soldiers* (n. 5), 10, prefer to consider that "some armaments and methods of fighting had an advantage over others and that some might be better suited than others to given circumstances." However, even this advantage is, to a certain degree, only theoretical and can be betrayed in practice on the battlefield.

[56] Chariot warfare, for instance, spread throughout the Eastern Mediterranean during the Middle and Late Bronze ages, and the only apparent requirement for the tactic was to have chariots; see Drews, *Coming of the Greeks* (n. 4), 74–120; idem, *End of Bronze Age* (n. 4), 104–34; van Creveld, *Technology* (n. 30), 12–13. However, against the widespread picture of Egyptian warfare as predominantly waged with chariots, see Ian Shaw's discussion on the role of archers and spearmen in the Middle and New Kingdoms, in "Battle in Ancient Egypt: The Triumph of Horus or the Cutting Edge of the Temple Economy?" in *Battle in Antiquity*, ed. A. B. Lloyd (London: Duckworth, 1996), 239–69.

and hardly maneuverable infantrymen, but they become 'light hoplites' when compared to Macedonian phalangites. This subjective evaluation of the application of weapons to specific tactics is much more evident on the battlefield, for "a technical progress in arms is not synonymous with a new battle formation." If we consider tactics as the practical application of the characteristics of weapons in order to perform a specific task in a complex scene, there is always the possibility of making a wrong assessment of that 'practical application,' and a weapon can, thus, be assigned an inaccurate function. In the real practice of combat, "human factors cancel out technological potentialities, and human responses can be at variance with engineering expectations." Potentially devastating weapons, like the elephant, the chariot, or the sarissa and the Macedonian phalanx, can be wasted in erroneous tactical applications.[57]

The operative use of weapons in broader tactical frameworks is thus not a clear and self-evident truth, but an 'on-the-spot' decision after a superficial analysis of many elements; mistakes can be made in this process. The weapon should be considered not as an isolated innovation,

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The Greek phalanx is thought to have appeared in Italy early in the Archaic Age, reaching first the Etruscan cities, and later Rome itself. See C. Saulnier, *L'Armée et la Guerre dan le Monde Étrusco-Romain (VIII–IV s.)* (Paris: Diffusion de Boccard, 1980); T. Rihll, "War, Slavery, and Settlement in Early Greece," in *War and Society in the Greek World,* ed. J. Rich and G. Shipley (London: Routledge, 1995), 91; Cornell, *Beginnings* (n. 4), 170–71 and note 73, 183–90; Hanson, "Phalanx" (n. 37), 41. Heavy infantry tactics are also thought to have spread through Northern Greece and Macedonia during the late fifth and early fourth century BCE: Hammond, "Training" (n. 52): 54.

Commanders and generals probably exchanged some tactical knowledge, especially during periods like the Hellenistic Age; see Beston, ""Hellenistic Leadership" (n. 47), 319. Philip's learning of heavy infantry tactics in Thebes is usually interpreted in this sense: M. M. Markle, "Use of the Sarissa by Philip and Alexander of Macedon," *AJArch*. 82.4 (1978): 486, 491; N. G. L. Hammond, "What May Philip Have Learnt as a Hostage in Thebes?" *GRBS* 38.4 (1997): 355–72. However, this seems to be for the most part a literary tradition rather than a real practice; see Beston, "Hellenistic Leadership" (n. 47): 319.

[57] Quotations in this paragraph: Pritchett, *Greek State* (n. 5), 44; Raudzens, "Firepower" (n. 39): 132. Heavy hoplites: Hanson, Western (n. 38); idem, "Hoplite Technology in Phalanx Battle," in *Hoplites. The Classical Greek Battle Experience*, ed. V. D. Hanson (London: Routledge, 1991), 63–86; idem, "Genesis" (n. 5), 19. Light hoplites: Markle, "Macedonian Sarissa" (n. 36): 329, 330. Weapons assigned to inaccurate functions: B. S. Strauss and J. Ober, *The Anatomy of Error: Ancient Military Disasters and Their Lessons for Modern Strategists* (New York: St. Martin's Press, 1992), 7. The elephant and the chariot: Glover, "Tactical Handling" (n. 52); idem, "Curiosities" (n. 44). The sarissa and the phalanx: Markle "Use of Sarissa" (n. 56): 494. In his account of the destruction of a Spartan *mora* in Lechaion, Xenophon says that the Spartans used their cavalry "badly", because, instead of pushing the pursuit of Iphicrates' peltasts further than the Spartan hoplites could do, they held the line with the hoplites, losing any chance of harming the enemy (*Hell*. 4.5.16).

but as a piece in combination with other elements: "A new weapon may indeed give one side a battlefield advantage, but only if that weapon is deployed within a proper strategic framework." Hence, the erroneous use of technology can tear tactics down, and a wrong tactic can cancel out an eventual superiority in weapons: Greek hoplites, for instance, proved to be ineffective against light-armed infantry on rough terrain, exactly like light-armed troops proved useless against heavy infantry on level ground.[58]

However, 'superiority' and 'effectiveness' are also relevant concepts in the deterministic interpretations of the expansion and diffusion of military technology and tactics: nobody, it is generally assumed, wants 'inferior' technology, and communities compete permanently against their neighbors to gain technological supremacy; there is a need to emulate the neighbor, so as not to lag behind in a sort of 'arms race.' As a result, a constant demand, based on a competitive principle, is supposed to have created a growing supply of 'superior' military technology: "Normally, military technology is the first to be borrowed by every society, because the penalty for failing to do so can be immediate and fatal."[59] The stress of military victory leads, then, to the perpetual acquisition of weapons and tactics. The Romans, for example, have a reputation for easily adopting foreign military practices, and the adoption of the Celtiberian short sword, identified with the *gladius hispaniensis*, is a common example (Polyb. frg. 179). The Hellenistic period as a whole witnessed an increasing flow and exchange of military innovations, encouraged by the competitive ethos of generalship at the time.[60] However, even when this

[58] Quotation: Strauss and Ober, *Anatomy of Error* (n. 57), 10. Hoplites against light-armed troops on rough terrain: Acharnania (Thuc. 2.102), Aetolia (Thuc. 3.94–98), Sphakteria (Thuc. 4.31–33), Amphipolis (Thuc. 5.10), Mitylene (Thuc. 3.18.4.2), Piraeus (Xen. *Hell*. 2.4.12–16), Bithynia (Xen. *Hell*. 3.2.3–4), Locris (Xen. *Hell*. 4.3.22–23), Lechaion (Xen. *Hell*. 4.4.17, 4.5.11–17), Acharnania (Xen. *Hell*. 4.6.8–11). Rawlings explains that Greek hoplites actually performed a wider range of military tasks beyond their service in the phalanx, in "Alternative Agonies" (n. 54). Their alleged specialization is just a modern interpretation encouraged by ideologically biased sources.

[59] Parker, "Introduction" (n. 4), 2.

[60] Some recurrent examples of 'arms race': Argive shield and hoplite phalanx: Lorimer, "Hoplite Phalanx" (n. 54): 108; Andrewes, *Greek Tyrants* (n. 36), 38; Salmon, "Political Hoplites" (n. 4): 96; Holladay, "Hoplites and Heresies" (n. 32): 99–100. Bronze-age chariots: Drews, *Coming of the Greeks* (n. 4), 74–120. Siege technology: Cuomo, *Technology* (n. 15), 46–59. Composite bow: Drews, *Coming of the Greeks* (n. 4), 86–100. Sarissa and Macedonian phalanx: Bar-Kochva, *Seleucid Army* (n. 51), 54. For a recent rendering of the idea, see Hunt, "Military Forces" (n. 32), 110. The Romans adopting foreign military practices: Roth, "War" (n. 39), 374–5. Exchange of military innovations in the Hellenistic period: Lendon, *Soldiers* (n. 5), 153–5.

pattern has been extended to the Western culture as a whole (and efforts have been made to substantiate it by resorting to a 'challenge-and-respond' phenomenon and its comparison to the biological model of 'punctuated equilibrium') the dynamics of the 'arms race' paradigm prove problematic when applied to ancient warfare.[61]

This approach to the spread and diffusion of military tools and knowledge is to a great extent based on the idea that the battlefield is a sort of 'laboratory,' where soldiers constantly experiment with arms in search of more effective models. Recent studies support the notion of 'experimentation' with weapons and tactics, but it is difficult to ascertain in what conditions this experimentation was carried out. Some widely accepted examples of alleged processes of experimentation are the introduction of the manipular system in Republican Rome, the introduction of the hoplite equipment and the phalanx in Greece, or the introduction of heavy cavalry in the Roman army. This 'scientific metaphor,' akin to the academic language on war, tries to rationalize the experience of combat, creating an illusion of order, efficiency and pragmatism. However, systematic research is rarely transferred into the sphere of warfare, and in the ancient world it is limited to a short list of isolated contexts, like Dionysius' 'school' or Alexander's circle. Hammond remarks that "detailed descriptions of military training before the Hellenistic period are extremely rare," so if some sort of 'experimentation' ever existed before that time, it captured small attention in our sources.[62] On the

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[61] Western culture: Parker, "Introduction" (n. 4): 2, 5. 'Punctuated equilibrium': ibid., 6–7.

[62] Hammond, "Training" (n. 52): 56. For 'experimentation,' see Parker, "Introduction" (n. 4): 2; Lendon, *Soldiers* (n. 5), 154, 157. Manipular system: Lendon, *Soldiers* (n. 5), 183. Hoplite equipment and phalanx: P. Krentz, "The Nature of Hoplite Battle," *CA* 4 (1985): 60–61; Hanson, "Hoplite Technology" (n. 57), 74–78. Cf. P. A. L. Greenhalgh, who argues that it is the lack of specialized training that leads to the swift spread of the phalanx, in *Early Greek Warfare: Horsemen and Chariots in the Homeric and Archaic Ages* (Cambridge: Cambridge Univ. Press, 1973), 74–83. Heavy cavalry: Eadie, "Development" (n. 5): 163, 168, 173. Other examples of experimentation: the evolution of combat between Romans and Carthaginians in the Second Punic War: Sabin, "Mechanics" (n. 5): 64–66. The evolution of the Greek equipment in the Persian Wars: Everson, *Warfare* (n. 4), 129–30. Academic language on war: Keegan, *Face of Battle* (n. 1), 30–32. Dionysius' 'school': Cuomo, *Technology* (n. 15), 43–46. Alexander's circle: Hanson, "Phalanx" (n. 37): 39. For practice in combat, see Thucydides on the 1000 picked Argives at Mantineia (Thuc. 5.67.2) and on the self-confidence of the Spartans, "knowing that long-continued actual practice meant more for their salvation than any brief admonition, however well spoken" (Thuc. 5.69.2). Neither of these references implies that practice leads to a conscious study of battle according to 'scientific' standards.

battlefield, practice and experience is one thing, but experimentation and research is quite a different matter.

The 'laboratory' image tends to reject the human factor, which in fact pervades the theory and practice of warfare. We are inclined to think that humans have a rational and pragmatic approach to warfare, but this is seldom the case. In fact, "men have always been slow, or reluctant, to read aright the lessons of facts."[63] Confidence, lack of exhaustive analysis, tradition, ignorance, conservatism, incompetence are all factors that can explain why a weapon could be applied to inaccurate tasks, or why wrong strategies could cancel out any technological superiority. It can be argued that if victory had been the real criterion to assess the superiority of a given weapon, military transference and exchange would have been much more frequent than it was: the Persians, Thracians, Italians and Sicilians defeated by Greek armies would have adopted the phalanx, the Argive shield and the thrusting spear; the Greeks themselves would have adopted the Macedonian formation, the sarissa and the telamon shield after Chaeronaea; and the Macedonians in turn would have been forced to incorporate the manipular system, the *scutum*, the *pilum* and the *gladius* after Kynoskephalai and Pydna.[64]

However, this did not happen, because the sphere of the military is extremely conservative, and human limitations frequently ignore or even impede military innovations. Some examples can easily be found: despite the spectacular performance of elephants in Italy from Pyrrhus onwards, for instance, the Romans took a long time to include them in their armies, and only reluctantly. Again, the belief in the invincibility of the legions hampered for a long time the introduction in the Roman army of a proper body of heavy cavalry, despite the frequent clashes against enemy cataphracts from the second century AD onwards. Similarly, the Macedonians had not developed yet a heavy infantry of their own by the fourth century BCE, and their phalanx was only introduced at the end of Philip's reign. Finally, Roman martial values in the

[63] Glover, "Tactical Handling" (n. 52): 11.

[64] Rational approach to warfare: Hanson, "Phalanx" (n. 37): 40. For a recent summary of these ancient military mistakes and miscalculations, see Strauss and Ober, *Anatomy of Error* (n. 57). For the adoption of the Roman manipular system by other peoples, see Lendon, *Soldiers* (n. 5), 190–1. Regarding the 'human factor', Xenophon reflects about command decisions taken out of rage, for "in dealing with enemies, to attack under the influence of anger and not with judgment is an absolute mistake. For anger is a thing which does not look ahead, while judgment aims no less to escape harm than to inflict it upon the enemy" (Xen. *Hell*. 5.3.7).

middle Republic, extremely aggressive and based on the display of individual and communal courage (*virtus*), prevented the Roman army from adopting more suitable strategies to fight enemies like Hannibal.[65]

We tend to think that the problems and disadvantages of technology are obvious, but ancient history shows that, if there were lessons to be learned, then people rarely paid attention. Aristotle recognized that it was difficult to learn from experience (*Metaph*. 981a 25–981b 9), and even with systematic experimentation, tradition and resistance to change can be decisive obstacles for technology. Prejudices can lead peoples to ignore, restrict or reject innovations; mistakes are frequently repeated, and 'scientific' learning from experience is sometimes hard to find. In the ancient world, battlefields from all periods have left many unattended lessons: the Romans, for example, had had encounters against elephants at least since the time of Pyrrhus' war, and Pliny recognizes that they had experience regarding how to combat them with their swords (Plin. *HN*. 8.7.18), but they continued to be terrified of them and to suffer heavy losses for many decades after. Scythed chariots proved to be highly unreliable in combat, and did not make any significant difference in the battles they were used in, but they were preserved for some five hundred years anyway. Similarly, Philip and Alexander reformed the logistics of the Macedonian army, turning it into a fast and almost autonomous military machine, and increased considerably the numbers and relevance of cavalry over infantry; however, the Diadochs returned to the old logistics of slow and oversized baggage trains and to the all-important lines of heavy infantry with cavalry as a mere auxiliary. Epaminondas' oblique phalanx was perhaps the only real innovation in two centuries of Greek land warfare, but it is completely absent from later land battles. The astonishing 'iron tube' used by the Peloponnesians in the siege of Delium (Thuc. 4.100) was never to be reproduced again, despite its success, and the impressive piece of Roman legionary plate armor, the *lorica segmentata*, was also simply abandoned in the third century.[66]

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[65] For obstacles to military innovations in general: Lendon, *Soldiers* (n. 5), 12–13. Elephants in Roman armies: Glover, "Tactical Handling" (n. 52): 2–3. Heavy cavalry in Roman armies: Eadie, "Development" (n. 5): 163–67. Macedonian heavy infantry and phalanx: Markle, "Macedonian Sarissa" (n. 36): 328, 329; idem, "Use of the Sarissa" (n. 56): 484, 488, 492, 496. Roman aggressive values: Lendon, *Soldiers* (n. 5), 200–203.

[66] Romans and elephants: Glover, "Tactical Handling" (n. 52): 6–10; Sabin, "Battle" (n. 5): 419–21. Scythed chariots: Glover, "Curiosities" (n. 44): 5–8; Sabin, "Battle" (n. 5): 417–18. Macedonian logistics: W. W. Tarn, *Hellenistic Military and Naval Developments*

As a result, the question is not whether the battlefield was a laboratory or not, but whether soldiers and commanders were ready to regard it permanently as such—that is, to display a permanent and conscious commitment with learning and training—and to draw conclusions from the experiment and apply them in new situations. In my opinion, this entails a scientific approach to warfare that would be for the most part anachronistic in the ancient world, especially in view of its problematic notion of progress. Even in an ideal context where all the requisites for learning are fulfilled, it is difficult to find two armies reacting similarly in similar situations, or applying the same weapon to the same function. If we accept that "every culture develops its own way of war," then we must assume that there are many possible connections between technology and combat, influenced by emotional, ideological and irrational concerns, as the Spartans' and Athenians' radically different ways of war, for instance, show.[67]

Thus, the mere acquisition of a technological innovation is not enough: "Simply copying weapons picked up on the battlefield could never suffice; it also required the 'replication' of the whole social and economic structure that underpinned the capacity to innovate and respond swiftly."[68] In practice, technological and tactical innovations can only offer but a momentary superiority, which lasts as long as the element of surprise. That was the case with the catapult, according to Diodorus, which "caused great consternation, since it had been discovered for the first time on that occasion (*dia to prōtōs heurethēnai kat' ekeinon ton kairon*)" (14.50.4). However, surprise is a temporary advantage, and some weapons prove to be ineffective in the long run.[69]

(Cambridge. Cambridge Univ. Press. 1930), 27–30; Hanson, "Phalanx" (n. 37): 41. Epaminondas' oblique phalanx: V. D. Hanson, "Épaminodas, la Bataille de Leuctres (371 av. J.-C.) et la 'Révolution' dans la Tactique Grecque," in *La Guerre en Grèce à l'Époque Classique*, ed. P. Brulé and J. Ouhlen (Rennes: Presses Univ. de Rennes, 1999), 241–60. *Cf.* Tarn, *Hellenistic Developments* (this note), 8, who believes that "his early death prevented the ideas he had used at Leuctra from being further developed," which is highly dubious. The 'iron tube': Gille, *Mécaniciens Grecs* (n. 49), 17–18; Strauss, "Battle" (n. 49): 239. The *lorica segmentata*: Lendon, *Soldiers* (n. 5), 8.

[67] Different applications of weapons: van Creveld, *Technology* (n. 30), 4, 5, 15. Quotation: Parker, "Introduction" (n. 4), 1.

[68] Parker, "Introduction" (n. 4), 8.

[69] Regarding the camel, Vegetius confessed that, "despite its novelty, it is ineffective in combat (*inefficax bello est*)" (3.23.2). The elephant was not a decisive weapon either, for in spite of its terrifying performance, both Macedonian and Roman armies managed to win their battles against them, as Alexander's victory at Hydaspes shows; see Glover, "Tactical Handling" (n. 52): 1. Heavy cavalry was also considered a superior weapon,

Furthermore, the alleged superiority of a weapon or a tactic could be counteracted through different ways. As Raudzens puts it: "each new weapon had a tactical antidote," that is, a specific weapon could be effectively counteracted by a tactical disposition.[70]

We are inclined to think that weapons and tactics are adopted in order to counteract the effects of these same devices in the hands of our enemies. This is in fact the very foundation of the 'arms race' phenomenon. But this is not always true: weapons and tactics can be counteracted through tactical ingenuity and adaptability. In part, military innovations are adopted also because we expect to cause the same effects as the enemy. However, this is a mere illusion, for the spread and diffusion of military technology leads in practice to a technological draw. Every single piece of technological or tactical innovation, like heavy cavalry, chariots, catapults, elephants, the phalanx, and so on, has led to this exact situation: armies with similar technologies fight on more or less equal terms.[71] From this point of view, superiority becomes a rather evasive reality.

Conclusions

Technological determinism tries to explain the complex historical process of military, social, and political transformations from a mechanistic point of view. The result is a simple and direct sequence of causes and effects, from the introduction of a technological innovation to political

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but after the initial impact the Roman legions won most of the battles fought against it; see Eadie, "Development" (n. 5): 163.

[70] Raudzens, "Firepower" (n. 39): 151. See, for instance, tactical countermeasures against the Greek phalanx: Markle, "Macedonian Sarissa" (n. 36): 339; idem, "Use of the Sarissa" (n. 56): 486; Hanson, "Genesis" (n. 5), 26. Against elephants: Glover, "Tactical Handling" (n. 52): 4–8. Against light cavalry: Eadie, "Development" (n. 5): 170–1, 173. Against chariots: Glover, "Curiosities" (n. 44): 7. Against the Macedonian phalanx: Markle, "Macedonian Sarissa" (n. 36): 332–3; see also Hammond, "Training" (n. 52): 54, who notes that Alexander armed his infantry sometimes with the sarissa and sometimes with the spear, according to the circumstances. Zama can be regarded as an example of two complex and highly trained armies with experienced generals, deployed in order to counteract the rival's tactical choices (Polyb. 15.9, 11–12, 16; Liv. 30.32–35); for a recent discussion on the battle, see J. Lazenby, "Was Maharbal Right?" in *SPW*, 40–42. Another example of changing tactical dispositions is Plataea, where Spartans and Athenians exchanged their wings several times, being answered by similar Persian arrangements (Hdt. 9.44–48). For the fluidity and mobility of troops in combat in the battles of the Second Punic War, see Sabin, "Mechanics" (n. 5): 68–73.

[71] van Creveld, *Technology* (n. 30), 17.

and social revolutions. This approach to historical change is based, as shown, on a few key points. First, technology is emphasized as a potential historical agent; thus the notion of 'superiority' of new weapons over older ones becomes central. Secondly, technological change is presented as a continuous 'progress,' and considered as intrinsically positive, desirable and immediately understandable for anybody. Thirdly, the battlefield is presented as a 'laboratory' where soldiers and commanders permanently and consciously experiment with weapons to develop better and more efficient versions.[72]

It has been pointed out that military history in general has a remarkable inclination to determinism: "military topics may appear more deterministic than those in other branches of technology because war itself and the factors shaping its outcome often appear deterministic."[73] According to Roland, deterministic approaches generally start from an anti-militarist point of view, allowing moral considerations on war to enter historical writing as a given.[74] This moral approach to the dynamics of history can lead to a certain lack of criticism of the inconsistencies of determinism; "the reason, one suspects, is that most are in sympathy" with this view, says Roland; "if the proper icons are being smashed, there is little interest in contesting fine points of logic or usage. Instead, readers are inclined to agree with the conclusion and blink at the inconsistency."[75] As shown, determinism displays some serious inconsistencies: the absolute pre-eminence of technology in war, the elimination of the 'human factor,' the consideration of weapons as decisive elements, the connection between weapons and tactics, and the ideas of superiority and progress, among others.

To a great extent, the inclination of military history towards technological determinism can be interpreted as a matter of narrative. History as a discipline is intrinsically subjective, and this deficiency can lead to an attempt to counteract it using the most scientific language possible.

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[72] Technological change as progress: Holladay, "Hoplites and Heresies" (n. 32): 100–102. Battlefield as a laboratory: Hanson, "Hoplite Technology" (n. 57), 74–78.

[73] A. Roland, "Science, Technology, and War," *Technology and Culture* 36.2 Suppl. (1995): S91. See also ibid., S89; J. Black, "Military Organisations and Military Change in Historical Perspective," *JMH* 62.4 (1998): 871.

[74] Roland, "Science" (n. 71): S84–S89. In his essay about Greek Hellenistic warfare, W. W. Tarn regrets that fighting played such a prominent role in ancient Greece: "It may be an unfortunate thing that war should have occupied such a large place in the outlook of every state during the period I am considering," in *Hellenistic Developments* (n. 64), 1–2. For a recent but brief discussion on this point, see V. D. Hanson, "The Modern Historiography of Ancient Warfare," in *CHGRW*, 1.10–13.

[75] Roland, "Science" (n. 71): S87.

Military matters, based on precision and accuracy in chronological, spatial and numerical details, are especially delicate in this respect. Hence, in order to make an objective and clean account of past events, the predictable element—machines—prevails over the unpredictable one—human beings—in a sort of 'rhetoric of military history.' Polybius reminds us of the extraordinary responsibility of historians when reconstructing events from the past, for most inconsistencies should rather be attributed "to the historian who on account of his inexperience is unable to distinguish the possible from the impossible in such matters" (12.22.4–6). Determinism is an academic matter, a controversy about the subjective perceptions and interpretations of modern historians. This is true because technology is certainly the best resort for a 'scientific' discourse: technological accounts, with their illusion of exact numbers, percentages, and details, are more 'technical,' attractive, dynamic, and compelling than common historical accounts. Moreover they are also cleaner, logical, and mechanical: as cognitive studies on military language show, it is easier to speak about machines than about people.[76]

Unfortunately, weapons are not logical either. As Polybius put it, "many ideas seem to be plausible and likely to succeed when described, but when put to the test of experience, like false coins exposed to fire, they no longer answer to our first conception of them" (29.17.2). This is certainly true for technology and military innovations: they are capricious and unpredictable, and they do not always develop in the direction we expect them to. Ancient heavy cavalry is a good example: to be completely effective, armored infantrymen needed stirrups to control their horses and gain a stable platform for frontal charge; however, cataphracts subsisted in the ancient world without them.[77] Although the stirrups seem like a rather logical step forward, this step was never taken, and a potentially crucial development remained ignored for centuries.

Strictly speaking, the cases of real innovations in military technology are quite few—missiles, chariots, stirrups, gunpowder, etc—while the rest are small and permanent adaptations to changing contexts and situations.[78] In any case, ancient weapons are not sophisticated enough to

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[76] Rhetoric of military history: Keegan, *Face of Battle* (n. 1), 36–46, 62–73. Determinism as an academic matter: Cuomo, *Technology* (n. 15), 2–3. Cognitive studies on military language: Keegan, *Face of Battle* (n. 1), 20, 31–32.

[77] Eadie, "Development" (n. 5): 162, 172.

[78] Raudzens, "Firepower" (n. 39): 152; van Creveld, *Technology* (n. 30), 14–15; Lendon, *Soldiers* (n. 5), 8; Lynn, "Battle" (n. 5): xviii.

make a real difference on the battlefield. Innovations are actually mere variations of four basic types—missiles, slashing weapons, piercing weapons and impact weapons—with few differences between them.[79] Weapons were improved through minor modifications, which in turn entailed changes regarding their practical use; and they led in turn to new ideas. This connection is not only complex, but also diachronic. Military technology evolved during the ancient world at a slow pace, offering permanent responses to momentary needs.[80] A weapon must be considered as part of a tactical structure, as one element of a complex mechanism: like the *gladius*, the *pilum* and the *scutum* inside the legion, weapons interact with many other elements to create the phenomenon of articulated fighting.[81]

However, "if there is little detailed evidence on technological impact, is the prevailing weapons consensus a fortress without a foundation, or the product of intuition more than verifiable data?"[82] As shown, even the most cursory survey of the available information reveals that technology is not the solution for the problems of the battlefield. Probably the most serious fault of determinism is its failure to recognize the human role in the process, for men are systematically ignored. For van Creveld, "although technological superiority can be very important in combat, it rarely decides a war by itself"; Strauss and Ober agree: "It is a supremely dangerous error to suppose that technology is a solution for the problems of war. A strategy devised by technocrats, based solely on superiority in weaponry is no strategy at all. Machines do not win wars."[83] This is true. Men win or lose wars: the soldiers who fight them, the officers and

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[79] van Creveld, *Technology* (n. 30), 15; Lendon, *Soldiers* (n. 5), 8.

[80] See, for instance, the case of the Roman heavy cavalry, evolving throughout a couple of centuries in a permanent process of adaptation: Eadie, "Development" (n. 5). According to van Creveld, "it is possible to argue that the technological changes introduced into field combat during the two millennia from about 500 BCE to 1500 CE were frequently minimal," in *Technology* (n. 30), 20. See also Lendon, *Soldiers* (n. 5), 8–9, who suggests that, despite this lack of revolutionary advances in the field of technology, what actually changed was the specific ways of using the weapons, i.e. the tactics.

[81] For the legion as an integrated system, see Hanson, "Phalanx" (n. 37), 44. For a general discussion of weapons in articulated fighting, see van Creveld, *Technology* (n. 30), 2, 17, 18.

[82] Raudzens, "Firepower" (n. 39): 131.

[83] van Creveld, *Technology* (n. 30), 232, cf. Parker, "Introduction" (n. 4): 2; Strauss and Ober, *Anatomy of Error* (n. 57), 10. According to John Carman, war is completely permeated with "cultural assumptions, ideas about what is 'proper' or 'appropriate' or 'right,' ideas about what can be done and what cannot, ideas about what war is for, and ideas about what is legitimate and what is illegitimate," in "Beyond" (n. 35): 39. Deterministic approaches leave all these concerns aside and place the greatest emphasis on technology.

commanders who wage them, the politicians who declare them and the people at large who suffer, support, or perhaps profit from them. Technological factors are crucial, as is the environment and the terrain; but human factors, with their corollaries of moral and psychological imperatives, are probably all important, for war was and still is a matter of human beings.

Determinism aims to eliminate the human factor, irrational and unpredictable as it is, from the clean equation of history: "Not only has it inhibited progress in understanding premodern military history in general, and premodern military technology in particular, but it has also too often and too easily removed the individual soldiers and their leaders from the military historical equation, replacing them with a technological, deterministic explanation."[84] The historical discourse tries to avoid subjectivity and the contradictions of human nature, for it remains true that "infantrymen, however well-trained and well-armed, however resolute, however ready to kill, remain erratic agents of death. Unless centrally directed, they will choose, perhaps badly, their own targets, will open and cease fire individually, will be put off their aim by the enemy's return of fire, will be distracted by the wounding of those near them, will yield to fear or excitement, will fire high, low or wide."[85] Hanson claimed that "no military history should ever avoid the human element: it is men, after all, who fight, wound, kill and die; it is men alone who deserve our attention, incite our imagination, earn our empathy."[86] Technological explanations should make our understanding of human behavior in combat much easier, because men are the raw material of any army. Deterministic arguments, therefore, are a rational attempt to compose a logical and simple history, the search for a mechanical explanation to irrational experiences.

Finally, to question the validity of determinism does not mean to nullify the role of weapons. They help to define the nature and shape of war, and thus how humans behave in their environment. They can even be influential in winning wars and transforming societies.[87] However, our

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[84] K. de Vries, "Catapults Are Not Atomic Bombs: Towards a Redefinition of 'Effectiveness' in Premodern Military Technology," *War in History* 4.4 (1997): 455.

[85] Keegan, *Face of Battle* (n. 1), 229.

[86] V. D. Hanson, "Ideology of Hoplite Battle," in *Hoplites. The Classical Greek Battle Experience*, ed. V. D. Hanson (London: Routledge, 1991), 3. See also Carman, "Beyond" (n. 35), 55: "we cannot ignore what war is ultimately always about: the breaking of flesh, the spillage of blood, and the making of death."

[87] As Carman assumes, "the technology of war (the specifics of weapons types) is, if not determinate, then at least reflective of the way in which bodies of fighters will

relationship with technology, especially with military technology, is not always straightforward, but sometimes quite irrational.[88] As a result, new weapons are not always superior to older ones, they are not always used in a single fashion, and they cannot fully explain either why societies change or why they change in the ways that they do.

move on the ground, and of the kind of attitude they have towards battle," in "Beyond" (n. 35): 48.

[88] Lendon offers a clear example of this complex relationship, describing the case of a bronze catapult washer dedicated by a Roman soldier in the spring of the goddess Sulis at Bath. As the object itself is part of one of the most sophisticated military machines, its use as a religious offering shows that "there is something profoundly alien about this soldier's relationship to technology," in *Soldiers* (n. 5), 7.