Short and Sweet

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Using perception as a strategy: Camouflage, surprise, and the moment of shock related to perception

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Abstract

Camouflage is often conceived as the art of hiding, but a more striking perceptual power lies in the moment of revelation. Drawing on historical evidence from Roman patrol vessels on the Danube, we, as an interdisciplinary team of historians, chemists, and perceptual psychologists, argue that concealment was strategically coupled with surprise to produce psychological shock. These vessels were painted to blend with their surroundings, yet their sudden detection triggered a perceptual "pop-out," amplified by dramatic features such as oversized eyes and ornamental bows. This specific quality, which is most obvious in a frontal attack mode, allowed a quick transition from invisibility to an imposing, fear-inducing presence that created a tactical advantage that disrupted enemy attention, motor preparation, and predictive coding. Roman shipbuilders seemingly exploited perceptual principles such as figure–ground reversal, attentional capture, and even Müller–Lyer-like illusions to manipulate enemy perception. Thus, camouflage was not merely defensive concealment but an active strategy of temporal control, staging perception itself as a weapon. Studying these dynamics highlights how surprise can destabilize observers and decisively shift the balance of confrontation.

Keywords

perception, camouflage, surprise, attack, strategy and tactics, Roman Empire, warships, eyes, fear, Germanic

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With the few exceptions of philosophers in the Roman Empire who dealt with topics of perception, it can be summarized that we have little written knowledge (preserved) of the effect of colors on permanent and perishable materials that was well established in ancient times, both theoretically and practically. We do not know precisely to what extent theoretical understanding and practical application went hand in hand, as only a fraction of this knowledge has been preserved, especially when the carrier material was perishable. However, rare descriptions provide differentiated insights for the Greeks and Romans. Around 150 BC, for example, the historian Polybius describes in his sixth book the funeral rites of the Roman nobility, in which, among other things, the dead were depicted alive with wax masks. Pliny describes the encaustic painting of ships, which was new for the Roman period,[1] and its intended effects in the 35th book of his Natural History, along with the associated intentions to use it.

Also, the thousands of Roman patrol vessels used in so-called Germania Magna, which refers to the occupied Roman provinces as well as in vastly unconquered territories north of the Danube and east of the Rhine, have to be mentioned in this context. Vegetius states that these patrol vessels were painted, as all war vessels were, according to Admiral Pliny. Well, first of all, as a patrol vessel, in the lines of Vegetius, you want to gather information about others, and so, you should conceal yourself so as not to be seen while spying on the others (see Figure 1). Camouflage represents a highly sophisticated concealment strategy refined by evolution in nature (Merilaita et al., 2017), from which humans have drawn inspiration and practical benefit by adopting its underlying principles (for an extensive review on camouflage and visual perception, see Troscianko et al., 2009).

As Roman offensive and defensive strategy proved quite successful over 500 years at the Rhine and Danube borders, the northern Roman provinces had to and did guarantee superiority against

Figure 1. Demonstration of camouflage of a Roman patrol vessel in Bavarian waterways in two different situations: either in fog (right) or with the natural shore background. With its drab paintwork, the vessel does not stand out much against the background on the opposite bank. The vessel was reconstructed by the University of Erlangen. © Boris Dreyer.

their neighboring Germanic tribes by predominant weaponry, well-trained and coordinated combat power. This refers to psychological features, as stated for war vessels of any kind (especially, pirate ships) (Philostratus), and as demonstrated by empirical studies: The Romans did not simply develop strategies of camouflage to remain unseen until the bitter end. The paint should also effectively strike the recognizer when these war vessels had to be offensive and were frontally directed at the enemy. Therefore, they relied on experience and theoretical knowledge to use camouflage colors based on the environment in order to achieve the greatest emotional effect on the enemy at the right moment, where the same colors in combination with the shape at the prow are directed at the enemy.

With one word, it might be a misconception to treat camouflage as a mere problem of visibility, as is done in research mainly. For an object in camouflage, it not only blends into its background. Actually, Meese and Strong (2025) argued on the basis of World War I warship camouflage that the object is not only hidden and only recently visible; when it is seen, its shape, direction, and size are also misinterpreted. When the object comes to the fore, in the moment when concealment "fails," the striking moment is even more intense, by the interplay of direction of movement (in relation to the unexpected threat), shape, and color. Then the hidden or misinterpreted figure suddenly "pops out": What was background becomes now figure, what was unseen or negligible becomes unavoidable.

So, with this in mind, the new attentive focus on the Roman vessel, identifying it as an enemy warship, can be advantageously used if the perceptual quality not only contains the primary quality of camouflage but also a secondary quality of an impressive, fear-inducing, and powerful appearance. Therefore, Vegetius' statements about the camouflage of patrol vessels and Pliny's assertion that Roman vessels were magnificently painted are not contradictory if one assumes that patrol vessels were painted with natural colors.[2] They did not stand out against the natural background of their location when on the prowl, but when attacking and landing on the enemy shore, they caused surrender and fear with their wide-open eyes at the front, with a menacing, terror-supporting, dynamic shape (a ram). Such vessels will glide along brilliantly when their sides are rubbed with leather cloths for a parade, causing the ("encaustic") wax paint to shine. In this way, all three modes of effect described by different authors at different times in antiquity (Dreyer & Speck, 2021), which seem to contradict each other, can be easily explained on one vessel aimed at a deliberately provoked triggering of preconceived perceptual effects. A profound knowledge of such camouflage–surprise dynamics highlights how perception does not merely register information but stages an oscillation between absence and presence, one that can disorient the observer and decisively advantage the camouflaged.

This Kind of Camouflage Unfolds in Two Phases

1. Hiding: During concealment, the camouflaged object effectively merges with its environment or—if it is seen—the angle and shape, and adumbrated natural colors pigments mislead about the danger (Figure 1). The perceptual system, tuned to contrast and discontinuity, treats it as "non-salient." The eye moves across it as though there is nothing there. The observers are lulled into a false sense of security, so they are rather unprepared and not mobilized to fight.
2. Revealing: Detection brings a perceptual snap. The object suddenly leaps into the foreground of perception, with the aggressive part of the prow and its menacing shape, and so of awareness. Once seen, it cannot be unseen anymore. What was "nothing" becomes "something overemphasized urgent."

Figure 2. (a) Illustration of the camouflage properties of different colored surfaces, including a distinctive and large eye area, on a version of a Roman patrol vessel reconstructed by the University of Erlangen, © CCC; (b) detail from a mural in Room 8 of the Casa della Danzatrice or Casa di Diana, Pompeii, depicting a Roman warship with pairiwisely arranged eyes on the bow of the ship—with courtesy of the Museo Archeologico Nazionale di Napoli (Inventory number 8603) via CC-BY-SA-4.0 license.

The power of camouflage lies precisely in the transition between these phases. It's not just about delaying detection; it's about the dramatic impact of sudden revelation. So, besides losing time, the observer must also interrupt previous perceptual and motor plans, reorient attention, and adjust behavior in a quick but also coordinated way (Hulleman et al., 2005).

Historical accounts suggest that Roman naval cooperation[3] exploited this very principle in the waters of Germania. Camouflaged vessels, concealed against the colors of the water and the typical background of sheer wilderness, would approach unnoticed or be estimated as negligible. When finally detected, the sudden revelation shocked the defenders by its typical outward appearance: a towering, neck-like curved bow with overly large, painted eyes, which gave the impression of a vast, unknown, and dangerous monstrous entity (Figure 2).

This strategic advantage, based on perceptual factors, was psychological as much as physical. Surprise destabilizes, and destabilization yields opportunity (Horstmann et al., 2016). Camouflage, in this sense, is not simply an art of hiding but a weapon of temporal control (Carbon, 2022).

We can learn several lessons of perception with such examples that humans used across the centuries by closely observing camouflage strategies in the animal and plant kingdom, ranging from prey to predators:

Predictive coding: The brain constantly generates expectations of what is present. Camouflage aligns with these expectations ("nothing here"), reinforcing them until a sudden contradiction forces rapid updating. The mismatch between prediction and input fuels surprise and creates attention.

Figure–ground detection and its multistable nature: Detection of a camouflaged object resembles a "Gestalt switch." The background reorganizes, and what was once ground becomes figure. Such reversals are cognitively costly; they consume attentional resources, and they ask for new framing.

Attentional capture: Once revealed, the camouflaged object commands attention. But that attentional capture comes at the cost of momentary disorientation: Attention must disengage from the prior focus and has to rapidly reallocate, which takes time and cognitive capacity.

In the case of Roman vessels (and many other shipbuilders used it as well), we can also observe a powerful application of the Müller–Lyer illusion (Carbon, 2022). The clever placement of

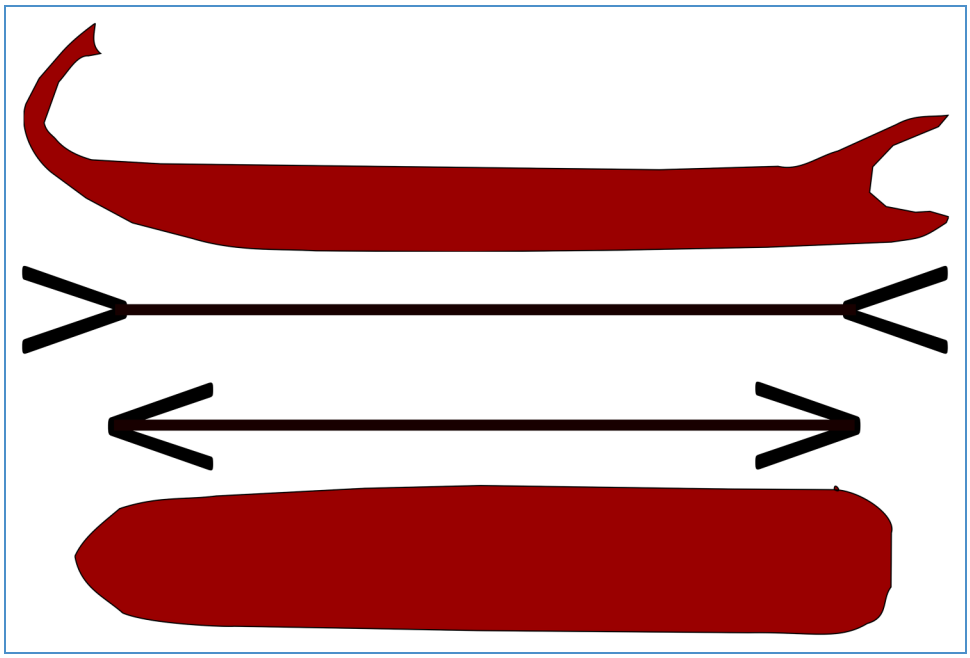

Figure 3. Illustration of the Müller–Lyer illusion using a sketch-like representation of a liburna, a typical Roman patrol vessel, in which the side view above appears significantly larger than the effective size for accommodating soldiers shown below (Carbon, 2022).

exaggerated ornaments on the bow and stern of the vessel made them appear much larger and more powerful than they actually were (see Figure 3).

Together with the overly large eyes, which are known to induce strong eyes-watching-you effects, especially when the arousal is already high (Hesslinger et al., 2017).

Most probably, at the time of Roman patrols in *Germania*, such oscillating factors of camouflage and the application of perceptual cues and illusions (Carbon, 2014) were intentionally used. Authors such as Vegetius (4.46.9) refer to new technical advances in the use of patrol vessels without providing further details. It can be assumed that the coloring of vessels was based on a differentiated, at least empirical experience, which, in addition to the identification of identical, mass-produced vessels, also included the camouflage technique described by referring to role models and the imitation of natural strategies and techniques. It is attested that Germanic tribes learned fast in all military techniques (Tacitus Annals II 45,1), so that Germanic armies of Arminius and Marbod fought against each other as they were Roman in weaponry and strategy. Therefore, Roman strategies had to be developed continuously to keep these tribes off their borders, and clearly perceptual strategies, including camouflage (Chen & Hegdé, 2012), were part of it.

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Notes

1. This sort of encaustic painting has to be separated from the traditional artificial painting, invented by the Greeks and often used for portraits, e.g. the Fayum mummy portraits.
2. Natural pigments mixed with wax while hot and applied to the planks (=encaustic painting) are well suited for camouflage against the natural background of the shore vegetation and the colour of the water.
3. We don't want to make the impression that the Romans were the first or the only ones who followed such considerations (see for extensive material Behrens, 2009), but we will focus here due to a fruitful coopeartion on this specfic topic between research areas of history, material sciences and psychology (Dreyer, 2022).

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