The fog of war

The extreme stresses of battle can cloud soldiers' brains, leaving them vulnerable to oncoming threats. **Peter Aldhous** peers through the mist for a cure

SIMON PEMBERTON

WHEN the mortar rounds started dropping, David Wells and his US Marine Corps buddies knew what they were supposed to do – get under cover and try to locate the origin of the threat. But when they came under fire in the Iraqi city of Fallujah in 2005, things didn't go according to the training manual.

Wells was a mortuary affairs specialist with the grisly task of ensuring that the marines' creed of "No man left behind" doesn't just apply to the living. His unit had been working for hours around a truck wrecked by a buried explosive device, painstakingly recovering the remains of fallen comrades.

Then the first blast went off, and the grim quiet erupted into pandemonium. Far from running for cover, Wells stayed in plain view, dropped to one knee and cocked his rifle. If the mortar attack had been followed by gunshots, he might not have lived to tell the tale. His comrades performed no better. "I remember one guy throwing down his weapon and diving under the truck," Wells recalls. "One guy just started yelling incoherently. Another was sitting there smoking a cigarette and he didn't move at all."

Military training aims to instil the appropriate response to such situations as second nature, but the extreme stress of combat can cloud even the best-trained minds, making people act in confused and sometimes dangerous ways. Researchers are now starting to understand the physiological origins of this cognitive "fog of war", finding that the

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severity of soldiers' symptoms correlates with the levels of various hormones and neurotransmitters. This work has revealed why some soldiers manage to keep their head amid the chaos while others are clouded in confusion, and it has even suggested drugs and supplements which could one day help all troops to think more clearly under fire.

Such intervention might also reduce the number of lives – like Wells's – that have been shattered by post-traumatic stress disorder, since it seems soldiers who experience the greatest cognitive disturbance during combat are most likely to suffer subsequently from PTSD. Although war leaves its mark on almost every combatant (see "Battle lines drawn in the brain", page 42), drugs that clear the mental fog during battle might significantly reduce the severity of the symptoms that linger long after the soldiers have returned home.

"If we understand the physiology, that gives us clues as to where and how we might intervene," suggests Charles "Andy" Morgan, a psychiatrist at Yale University and the US Department of Veterans Affairs National Center for PTSD in West Haven, Connecticut.

This provocative idea has emerged from Morgan's studies of what happens to the brain under combat-related stress. Running cognitive tests and taking biochemical measurements of soldiers in the heat of battle would be near impossible, but Morgan gained access to the nearest thing: troops enrolled in the notoriously demanding Survival, Evasion, Resistance and Escape (SERE) training scheme run by the US army's John F. Kennedy Special Warfare Center and School at Fort Bragg in North Carolina.

The training programme, mostly undertaken by special forces who may need to operate behind enemy lines, involves a brutal war game that is almost as stressful as real combat. Trainees get next to no sleep, eat only whatever they can gather or kill from the wild, and are subjected to simulated fire from a pursuing force. When captured, they are put in a mock prisoner-of-war camp and interrogated using techniques including waterboarding.

No wonder, then, that levels of the stress hormone cortisol among SERE trainees exceed those in patients about to undergo major surgery and skydivers making their first jump. Stress also triggers the production of noradrenaline – a neurotransmitter and hormone that prepares the body for a "fight or flight" response by increasing mental arousal, quickening the heart rate and increasing blood flow to the muscles. Cortisol, meanwhile, boosts blood sugar, making more energy available.

Surging cortisol and noradrenaline may have served humans well in stressful situations in our evolutionary past, but in the extreme and prolonged stress of the modern battlefield the high levels they reach can be counterproductive. This is particularly true for noradrenaline. While it enhances the formation of memories about stressful events – helping to explain why PTSD sufferers can experience vivid flashbacks – at high levels it disrupts key functions of the brain's prefrontal cortex, including planning, decision-making and short-term memory.

These effects are clear in Morgan's studies of cognitive performance during SERE ›

training. For example, in 2006 his team found that soldiers have significantly more difficulty in drawing a complex figure from memory after a brief exposure to the image (*Biological Psychiatry*, vol 60, p 722). They also perform poorly on the confusing Stroop test, in which words for various colours are printed in another colour that has to be identified. In combat, cognitive deficits that impair short-term memory, attention and other skills could result in poor decisions that risk the lives of the troops or lead to the accidental shooting of a civilian.

At its worst, the fog of war can involve a disengagement from reality. Morgan's team has found that almost all SERE trainees experience some degree of "dissociation" – perceptual distortions in which time can appear to speed up or slow down, colours or smells can seem unusually intense, or the sense of self can shift. In extreme cases, troops report out-of-body experiences (*The American Journal of Psychiatry*, vol 158, p 1239).

Combat veterans being treated for PTSD recall similar sensory distortions. "It's a very strong psychosis feeling. You feel confused but very aware," says Brooks Tims, a former medic with the Marine Corps, who served three tours of duty in Iraq. "A couple of gunshots coming in at you can feel 10 minutes long."

Not everyone experiences these symptoms to the same degree, however. Morgan's team has found that soldiers who dissociate least, and whose cognitive abilities hold up best under the stress of SERE training, have physiological differences from their peers.

Clearing the fog

Before undertaking his studies, Morgan had expected the best-performing trainees to be the least stressed, and so to produce the least noradrenaline and cortisol. But when the researchers measured levels of the hormone in saliva samples taken during SERE training, they found exactly the opposite. "The people who were doing the best also had the highest levels of cortisol," says Morgan.

These high-performing troops also seem to make better use of the surge of cortisol and noradrenaline during acute stress. For instance, their heart rate shoots up more dramatically when stimulated by noradrenaline (*Psychophysiology*, vol 44, p 120).

That might explain their superior physical performance, but how do these troops maintain a clear head with such high levels of noradrenaline swamping their brain? The answer seems to be that their bodies are simultaneously jamming down hard on both the accelerator and the brake. Yes, they produce more cortisol and noradrenaline, but crucially, they also ramp up production of calming factors that help keep the brain's higher functions intact.

In the elite performers, Morgan's team found elevated levels of the hormone dehydroepiandrosterone, or DHEA, which seems to buffer the brain against the negative effects of stress, although the mechanisms for this are not fully understood (*Archives of General Psychiatry*, vol 61, p 819). "If it was up to me, I'd have DHEA loaded in their rations," says Gary Hazlett, formerly a US army psychologist at Fort Bragg, and a member of Morgan's team.

Some soldiers have already latched on to the benefits of DHEA, which can be purchased as a nutritional supplement – although they were probably attracted by its reputation for enhancing athletic performance, rather than its effects on the brain. "In the special operations culture, you'll find that an awful lot of soldiers have gone to the health food store and experimented with a lot of things," Hazlett says.

The most potent protective factor, however, is a neurotransmitter called neuropeptide Y (NPY), which binds to receptors on neurons in the prefrontal cortex and alters their response to noradrenaline, acting as a brake to its accelerator pedal. For the best performers in SERE training, levels of NPY rise to about one-third higher than in their peers, and quickly return to a healthy baseline once the stress is over.

Less-resilient individuals, on the other hand, seem to have a lower capacity for NPY production. What is more, their smaller surge of the neurotransmitter during SERE training seems to deplete their reserves, causing NPY levels to drop below baseline for at least 24 hours (*Biological Psychiatry*, vol 52, p 136).

Soldiers with the highest levels of NPY also experience milder symptoms of dissociation during SERE training (*Biological Psychiatry*, vol 47, p 902). That could have

Battle lines drawn in the brain

It is hardly surprising that an experience as stressful as armed combat can disrupt the normal functioning of the brain. And in soldiers diagnosed with PTSD, some of the changes are long-lasting – in addition to emotional problems and intense flashbacks, sufferers can have difficulty concentrating, and startle easily.

"Every time I go into public and hear a loud noise, I freak out," says Brooks Tims, a US Marine Corps veteran now being treated for PTSD at The Pathway Home in Yountville, California. "I end up taking cover or doing something extreme, and have people looking at me like I'm an alien."

But what of the combat veterans who don't suffer from PTSD? It seems that their brains also bear the signature of war that can last for months after leaving the battlefield.

Jennifer Vasterling, a psychologist with the US Department of Veterans Affairs Boston Healthcare System, has studied more than 650 veterans, measuring their performance on a series of cognitive tests before and after deployment in Iraq.

Before deployment, the troops performed just as well as a matched sample of more than 300 soldiers who remained in the US. But when tested again about 75 days after returning from Iraq, they scored significantly worse on tests of attention, verbal learning and visuospatial memory (*The Journal of the American Medical Association*, vol 296, p 519). These cognitive deficits were associated with higher scores on tests measuring confusion and tension.

"You can't consider it just as acute distress – they're back home," says Vasterling. The Iraq veterans did, however, perform better on one key measure: their reaction time was faster.

Vasterling will soon publish a follow-up study revealing if these changes persist one year after leaving the combat zone.

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The cognitive fog of war can lead soldiers to make unsound decisions

important implications for troops' long-term mental health, since studies have found that sufferers of PTSD report greater levels of dissociation during combat than those who experienced similar trauma but did not develop the condition.

The most intriguing implication of Morgan's research, however, is the suggestion that supplementing levels of DHEA or NPY could enhance soldiers' ability to think straight in the heat of battle – and perhaps also offer some protection against PTSD.

Morgan is keen to run trials of the effects of DHEA and NPY on the cognitive resilience of SERE trainees. His team has already demonstrated the basic principle of intervening to improve cognitive performance, in a disarmingly simple experiment published earlier this year. Immediately after SERE training the researchers gave soldiers a drink containing either a low or high dose of a carbohydrate that is rapidly digested to glucose, or a similar-tasting inert drink.

The brain needs a large amount of energy to function, and in the food and sleep-deprived SERE trainees, the glucose proved effective at boosting their mental acuity. The following morning, those given the carbohydrate drinks performed significantly better on the Stroop test (*Military Medicine*, vol 174, p 132).

Giving troops energy-rich drinks is one thing, but the idea of intervening with drugs to enhance military performance is more controversial, as reactions to another proposal have shown. The beta-blocker propranolol has the potential to lessen the fearful reactions of PTSD sufferers recalling traumatic events, but the suggestion of giving it to troops as a prophylactic has alarmed some observers, who worry that taking the emotional sting out of bad memories might make troops operate without the restraint of conscience. "Do we really want guilt-free soldiers?" asks Jonathan Moreno, a bioethicist at the University of Pennsylvania in Philadelphia.

DHEA and NPY should not turn soldiers into cold-blooded killing machines, however, as they don't work by lessening emotional responses to disturbing situations. Indeed, Hazlett argues that helping soldiers think straight under extreme stress should make atrocities less likely, not more. "You would have a soldier with a conscience, if they're thinking effectively," he asserts.

As the toll of PTSD continues to mount, Morgan's work is attracting increasing attention. "We need to better understand the stress response," says Jennifer Vasterling, a psychologist with the Department of Veterans Affairs Boston Healthcare System. "Psychological responses don't occur in a vacuum; there's this biological component as well."

No one expects DHEA or NPY to be a panacea for PTSD. "Dissociation is one of many risk factors," says Vasterling. And if traumatic experiences are sufficiently intense, prolonged and repeated, even the most resilient individuals might succumb.

When *New Scientist* talked with Wells and Tims at The Pathway Home, a recovery centre for veterans in Yountville, California, they were unsure whether anything could have prevented their lives from disintegrating on their return from Iraq, haunted by horrific memories that few civilians can conceive of. "Even if I'd had something that made me perform even better, I don't know if it would have affected my thoughts and emotions," says Wells. He is now returning to duty, not to the battlefield but to train as a psychologist so he can help comrades stricken by the symptoms that once saw him filled with rage, withdrawn from society and seeking solace in alcohol.

Nearly 2 million US soldiers have been deployed in Iraq and Afghanistan since 2001 – with many facing repeated exposure to trauma that can put them at a particularly high risk (see diagram, left). With so many in danger, can Morgan's ideas prevent soldiers from slipping into the nightmare of PTSD, and keep others from life-threatening confusion on the battlefield?

Only experimental trials will answer this question, and Morgan says he hopes to win permission to test DHEA or NPY on SERE trainees as soon as possible: "The time is ripe for assessing whether giving these agents can help." ■

Tours of trauma

Repeated deployment in war zones puts soldiers at high risk of post-traumatic stress disorder, but estimates of the number of soldiers with PTSD vary

SOURCE: VETERANS AFFAIRS NATIONAL CENTER FOR PTSD

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