

THE  TIMES

Eureka

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FEAR

Neuroscience: the other
war on terror

Plus: Untangling string theory | Ben Miller | Business of genomics | Good dad/bad dad



FEAR

"The heart beats wildly, or may fail to act and faintness ensue; there is a death-like pallor; the breathing is laboured; the wings of the nostrils are wildly dilated... the uncovered and protruding eyeballs are fixed on the object of terror; or they may roll restlessly from side to side... The hands are alternately clenched and opened, often with a twitching movement."

— CHARLES DARWIN 1872

PART ONE: HOW TO FORGET IT

PART TWO: HOW TO EMBRACE IT



PART ONE: HOW TO FORGET FEAR

Ed Yong

&

Alice Fishburn

Imagine if you could rewrite your mind as quickly as a document on your computer. No more painful memories, no phobias or ingrained fears, just a blank slate where the scars that mark each human life used to be. This may sound like the stuff of Hollywood fantasy but last month it came a step closer to reality at New York University. By manipulating memory a research team managed to remove a conditioned fear response among volunteers. As scientists learn more about the mechanics of the mind, such targeting and erasing of traumatic recollections will become easier and easier.

Fear tortures all of us in one form or another. The Ancient Greeks blamed sudden knee-knocking terror on a lecherous, goatish divinity, Pan. While his ability to inspire panic was enough to rout the Titans, the force behind it was too mysterious for mere mortals to comprehend. But they knew it when they felt it.

We all recognise the physiological symptoms when danger threatens: our stomachs lurch and adrenalin fires up our muscles. Charles Darwin chronicled this in *The Expression of the Emotions in Man and Animal*: "...the eyes and mouth are widely opened, and the eyebrows raised. The frightened man at first stands like a statue motionless and breathless, or crouches down as if instinctively to escape observation."

These reactions are triggered by both memory and instinct. Evolution has endowed us

with innate impulses that warn against age-old dangers. Thus spiders or snakes may set our pulses racing, but most of our anxieties are learnt through experience. We recall that something hurt or scared us and these memories help to trigger our nervous system. Neuroscience suggests that both reactions can be traced back to a small almond-shaped part of the human brain, the amygdala. It plays a key role in responding to stimuli, recognising danger from previous situations and sounding the alert.

How we recall fear has fascinated scientists for centuries. In 1920, the unfortunate "Little Albert" was one of the early targets for experimentation. Over several months the baby boy became a guinea pig for scientists at Johns Hopkins University in Baltimore. Their aim? To try to condition fear. First, the researchers placed a white rat in front of the baby. This didn't scare him. Then they linked the appearance of the rodent with a loud bang. After exposure to this combination, Albert began to weep on cue when he saw the rat alone. Their report suggests that his reaction to white fur became so extreme that even a Father Christmas mask induced fear.

Albert's mother never gave consent, rendering these experiments highly unethical by today's standards. That said, current approaches are not dissimilar, simply more sophisticated and informed. Last year Merel Kindt and her team at the University of Amsterdam experimented



with chemical intervention to dull the emotional sting of a scary memory. Kindt made her considerably more adult Little Alberts anxious by showing them images of spiders and giving them mild electric shocks at the same time. She found that if they took a beta-blocker, propranolol, before reminiscing about their experience, they were no longer scared of the spider images.

This experiment capitalised on the knowledge that traumatic memories are not written just once but every time we remember them. When we first record memories the presence of certain proteins strengthens connections between the synapses — the gaps between nerve cells — in the brain. However, every time we recall these memories subsequently the proteins break down and must be remade from scratch. During this period of reconsolidation our memory is vulnerable to reshaping. Like that open Word document on your laptop, it can be rewritten.

When Kindt gave propranolol to her volunteers she managed to interfere with the process of reconsolidation. If her team didn't reactivate volunteer memories by showing them the spider pictures, the drug did nothing. But if the spider triggered a fearful response, thus opening the reconsolidation window, the drug managed to interfere with it. Propranolol did not erase these memories; it simply blunted their emotional edge. While the

volunteers still expected a shock, they were not scared by the prospect.

The ability to update our memories with new information highlights the flexibility of our brain. Every act of remembering gives us an opportunity to shape memories, or even erase them. The discovery of the reconsolidation window has kick-started a lot of new memory research, advances in which could have important implications for people who suffer from unwanted fearful memories. Potential treatments for anxiety, phobias or post-traumatic stress disorder (PTSD) may be close at hand. Propranolol, or other chemicals that do the same job more effectively, could help sufferers to get on with their lives more easily. These discoveries could have much wider applications than removing fear: for instance, in people who struggle to control their impulses, they may help to erase addictions.

But the possibility of removing past fears ramps up new concerns about ethics, with strident editorials decrying attempts to meddle with the human mind. The most extreme writers describe the research as “threats to human identity” and “the stuff of science-fiction nightmares”. There are inevitable comparisons

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Fear is a vital teacher: moments of fright are how we learn about dangers. That memory of what went wrong the last time we left the stove on can stop us from making costly, even lethal, mistakes

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with the film *Eternal Sunshine of the Spotless Mind*, in which mind-wiping technology robbed characters of the experiences that enrich our lives and make us human.

These concerns are overblown where propranolol is concerned. The drug merely changes the emotional content of memories, rather than erasing them. Scientists are well aware that fear is a vital teacher: moments of fright are how we learn about dangers. That memory of what went wrong last time we left the stove on can stop us from making costly, even lethal, mistakes.

Our brain goes to some trouble to solidify such recollections. Memories of shocking or traumatic events are sometimes known as “flashbulb memories” because of their exceptional vividness. Our bodies even offer them special protection through molecules called CSPGs, which act like bodyguards. Last year, scientists at Harvard University showed that large chains of proteins and sugars form defensive nets around specific nerve cells, protecting the memories encoded within from being lost.

Tampering with such important memories, unwanted though they may be, is clearly not something we should undertake lightly. Indeed the act of changing the emotional intensity of scary memories, as propranolol can do, could have legal implications. If victims of crime

MY FEAR THE BOXER Joe Calzaghe



How scared were you before your first professional bout?

Actually, out of all my pro fights, that was probably the most relaxed. I'd already been an amateur champion and had more than 120 fights. You start off fighting guys called journeymen who are basically not very good. All I remember is that it was really cold and there was hardly anyone there.

How does your fear manifest itself?

I don't feel scared. When I go in the ring, I obviously get adrenalin and get nervous but over the years, I've managed to control it and use it as a positive. You need nerves. To be relaxed is bad but to be too nervous is bad because you burn up too much energy. I've always been able to balance it by listening to my iPod and relaxing with friends.

Does it feel the same every time you box?

No. As you progress through your career, you fight better fighters. I'll be honest with you — if you ask me when was the most nervous I've ever been, that was against Chris Eubank in October 1997. That was so much pressure on me because that was the first time I'd fought for a world title. I had a mortgage to pay and a baby on the way. I needed to win.

Were you ever concerned about serious injury?

In the 1990s Michael Watson got injured against Chris Eubank. I was a big fan of him and he was obviously my weight. When that happens it strikes home, the reality of how dangerous the sport is. But all you can do is be as fit as possible and try and make the weight. Boxing is as safe as it's ever been. If you start thinking about it too much and start worrying, you shouldn't be in the sport.

Do you have any rituals to psych yourself up?

Not really. One thing I do is never do up the top lace of my boots. I suppose that's a ritual. When I was 13, I lost and I'd done my boots all the way and it stuck in my mind. That's weird.

What advice have you been given on how to combat your fears?

Relaxation techniques. The most nervous time is the day of the fight — not in the venue but before when you're waiting. So I do some techniques, breathing and think of something nice. There's this fight in front of thousands of people and somebody trying to knock your head off, so I try not to dwell on that.

What advice would you give people on how to overcome their fears?

It's difficult because everyone's different. Lennox Lewis used to try to sleep before going into the ring which would never be possible for me because I'm getting so psyched up on adrenalin, I can't keep still.

What is your biggest non-career-related fear?

I don't like flying much. I don't like heights. I don't like spiders. Oh, and of course another one of my fears is dancing.

Just how scary was Strictly Come Dancing?

Everything is completely the opposite when you're doing something outside your comfort zone. I could never relax on the live show, I just freaked out. All I was thinking about was who was watching me and feeling stupid. I couldn't seem to handle it. It was probably the scariest thing I've been through.

Joe is Britain's only undefeated world boxing champion. His testimonial dinner will be held at the Grosvenor House Hotel, London, on March 22. For ticket details, go to joecalzaghe.com

use the drug to reduce their stress, it could be tantamount to tampering with evidence. The dulled emotional content of medicated recollections may hamper the ability to make a solid case in court, and doctors who prescribe the drug could be accused of obstructing justice.

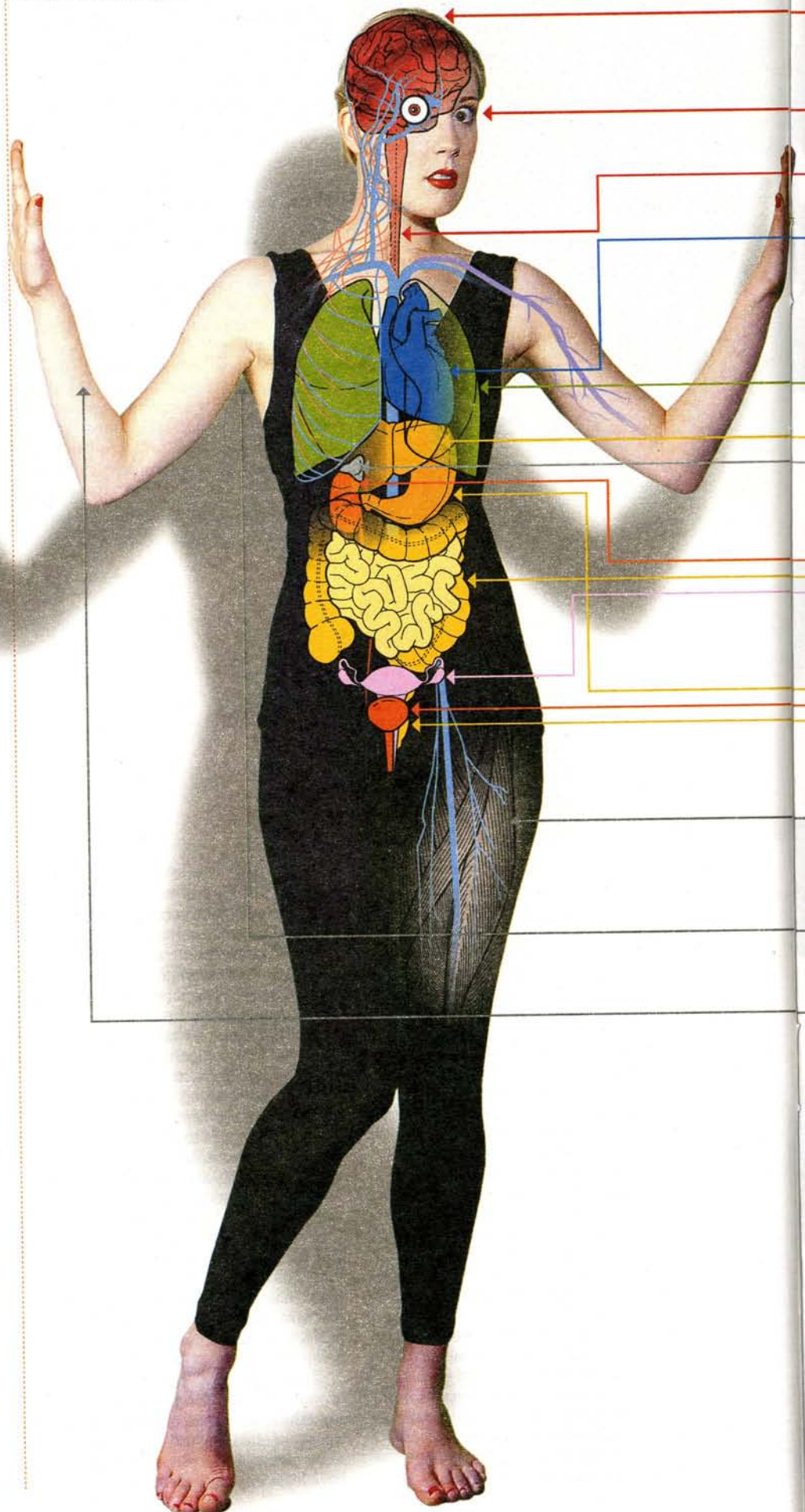
Many of these worries stem from our unease over the use of mind-altering pills. We forget that chemicals are only one method of playing with our minds. The point of the reconsolidation period is to allow the brain to incorporate new data into its framework. This means that we can change memories simply by presenting the right information at the right time. Good adverts or teachers can exert as much power as a drug.

Kindt thinks that many of the knee-jerk responses ignore the fact that our everyday lives are full of things that can alter our memories. "Some people are very afraid of the idea that if you take a pill, it could influence your memory," she says. "But psychological processes, such as repetition, interference and even sleep, could also influence the neurobiology of memory, more so than a pill."

Indeed, scientists are expressly trying to harness these techniques. They realise that a distraction can rewrite fears just as effectively as chemical intervention. And what better distraction than Tetris? Emily Holmes, from the University of Oxford, asked people to play the classic video game after seeing a grisly film featuring surgery and accidents. She found that while these volunteers remembered just as many details of the film as those who did not play Tetris, a week later they had fewer flashbacks and were less affected emotionally by what they had seen.

Holmes thinks that the game hogs the brain's processing power. As a result, during the time window when memories would have been firmly

Fight or flight — The body's response



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etched, the volunteer's visual and spatial faculties were not available to record long-lasting imagery. Instead, they were busy pushing geometric blocks around a computer screen. Tetris acts as a mental vaccine that protects against the creation of strong fear memories and removes their emotional burden.

Such experiments can ease the load of those suffering from PTSD or acute phobias. These people form a significant part of the population. PTSD and depression are estimated to affect nearly 20 per cent of Americans who have returned from service in Iraq and Afghanistan. The US National Institute for Mental Health believes that around 19 per cent of American adults suffer from a significant phobia. Memory manipulation could get rid of painful associations that certain objects or recollections carry.

BRAIN

The amygdala region plays a central role in the body's psychological response to fear, recognising threats and triggering nervous responses

PUPILS

Pupils become enlarged, increasing the field of vision

SYMPATHETIC NERVOUS SYSTEM

The SNS, which controls reflex actions, becomes primed for sudden activity

HEART

Rises in heart rate and blood pressure increase blood flow to the muscles and brain

LUNGS

Fast breathing and heightened ventilation increase the amount of oxygen available to the brain and muscles

LIVER

Glucose is released from the liver to fuel the fight or flight response

ADRENAL GLANDS

These release adrenaline into the blood to prepare the body for action

KIDNEYS

DIGESTIVE SYSTEM

Blood vessels to these systems and organs, which play no part in fight or flight, become constricted, temporarily shutting them down

STOMACH

BLADDER

BOWEL

Contents might be released. This mechanism could have evolved to distract an attacker and "lighten the load" the body has to carry

SKIN

Paling of the skin is an effect of adrenaline, which re-directs blood away from the body's surface and the stomach to the brain and muscles, especially those in the legs and arms

SWEAT GLANDS

Sweat glands open to allow cooling of the body in the event of a fight or flight response

BODY HAIRS

Stand on end to make the body more sensitive/reactive to external stimuli

The recent evidence from Elizabeth Phelps at New York University suggests another way to reshape memories. After training volunteers to be wary of a coloured square by pairing its appearance with a mild electric shock, she found that she could remove their anxiousness by deliberately triggering their fearful memory and rewriting it. She did this by exposing them to the square without the shock. Remarkably, the effect lasted for at least a year. An existing treatment, called Eye Movement Desensitisation and Reprocessing (EMDR), works along similar lines: patients keep a traumatic memory in mind while moving their eyes about. This is thought to interfere with the reconsolidation process.

But perhaps the most effective way of erasing memories was discovered a few years ago by Todd Sacktor, from the SUNY Downstate Medical Centre in New York. He believes that memories are strengthened by a protein called PKMzeta. This effectively acts as glue, turning up at specific synapses when we learn new things and doubling the strength of their connections.

Sacktor says that this discovery has prompted a "revolutionary change in how neuroscientists have thought about memory". It suggests that our memory is a dynamic machine that needs the constant activity of PKMzeta to stand the test of time. With this power supply memories can last for years; without it they are lost. It is likely that the process of reconsolidation involves breaking down and remaking PKMzeta at specific synapses, and drugs such as propranolol work by obstructing this process.

In order to test his theory, Sacktor trained rats to avoid the taste of saccharin, an artificial sweetener. He then removed this aversion with a single injection of ZIP, a chemical that interferes with PKMzeta. The dose does not stop rats from laying down new memories, but it does erase existing ones, even if they are very strong and relatively recent. Even more dramatically, the process seems to be irreversible and universal. Sacktor says: "It applies to all parts of the brain that store different types of memory, like the amygdala that stores fear memories, the hippocampus that stores place memories, or motor memories in the motor strip. They're all using PKMzeta."

The discovery of this protein has raised yet more ethical concerns, especially about the potent and far-reaching effects of blocking it with ZIP. Such queries remain the field's greatest dilemma: does the excitement of new discoveries outweigh concerns about their application? "I was initially worried, too," says Sacktor, "but [applications] wouldn't happen for a long time in the future. And it's not just about the dystopian fantasies of making zombies or toying with people's memories. I think the actual good is going to far outweigh the potential for bad."

The little round pill that wipes away all our memories remains firm fiction. Instead, scientists strive to blunt the most painful edges of our memories while leaving the substance intact. Until we understand how memory works, sufferers of acute fear will remain paralysed. "We are our memories; our mental states are based upon everything we've learnt," Sacktor says. "You can't hope to treat addiction or post-traumatic stress disorder in a fundamental way until you really know how these processes work." With so much to gain from memory research, it would be shameful to let fears of misuse cloud our judgment. As Nietzsche put it: "The only thing we have to fear is fear itself." ●

MY FEAR THE BOMB DISPOSER Nick Watts



How scared are you when you go into the field?

There are different levels of task and, depending on the level, you can be almost quite nonchalant right through to being extremely wired. You are going from a safe haven and are going to be dropped off into an area where you don't necessarily know what is going to occur. I'd say it's nerves rather than fear at that point.

How does your fear manifest itself?

For me it's higher heart rate, being more alert and, again, that flight or fight mechanism feeling inside you — you are ready to go. I am very aware of what I am about to do. You start focusing on the job at hand as opposed to anything else.

How do you overcome your fear?

You get over it by being terribly busy and concentrating on the task, and therefore not having time to be scared. You can't afford to be — you have to be going in there 100 per cent focused. If you are telling people what to do, it actually reduces your feeling of fear because you are imparting confidence on to them and you can see that they are buying into what you are telling them. It gives you a feeling of confidence.

What goes through your mind when you are about to go into the field?

From the moment you hit the ground, you try to get your spatial awareness and your situation awareness. You are on a massive fact-finding mission to build up a threat assessment. Asking questions and taking all this information in reduces your level of fear. You start to understand the different aspects of the job and it gives you confidence that you are going to be able to resolve the situation.

Do you have any rituals to psych yourself up for the job?

We generally smoke a cigarette because it gives you a definite pause between what you are doing. If you don't pause for some kind of thought you can find yourself rushing to get down the road without thinking about what you are going to do next. You have to have a definite plan in your head and that is that process, that pause for thought. For me it was a cigarette. Possibly two!

What advice have you been given on how to combat your fears?

I was scared to death the first time I jumped out of a Hercules and was told to have confidence in my kit. I would say that goes right across the board in the military, as it's all about having confidence in your team and your equipment and the fact that everybody is trained to a high standard.

What has been the scariest moment in your life or career?

Jumping out of a Hercules! Obviously, I have been scared dealing with devices but it is not raw fear, you think about it later when you have gone to bed. Another thing that makes you think more is when you have kids. The thing that worries a lot of people is the need to get back and look after their family.

What is your biggest fear?

I don't like big spiders. I used to have nightmares about camel spiders from Iraq. I used to wake up in the morning and they'd be hanging off my mosquito net.

Nick is a former Army bomb disposal officer and a director of the consultancy company Explosive Risk Management



really good rollercoaster, it seems. Before the ride, I took a reading from a portable heart monitor, and it recorded a relaxed, regular beat. Immediately afterwards — half a minute after the apex of my terror — the machine kept saying “Error: please seek medical advice”. But the effects were remarkably short-lived, leaving me wondering just how much adrenalin had really been produced. Within four minutes, my heart rate was back to normal.

Since the first genesis of the rollercoaster humans have loved the feeling of being blasted into the air, dropped down and spun helplessly in a scenario over which they appear to have no control. The ice slides of 16th century Russia have become the corkscrews and pneumatic propulsion systems of today, but, although the technology may now be equal to supporting astronauts in outer space, the sensation and urge behind it remains unchanged.

The technicians behind the rollercoasters have an increasingly sophisticated take on what makes us scared — and how to induce us to part with hard cash to feel the thrill. The new holy grail in rollercoaster technology is an entertainment experience that can measure the physiological and psychological responses of participants — and transport them on a ride to the ultimate tailored thrill.

Brendan Walker has a peerless reputation in this arena where art, science and entertainment meet. Formerly an aeronautical engineer at British Aerospace, Walker now describes himself as the world’s only “thrill engineer”.

When he was a little boy Walker, now 38, used to dress up as a red devil and run up into the hills of the Peak District to watch planes fly overhead. Later, as a young man and aerospace engineer, he designed planes himself, but quit when he found that those that crashed and burnt were more interesting than those that stayed in the air. He now works with geneticists, academics and rollercoaster technicians, and runs a production consultancy specialising in “the creation of tailored emotional experience”.

“I was looking to find relationships between extreme emotional experience and the social, cultural and psychological conditions that are necessary to create these kind of sensations,” Walker says, wearing his trademark red “Thrill Laboratory” boiler suit.

Starting with smaller experiments on existing theme park rides, Walker wired up subjects to monitor their heart rate, sweat production and facial muscle reactions — all designed to gauge fear and pleasure. That data provided the basis for his first adaptive simulation: a single-rider bucking bronco from which

measurements are taken and then used to adjust the ride to increase fear and arousal.

Walker works with the Mixed Reality Lab at the University of Nottingham in conducting his bucking bronco experiments. According to Steve Benford, Professor of Collaborative Computing at the university: “We wanted to find out if you could have a meaningful relationship between what your body gives off and what you’re experiencing. If so, can you adapt a ride accordingly, and, even if you do, will anyone notice the difference?”

Since Disney built the first steel-based rollercoaster, the Matterhorn in 1959, the basic ingredients of design have remained the same: acceleration, g-force, inversions, loops, free falls and speed. But technology has made them higher and faster. The US leads the thrill pack, followed by Japan and Germany. American Premier Rides invented linear indication systems. Swiss company Intamin created the hydraulic launch and the German Gerstlauer is

responsible for inverted drops of more than 90 degrees.

As a result, rides in a pure “thrill park” might now be able to shoot visitors up to 120m (400ft), as the Kingda Ka ride in Six Flags New Jersey does, drop them at an angle of 97 degrees as at Rage at Adventure Island in Essex, and then spin them like a washing machine. But Walker, and bigger players in the industry, believe the ultimate ride involves engineering a more complicated emotional journey.

The development of rides such as Saw at Thorpe Park in Surrey involve a complex back story, music tracks and a long pre-ride sequence that builds expectation before the rider even sets foot in the car.

In an age saturated with sensation, only novelty and increased intensity provide satisfaction. Even the granddaddy of the theme park industry, Disney, admits that constant

innovation is vital to pleasing audiences who have seen it all before. “We are not a thrill park. We don’t have rides, we have attractions,” says David Wilson, a former Nasa technician and nuclear engineer who is now employed as a project manager for Walt Disney Imagineering, based in Paris. “We can create cool technology, but at the heart of what we’re doing is the story we want to tell.”

Recognising the need for a free fall attraction, Wilson helped to create the Tower of Terror at Disneyland Paris. But, being Disney, the ride could not be merely a tower with a drop. The Tower of Terror is themed around an old Hollywood hotel that uses a lift to propel riders to different floors, before the doors open to reveal various horror film scenarios and then free fall drops to different levels. The ride can accelerate both up and down from 0-30 mph in 1.6 seconds, and generates enough power to run 1,864 Smart cars. But the key to the ride’s success, according to Wilson, is that the drops can happen three or four times in unpredictable combinations. “Thrill and delight is absolutely generated by the unexpected. We have another attraction where you can feel the sensation →



LIFE SCIENCE

Why do rollercoasters make some people sick?

The motion causes conflicting signals between the eyes and the inner ear, which is responsible for balance. This triggers a feeling of nausea, but we don’t really know why. Different people have different tolerances. Again, it’s not fully known why.





PAGES 22-23 JENSEN WALKER FOR EUREKA. MARK HARRISON FOR EUREKA

of a rat running across your feet. There are no loops or negative gs, but it works every time."

Novelty, intensity, complexity and variety form the four elements in what psychologists measure as sensation-seeking experiences. Physical thrill is only one facet of these, and high-scoring sensation seekers often also score highly in other areas; looking for more sex, drink, drugs and extreme sports. High sensation seekers who love the thrill of a ride are also impulsive when it comes to changing jobs and partners, and frequently underestimate how risky their activities are. A thrilling ride will incite the same fear and arousal as other illicit activities, such as shoplifting.

Marvin Zuckerman, of the University of Delaware, has studied sensation seeking for 30 years and claims that the thrill quickly wears off. "Activities need to escalate to become more risky, or more unusual," he says. "Skydivers become base jumpers, movies become more explicit." Not surprisingly, high sensation-seekers

“*Walker's interest in fear lies in vicarious response rather than personal thrill. I go on planes and read out accounts of air disasters to see how people react. My girlfriend hates it when I do that***”**

love theme parks and horror movies, while "low sensation-seekers don't go on rollercoasters". High sensation-seekers also tend to be young and male, an association that scientists believe is linked to testosterone and levels of dopamine associated with D4DR, the "thrill gene".

A long-form mutation of the D4DR gene has been linked with lower levels of dopamine in the brain, and the need for high sensation-seekers to pursue more risky and exciting activities as compensation, according to consultant immunologist Dr Hilary Longhurst, from Barts and the London NHS Trust. Longhurst recently tested Brendan Walker for the gene mutation, and is waiting for the result.

"I honestly don't know if I have the thrill gene," Walker says. His interest lies in vicarious response rather than personal thrill. "I go on planes and read out accounts of air disasters to see how people react. My girlfriend hates it when I do that." His current work encompasses the psychological and physical aspects of sensation-seeking. "There's the idea of spectacle, a very visual idea. Then there are bodily sensations of speed, sound, taste. And then there is power and control. Finally there's mortality. Will you be in mortal danger, or will you stay alive?"

Walker recently undertook a "thrill road-trip" across the US and had a brush with death when a parachute failed to open during a sky dive; an

experience that seems to have left him shaken, rather than exhilarated. His travels left him wanting to map out the inherently emotional elements that make up a thrilling experience. Could they be quantified? "In the old days fairground workers knew how to work with all those elements," Walker says. "They could read from people's expressions how afraid they were, and they'd make the ride go higher, or faster — or come and spin your car if you were on the waltzer. What we want to do is measure those responses in a quantifiable way and program the rides themselves."

Working with the British ride company RoboCoaster, Walker is beginning to construct, at the Max Planck Institute in Germany, a larger prototype of an adaptive ride that can be programmed and changed to suit different responses. RoboCoaster rides, which are based on industrial robots, come in two or four-seat variations. Their smaller size makes them most adaptable to an individual experience. Walker predicts that larger rides could group together similar-scoring sensation-seekers for a pre-programmed experience suited to their needs.

At the Mixed Reality Lab in Nottingham the thrill team have assembled to demonstrate how Walker's physiological and physical experiment works on the bucking bronco. Blair Barnett, their volunteer, is a blonde, pigtailed Californian rodeo rider. Wearing an orange jumpsuit, her hands, chest and face are wired to a monitor while a camera mounted on a helmet records her facial expressions and the muscle twitches around her eyes and mouth.

In the heat of the studio, the shiny red bullet-shaped bronco is slippery. Walker quickly adapts a rubber bath mat for Blair to sit on so she doesn't slide off too soon. With another thrill technician at the controls the bronco gyrates; Blair grimaces, smiles, and her heart rate blips. In addition to rodeo riding, Blair is an actress who says she "dislikes happy endings", which is fortunate as she spins off on to the floor. Paul, the technician who has been controlling the ride, reviews the data and reveals that Blair gets most pleasure from a slowly rocking bronco, and is frightened when he spins it around in fast, jerky motions.

The optimum ride that causes the monitors to register pleasure and fear in equal amounts is the one that incorporates fast, random motion. "Is it acceleration? Is it anticipation?" asks Steve Benford, who has been watching. "More importantly, can we sustain it multiple times?"

"It's the thrill isn't it," said one teenage boy about to ride on Saw at Thorpe Park. "It's a feeling in your stomach, you can't get that feeling anywhere else." Of course, you can — but nowhere so safely. "It's a euphoric sensation," says Brendan Walker, "a zooming emotion that blocks out everything else. You know the moment people enjoy the most? It's in the queue before they even get on. And sometimes they hate it while they're on it, but what an afterglow." ●

Brendan Walker's work is highlighted by the campaign Science: So What? So Everything, which aims to show people the science behind their everyday lives. Visit www.direct.gov.uk/sciencesowhat



MY FEAR THE COMEDIAN Mark Watson



How scared are you when you go on stage?

It's not exactly fear — you get over that fairly early in your career. I tend to buzz with nervous energy. It's more like the adrenaline before a sports match. Having said that, there are quite established comics who are almost physically sick every time.

How does your fear manifest itself?

When I am doing a gig, I'm unusually nervous — I talk too fast, jerk about too much and basically look like someone who's never spoken in public before.

How do you overcome your fear?

You can't really talk yourself out of it; you just have to incorporate it into your performance. My style is quite hyperactive and kinetic and jittery anyway, so it doesn't always show. It must be harder for people who deal in straight-faced, composed one-liners and don't move off the spot. I pace up and down an average of 25 miles per gig.

What goes through your mind when you are about to go on stage?

I normally like to think about things other than the show itself, for example my predictions for the weekend's football, or what my friends are up to. Sometimes if an MC is bringing you up on stage and you hear your name yelled out, there is a weird existential moment when you think: "That's me! He's called out my name! What do I do now?"

Do you have any rituals to psych yourself up before you go on stage?

As I've mentioned, I tend to be pretty psyched up anyway, so if anything, I'm in the business of calming myself before going on stage. I do this by playing Scrabble online (although that brings its own tensions), or texting friends, or drinking wine.

What have been your biggest fears during your career and your life?

In my career, basically being mediocre, failing to make an impression. In normal life, being struck by lightning. I have a terrible, lifelong phobia of it.

What advice have you been given on how to combat your fears?

The key to beating a phobia is apparently exposure to whatever you're scared of — in my case, I went to a museum exhibition on lightning, hoping greater understanding of the phenomenon would remove the fear. But if anything, I just left with even greater awe of how much damage it can do.

What advice would you give people on how to overcome their fears?

I'm a bad person to ask — I'm hopeless at overcoming fears. But I guess I'd advise people to try to rationalise their fears. Nearly all planes don't crash, nearly all spiders don't hurt you, and so on. Life is more mundane and dull than phobias make you believe. But that's not much consolation if you are in the grip of one. *What has been the scariest moment in your life or career?*

I once had to perform an open-air gig at a summer festival in a fairly bad lightning storm and I could hardly speak. Afterwards, I was drenched in sweat and continued shaking for a long time. The audience quite liked it, though. They thought it was some bizarrely contrived character act.

Mark Watson will be touring the UK with his brand new stand-up show in 2010. Go to markwatsonthecomedian.com for details