Understanding Fear in Animals

Professor Jeansok Kim

SCIPOD

UNDERSTANDING FEAR IN ANIMALS

Research into animal fear typically utilises laboratory techniques based on Pavlovian fear conditioning, but these approaches are limited. **Professor Jeansok Kim**, from the Department of Psychology, University of Washington (USA) has developed a much more realistic way to study fear that closely mimics risky conditions in the wild. New discoveries by Professor Kim and his team are challenging existing paradigms and providing exciting insights into the underlying brain mechanisms of fear in both animals and humans.

Time for a New Approach

All animals have to search for resources, including food, water, and shelter. Ironically, while searching is absolutely essential for their survival, it may also bring about their demise if they encounter a predator. To confront this dilemma, animals have developed the ability to feel afraid. In human terms, fear may not be seen as beneficial, but, for animals in the wild, recognising potentially dangerous situations – as a result of genetics and experience – may be what keeps them alive.

This ability to instinctively recognise and respond appropriately to certain dangers (even threats never encountered before) varies for each species, depending on their environment. For example, the main fear response for the woodland deer mouse is to freeze and this confuses its predator's sensitivity to movement. However, the desert deer mouse opts to leap as high as possible to avoid the snake's strike.

For a long time now, research into fear has relied on Pavlovian fear conditioning, where an innocuous stimulus (like a tone, for example) is associated with an aversive stimulus (such as an electric shock) which, in turn, activates a fear response. In this case, animals learn quickly that a tone is followed by an electric shock and start demonstrating conditioned fear responses as soon as they see the tone.

While the Pavlovian fear conditioning paradigm has allowed many major developments, Professor Jeansok Kim, based at the Department of Psychology, University of Washington (USA), believes it is now time for a new approach. According to Professor Kim, the fear conditioning approach does not allow us to explore the much more dynamic range of fear responses that animals need to survive in the wild.

To observe a wider variety of responses, Professor Kim and his team developed a much more naturalistic environment to study rats, where the animals' fear responses are not confined in small cages but instead expressed freely in a large enclosure, with a safe nest and a risky foraging area. In this enclosure, just as in the real-world, food does not come easy: the rats need to leave the safety of their nest, and face a LEGO robot

called Robogator that is programmed to surge toward the animal as it emerges from the nesting area in search of food. With moving eyes, jaw, and tail, the Robogator simulates an unpredictable attack by a predator, allowing Professor Kim and his team to obtain data that is not possible with real predators.

It's All in the Brain

Studies have identified a particular area in the brain – known as the amygdala – as the crucial structure regulating fear in animals, including humans. However, it has been very difficult to determine its exact functions due to technical difficulties in quantifying these responses in natural fear responses with real and unpredictable predators.

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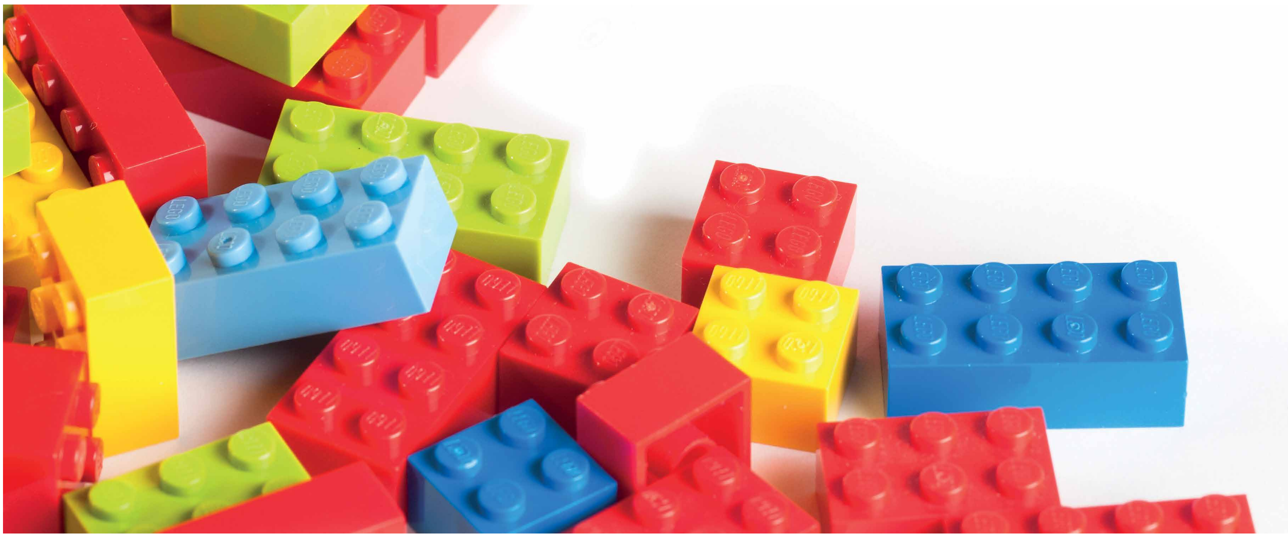


Using the Robogator, Professor Kim observed that rats would initially venture out of the nest, only to run back and freeze inside the nest at the first sight of the robot. Eventually, hunger would start to win over their fear, and the animals would start stretching and popping their heads out of the nest to scan the area. When they attempted to venture out of the nest, the Robogator was used to trigger their fear response once again. This meant that the animals could not retrieve food that was far away from the nest, and were only able to obtain food that was more closely placed to safety. Professor Kim proposed that ‘the farther the food is from the nest, the more strongly the fear motivation for self-preservation inhibits the hunger motivation for foraging. Nonetheless, the fact that rats do not simply avoid foraging altogether in the presence of the Robogator but instead make repeated efforts to procure the food indicates the utilisation of risk assessment on the part of the animal.’

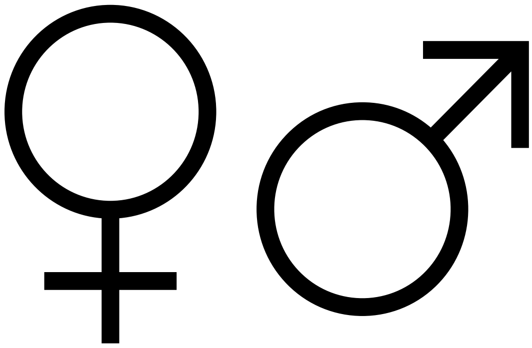
Repeating the same experiment with animals with either an inactive or an overactive amygdala confirmed its involvement in these demonstrations of fear responses: rats with low amygdala activity did not show any fear towards the Robogator – at most, they paused temporarily but did not flee to the nest. In contrast, animals with heightened amygdala activity took longer to leave the nest and covered a shorter distance to collect food.

Looking further at how the amygdala dynamically interacts with the prelimbic cortex (a structure implicated in decision making) during naturalistic problems of foraging, Professor Kim identified a dual response to dangerous situations: a short and fast period of activity in the amygdala in anticipation of an imminent predatory threat as the animal moves towards food, and a slow and longer period of activity in the prelimbic cortex as the animal exits the nest, as if preparing for an upcoming danger. Professor Kim suggested that this short burst would enable a quick escape while there is still time to do so, followed by a prolonged period of re-assessing the situation, maintained by the longer periods of brain activity.

Professor Kim’s hope is that ‘this ethological approach may be useful in revealing how the amygdala and its associated circuitry are involved in risk-taking and thrill-seeking behaviours in humans, and in addressing the neuronal basis of the basic approach–avoid conflicts that may contribute to human psychopathologies. Aberrant activity and wrong spike synchrony may underlie complex fear-related conditions, such as anxiety, panic, and PTSD.’

Not Just the Amygdala

Having demonstrated how the amygdala regulates fear responses even in naturalistic settings, Professor Kim was keen to analyse what other parts of the brain may also be involved. He was particularly keen to explore an area called the periaqueductal gray, which, although already implicated in fear responses, remains a mystery in terms of underlying mechanisms. Some previous studies have suggested that independent activity is undertaken by the amygdala and periaqueductal gray, whereas others seem to suggest that they function in an intertwined manner, with both contributing to fear responses.



Using his newly-developed approach as well as traditional fear conditioning, Professor Kim assessed the involvement of the periaqueductal gray, by itself and also in combination with the amygdala.

In the fear conditioning approach, while an inactive amygdala meant that the animals never showed any signs of fear, an inactive periaqueductal gray area did not stop frightened behaviours, mainly jumping and running. In contrast, in the large foraging chamber, the animals opted to run towards the safety of the nest instead. The different responses 'further highlight the importance of the context in which brain stimulation occurs in the expression of fear responses,' says Professor Kim. 'In other words, the environmental setting can significantly influence the behavioural readout.'

These results are important for a second reason. The model tentatively proposed so far places the periaqueductal gray area as acting after the amygdala in promoting a fear response. Professor Kim is now leaning towards the reverse scenario, suggesting that the amygdala is receiving instructions instead. More studies are still needed to confirm these underlying mechanisms in the brain.

When it comes to humans, it is possible that aberrant activity in the periaqueductal gray area contributes to fear-related psychopathologies such as anxiety, phobic, panic, and posttraumatic disorders. 'Looking beyond the amygdala and toward a circuit-level understanding of fear behaviour will provide more power to the treatment of fear-related disorders, but it is imperative that future studies use diverse and representative experimental designs to best converge upon the functions of fear circuitry,' states Professor Kim.

Females vs Males

There are fear mechanisms that seem to be shared by all species: the decision to go out and search for food needs to take into account the risk associated with meeting predators. One big question is whether there any differences between men and women. Anxiety and other mental health disorders tend to afflict more women than men – might this stem from fundamentally different fear mechanisms between the sexes?

Male and female rats do react differently to dangerous situations. Both demonstrate fear in response to danger but in contrasting ways. Males opt to increase the amount of food collected in each trip to cover their needs whereas females sacrifice their body weight rather than chance an encounter with a predator. This is not surprising, as females usually attribute higher importance to caring for their offspring while males put more effort into reproducing. Risk-taking males are more likely to achieve social dominance and win female attention.

Human fear vs Animal fear

Predation has been a major driving force in the evolution of fear in all animals, including humans. Observing and monitoring activity in conditions similar to those in the real world will continue to advance our understanding of the underlying fear mechanisms in the brain. This includes revisiting the results obtained from traditional fear conditioning studies so that we can better understand how fear shapes behaviour when animals are making real-world choices.

Future research also needs to evaluate whether human fear and animal fear involve the same mechanisms. This approach 'may provide a deeper insight into human disorders that are abnormal amalgamations of innate/learnt fear, risk-assessment, and decision-making processes,' concludes Professor Kim.

Meet the researcher

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Professor Jeansok Kim obtained his doctorate in behavioural neuroscience at the University of California, Los Angeles, USA, in 1991. He then took up a postdoctoral position followed by a research assistant professorship, both positions being held at the University of Southern California (also in Los Angeles). From 1996 to 2002, Professor Kim held positions first as an assistant professor and then as an associate professor at Yale University, New Haven, USA. In 2003, Professor Kim took up his current professorial appointment in the Department of Psychology at the University of Washington, Seattle, USA. Professor Kim is a distinguished academic, having received multiple awards throughout his career. In addition to being a popular invited speaker at conferences across the world, Professor Kim has amassed considerable funding, contributed to more than 100 publications, and serves as an editor and reviewer for a number of high impact journals reflecting his ongoing scientific contribution to his research field.

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FUNDING

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