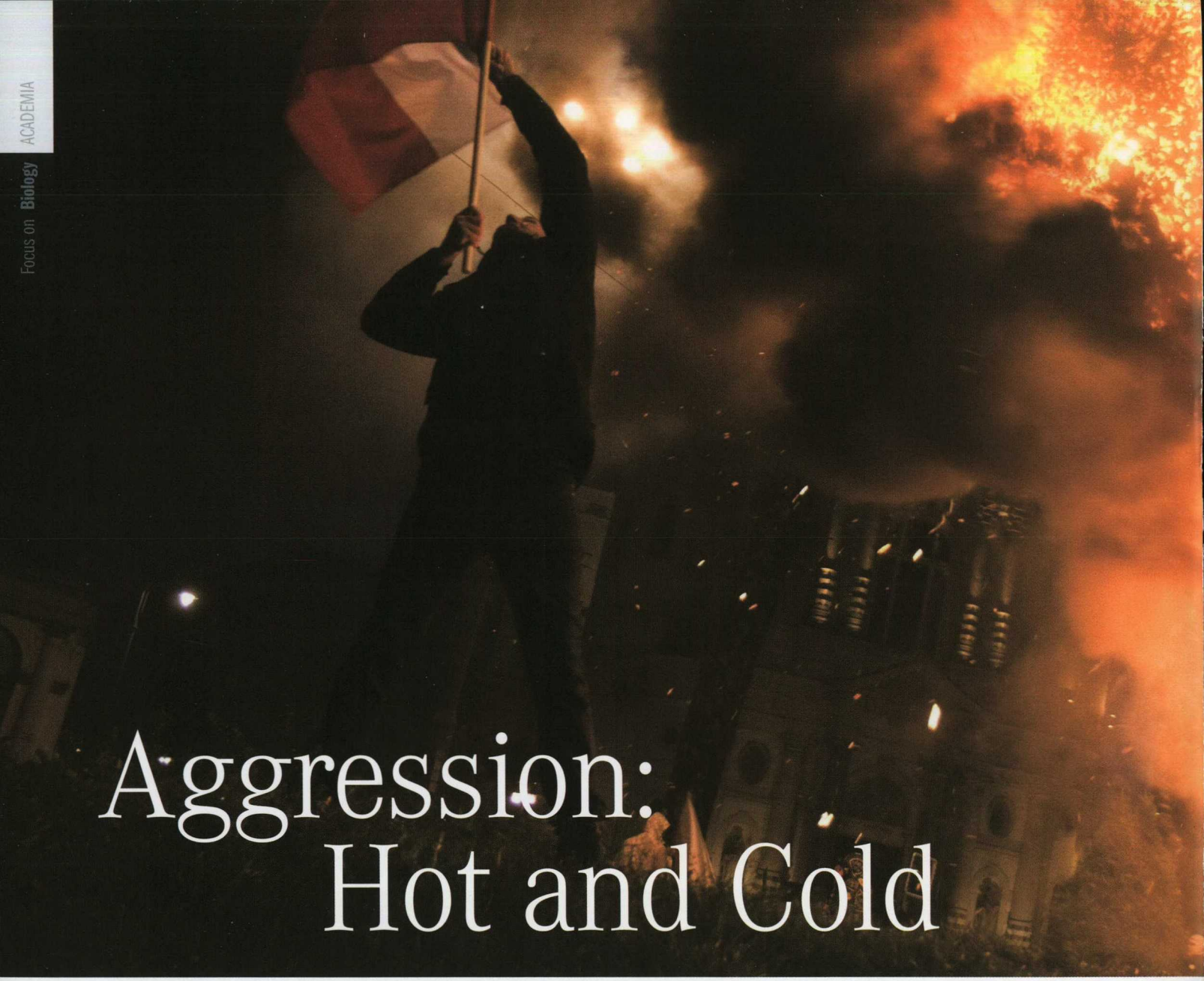

Aggression: Hot and Cold

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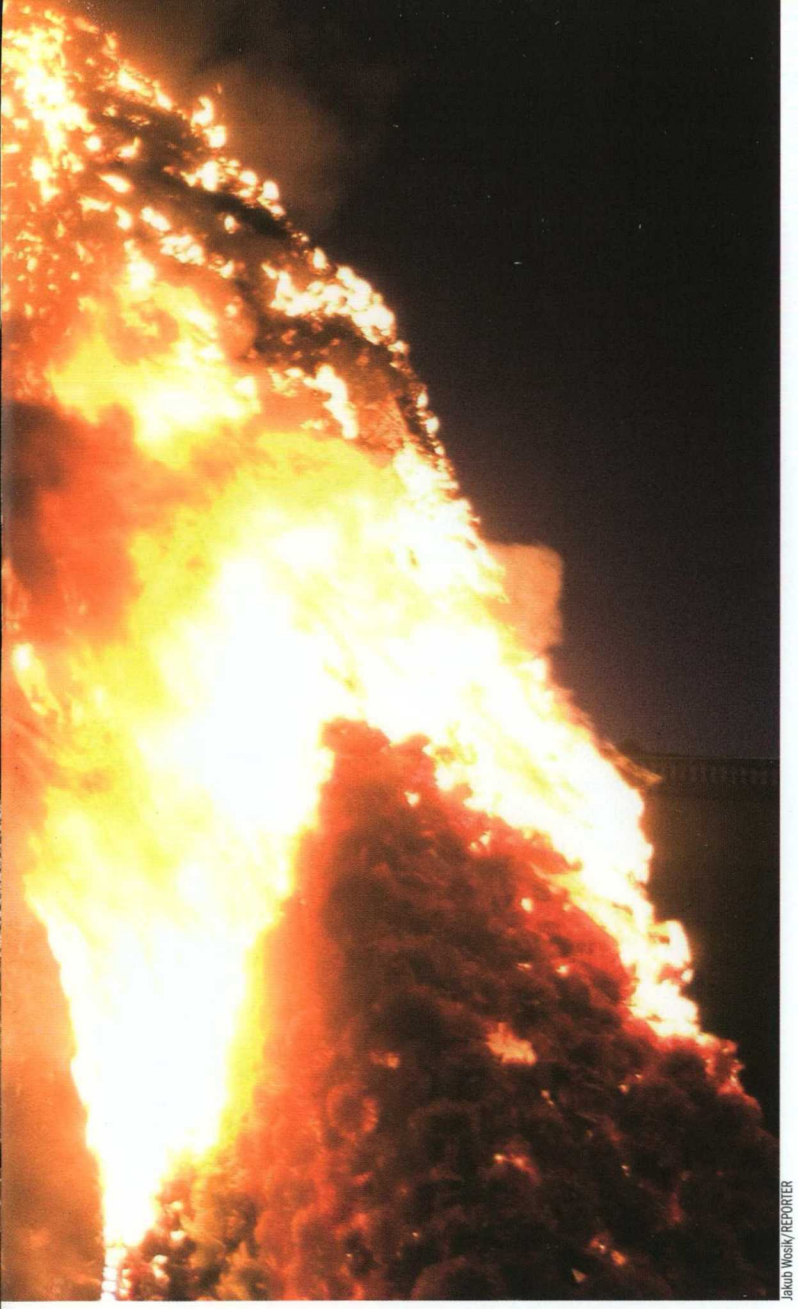
The Ancient Greeks described many different impulsive behaviors, including *mania* – a religious frenzy – and *lyssa* – the mad fury of war. The division is analogous to that made by contemporary neurobiology, which classifies aggressive actions as cool or emotional, each driven by distinct, mutually exclusive neurological mechanisms

Calm, rational thinking and cool assessment of facts are virtues we recognize and even demand from ourselves and others, in particular of people in positions of power. However, we are also quite aware of how far we are from this ideal and of how frequently our decisions are driven by impulses; at times we are not even able to explain our motives lucidly. This is because our rational thinking ability, based in the prefrontal cortex, evolved relatively recently, and has a significantly lower influence on our behavior than we are wont to believe.

Does free will exist?

In terms of functionality, the human brain – similarly to other mammals – can be divided into "rational" and "emotional" parts. In evolutionary terms the latter is far older, and it plays a deciding role in behavior, even though we usually rational-



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Aggression played an important role during the early stages of human evolution, when hostility towards groups of outsiders was necessary for survival. Traces of these primal behaviors are still visible in contemporary societies. The floral rainbow structure shown here, symbolizing tolerance, was set on fire in Warsaw on 11 November 2013 by nationalist participants in a march held to commemorate Poland's Independence Day

ize its commands. This creates a subjective impression that our decisions are made consciously and logically, as demonstrated elegantly in Freud's experiments with posthypnotic suggestion. Although we can undoubtedly question the scientific value of psychoanalysis, the author postulated – quite correctly – that the majority of our decisions are actually made beyond our awareness. People under hypnosis, ordered to perform certain actions after awakening (such as "Kneel when you hear the word 'umbrella'"), do indeed carry them out despite not remembering having been given the order; when asked about their motivation, they find false although apparently rational reasons such as "My ankle was itchy," "I had to tie my shoelace," or "I thought I saw something on the ground."

Contemporary neurobiology research suggests that decision-making processes and our being aware of them are distinct in terms of timing; in other words, the decision-making process occurs in the brain before the information trickles down to our consciousness. In 2008, John-Dylan Haynes analyzed the rate of blood flow in different parts of the brain to show that it is possible to predict as early as 7 seconds in advance which hand the subject will use to press a button pausing a string of digits scrolling across a monitor. It does appear, then, that our actions are governed by unconscious processes, and we are left with a mere illusion of rational and logical reasoning. Does this question the existence of free will? As a neurobiologist, my answer to the question must be an emphatic no. Although decisions do first arise in the brain on a subconscious level, they must be "approved" consciously before they are acted upon. In the cerebral cortex, there are areas responsible for a "conscious veto" located in the medial frontal cortex and anterior ventral insular cortex, which are activated when we refrain from acting on decisions taken on a conscious level by the brain. This is very important in terms of adaptation, and in evolutionary terms it is subject to strong selective pressures; it is easy to imagine the fate that would befall a person who couldn't retract their decision to attack an unexpectedly large animal, or to step onto a road while a car is fast approaching.

From euphoria to fury

Free will and rational assessment of facts act as brakes for emotional actions rooted in impulse or obsession, commonly referred to as madness or passion. The definitions encompass many different types of behavior, from creative euphoria to bouts of fury. The Ancient Greeks, as we have noted, distinguished two types of madness which happen to correspond fairly closely to findings of contemporary neurobiology. These were mania – a frenzy with religious undertones – and lyssa – a mad fury with martial connotations. Today, we tend to describe violent behavior in terms of cool aggression vs. emotional aggression. Cool aggression is required during activities such as hunting; since its specific aim is to obtain food, it does not tend to be linked with intense emotional experiences. The other type of aggres-

sion is closer to the commonly-understood concept of passion, which tends to have a powerful emotional involvement, such as violence triggered by social interactions. Allan Siegel's classical experiments in cats show that the two types of aggression can be triggered by stimulating different regions in the brain. Cool aggression arises as a result of stimulating the ventromedial nucleus, while emotional aggression follows stimulation of the upper part of the periaqueductal gray and the medial part of the hypothalamus. Curiously enough, the neuronal systems inhibit one another via GABAergic links, meaning that cool aggression blocks emotional aggression and vice versa. In cats, for example, stalking a mouse would be an example of cool aggression, whereas attacking another cat trying to snatch the trophy away would be emotional aggression.

Chemistry of aggression

We have also learned quite a great deal about the neurochemistry of aggression. The two key hormones are serotonin and testosterone, with serotonin linked to impulsive behavior, and testosterone to group hierarchy and the need for domination. In people with clear violent tendencies, we observe significantly higher levels of testosterone, regardless whether they are young children or convicted criminals. Testosterone has been studied extensively, since its levels are easily measurable in saliva, making collecting samples very easy. One notable study was conducted in female prisoners in a high-security prison in the US. The highest levels of testosterone were indeed found in the most aggressive prisoners; however, those described by guards as "cunning" or "sneaky" and not openly violent, had lower levels of the hormone. The example demonstrates that there are many different facets to aggression, not always as obvious as physical force: it may manifest itself as psychological harassment, or even as covertly making life difficult for someone we do not like.

Although measuring serotonin levels is more difficult, we do know that the hormone controls impulsive behavior, and its reduced level in the brain is associated with triggering such actions. Serotonin levels in the brain can be lowered by administering a blend of amino acids that excludes tryptophan – the main precursor of serotonin in the brain. Within a few hours of ingesting such a mixture, aggression levels in subjects increase notably. Low serotonin levels in the brain foster emotional aggression, observed in various types of disorders. The hormone can be partially controlled with prescription psychotropic drugs and selective serotonin re-uptake inhibitor (SSRI) type antidepressants. One substance effective in reducing both aggression and anxiety is the beta blocker propranolol, a drug commonly used in the prevention of heart attacks. A dose four times lower than that prescribed to cardiovascular patients tends to be sufficient to calm the nerves; it can be used to combat stage fright in actors or prevent tremor in marksmen, since it does not diminish thought clarity in a way that classical sedatives do. In the majority of cases, sedatives such as benzodiazepines do not lower aggression, since they inhibit processes in the cerebral cortex. In a way, they "switch off" regions linked with conscious behavior control, which is why patients who take them have a tendency to act impulsively – an effect similar to that of alcohol.

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Emotional aggression is closely linked with social interactions, such as establishing hierarchies or competing for females. In many species, such as felines, it can involve direct conflict

Why the need for aggression?

Aggression has an adaptive significance, which may be why it is often accompanied by feelings of pleasure. Deliberate actions that harm others may increase the individual's own chances of survival, given that organisms compete with one another for limited resources. Echoes of these relationships continue to resound in our own species, even though much has changed since the first *Homines sapientes* walked the Earth. In the earliest days, humans lived in small groups of between 10 and 30. In order to survive, individuals in each group had to work closely together and respond aggressively to any external threats, including those from other humans. The development of civilization had a dramatic effect on these conditions: we now live in congregations numbering thousands, even millions, and although the ancient mechanisms have lost much of their significance, their traces remain in xenophobic attitudes and the tendency of young men to get involved in fights. In any case, higher levels of aggression in males are not exclusive to our species, and they are associated with the need to compete for females. Since producing offspring is a major burden, before choosing a partner, the female needs to be sure that the future father will pass on the best possible genes to their progeny. This makes females very picky; they strive to mate only with partners who are able demonstrate their superior attributes, for example by fighting and defeating others. In many cases, the combat is ritualized, since its aim is not to actually kill or even maim the opponent, but rather to prove the victor's dominance and to gain the approval of the female. One means of channeling the natural desire for aggression in human societies during peacetime is sport, which provides a compromise between permitting confrontation and avoiding the negative consequences of genuine combat.

Although aggression is natural in and of itself, and in many cases brings tangible biological benefits, the frequency and intensity of these types of interactions are tempered by cultural and social norms. In the Yanomami tribe in Brazil, for example, the respect awarded to individual men is related to the number of individuals they have killed. This marks it as an extremely violent group that selects in favor of aggression, with not many members surviving much beyond the age of 30, simply because older individuals are easier to defeat. On the other end of the spectrum are the Semang tribes of the Malay Peninsula, who were reported not to even be capable of expressing the notion of "killing someone" in their native languages. Yet when the conflict of WWII reached the remote community during the 1940s, the arriving British soldiers trained the locals to fight Japanese forces on their behalf. The Semang were rapidly transformed into extremely aggressive, unstoppable soldiers, as though all cultural restraints had suddenly been lifted.

It is also notable that aggression is frequently associated with the seemingly opposite trait of empathy. The two types behavior are especially marked in females caring for their offspring: the maternal instinct manifests as formidable aggression towards anyone or anything perceived as a threat to the young. This can even be observed in females of species generally regarded as docile, such as deer. In human societies, the intertwining of the two emotions has echoes in criminal law, where our sympathy for victims often goes hand in hand with the desire to take retribution on the perpetrator. Cultural differences also play an important role: prisons in Scandinavia are frequently seen as far too lax and comfortable by people in other parts of the world, yet the conditions endured by prisoners in some countries in the Middle East are regarded as unacceptably cruel by Western societies. It is clear, then, that empathy and violence are subject to cultural factors, and natural behaviors are shaped by social norms. ■

Further reading:

Soon C.S., He A.H., Bode S., Haynes J.D. (2013). Predicting free choices for abstract intentions. *Proc Natl Acad Sci USA*. Apr 9; 110 (15):6217-22. doi: 10.1073/pnas.1212218110.

Gregg T.R., Siegel A. (2001). Brain structures and neurotransmitters regulating aggression in cats: implications for human aggression. Prog *Neuropsychopharmacol Biol Psychiatry*. Jan; 25(1), 91-140.

Vetulani J. (2013). Neurochemia impulsywnosci i agresji [Neurochemistry of impulsiveness and aggression]. *Psychiatr Pol*. Jan-Feb; 47(1), 103-115.