

Some suggestions for revitalizing aggression research

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Abstract. Aggression research is moribund. Lack of research over the past two decades has left many issues. (1) Understanding varieties of agonistic behaviour in an ethological context: categories differing in behaviours, target sites and function include offence, defensive attack, and predation. Biological systems must be determined for each of these. (2) Insuring availability of ethologically valid laboratory models of agonistic behaviour and describing (possibly species-specific) standards for these. We shall present models and consider the problematic issue of biting. (3) Use of non-damaging behavioural markers that precede fights. These should be independently analysed, measured and verified as potential substitutes for biting attack. (4) Interaction between fear and offensive aggressive motivation systems must be understood in order to evaluate whether independent variable (e.g. pharmacological, genetic) effects involve a specific motivational system rather than reflecting changes in oppositional systems. (5) Knowledge of agonistic systems and their biological basis must be extended to humans, focusing on both normal aggression in each category, and the development of models of aggressive psychopathology. Placing aggression research in an ethological context and focusing on its biomedical relevance may help to counter forces suppressing this work.

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Basic research in aggression: a dying field?

It is a considerable irony that during the past 30 years, a period in which problems of interpersonal and group violence in real world settings have come more and more strongly to the attention of the public and the media, the relative attention of the scientific community to basic experimental research on aggression has sharply declined. This statement is based on data for research on the three rodent

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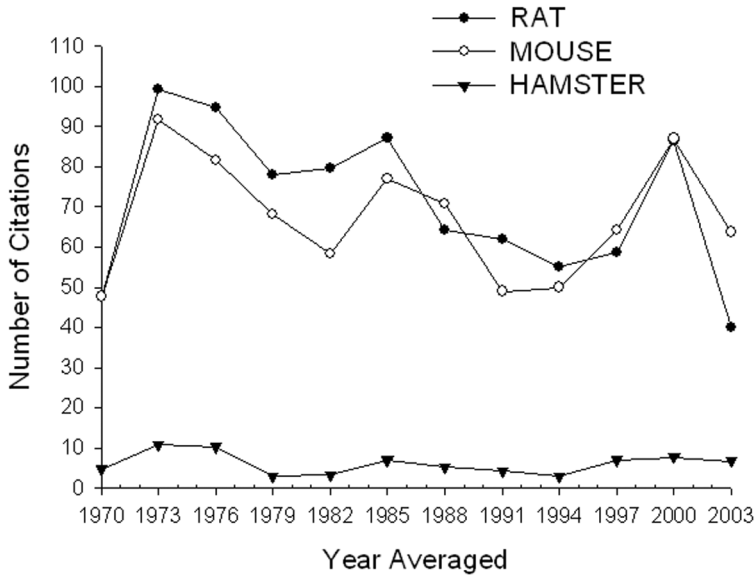


FIG. 1. Average number of citations per year from PubMed during successive three-year periods, retrieved in response to search terms 'aggressive behavior AND rat' ('... AND mouse' or '... AND hamster').

species that are used as subjects of most experimental aggression experiments: PubMed citations appearing in response to the search terms 'aggressive behaviour' and 'rat' (or mouse, or hamster) during three year periods from 1970 to 2000 indicate that citations for rats and mice are about equal, and appear to reflect a peak in the early 1970s followed by a slow decline. Hamster studies, fewer in number, remained relatively steady over this period.

In contrast to this steady state, comparable figures for studies of sexual and stress-related behaviour for the same three species of laboratory animals indicate a sharply increasing trend over the same period. Although both areas received attention comparable to that of aggression research in 1970, studies of sexual behaviour have since almost tripled, and stress-related behaviour increased nearly 20 times. Thus, on a baseline of activity in comparable areas of behavioural research, it can be seen that aggression research has substantially declined over the past 30 years. The comparison with stress research is particularly interesting, as increased restrictions on animal research involving aversive events might be blamed for the decline in experimental aggression work. However, the striking increase in rodent research on stress indicates that, although restrictions on animal research may have exerted considerable inhibitory influence overall, they

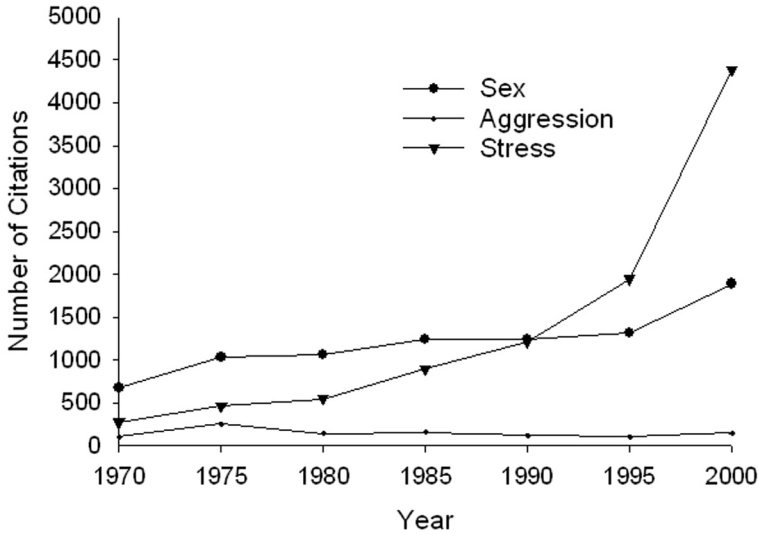


FIG. 2. Total number of citations per year for index years (1970, 1975, etc.) retrieved from PubMed in response to search terms ‘stress AND rat’ (‘... AND mouse’ or ‘... AND hamster’... summed over the three species), and for ‘sexual behavior AND rat’ (‘... AND mouse’ or ‘... AND hamster’... summed over the three species). These are shown in comparison to data for ‘aggressive behavior AND... representing summed data over the three species from Fig. 1.

do not appear to have served as a specific and differential inhibitor of work involving response to stressful or provocative conditions.

Finally, while the absolute numbers of aggression studies involved may seem adequate even if suffering in comparison to other areas, these numbers provide an overestimation of the magnitude of true aggression research. Individual analysis of citations for a single year (2000) indicated that only about 24% of the studies retrieved by this search — some 36 studies for the year 2000 — contributed directly and empirically to our knowledge of offensive aggressive behaviour in the three laboratory species in which it has been best and most thoroughly analysed.

What is aggression, and why should it be studied?

Aggression is something of a ‘catch-all’ term for several types of evolved behaviours (Blanchard et al 1999). Like other evolved behaviour patterns, these behaviours are adaptive under a range of circumstances, but may be maladaptive in other situations. Analogously, evolved appetites for fats and sugars are adaptive when these nutrients are in relatively short or sporadic supply, but may result in

widespread obesity and other health problems when such food items are abundant. Evolved behaviours also involve underlying brain and neurochemical systems, and additional problems may occur when these are hyperexpressed, resulting in pathological manifestation of behaviour; too much, too poorly controlled, or in the wrong situation (Marks & Nesse 1994). As will be detailed later, one variety of aggression — offensive aggression — is particularly sensitive to its own consequences, in the form of behaviour change on the part of the opponent. This sets up conditions for it to serve as an operant; offensive aggression increases when it is reinforced, leading directly to functions that are sometimes grouped under the rubric ‘instrumental aggression’ and providing for another avenue by which aggressive behaviour can become problematic. Finally, there is the problem of group aggression. This is a relatively rare phenomenon in other mammalian species, showing, however, a clear increase in larger-brained primates and reaching extraordinarily high levels in people. In combination with other factors such as the sensitivity of offensive aggression to successful consequences, and technological enhancement of the capacity of aggressive behaviour to cause damage, group aggression has been a prominent problem throughout human history (Keeley 1996).

This problem, that hyperexpressed and damaging aggression is common in human societies, constitutes one important reason for studying aggressive behaviour. The second is simply that aggression, even when normal and adaptive, includes several deeply interesting examples of evolved behaviour patterns that are simultaneously highly responsive to antecedent circumstances and to their own consequences. These patterns may be common across mammalian species, but there are important differences from one species to another in when, how, and to what effect the various types of aggression are expressed. All varieties of aggression known in inframammalian species are found in people, and the brain systems and behavioural budgets of both human and non-human mammals devote an extraordinary amount of space or time to them. They are worthy of study.

Aggression systems

In summary of material that is available in much greater detail elsewhere (e.g. Blanchard et al 1999), there are at least three major types of aggression in mammals: offensive aggression, defensive aggression and predatory aggression. Other categories, such as ‘play fighting’ or ‘maternal aggression’ have been proposed, but these either fit into one of the three rubrics given above (e.g. ‘maternal aggression’ may consist of both offensive and defensive attack components) or, as with play fighting, resemble aggression only superficially. Thus play fighting in rodents does not include hard bites, and it occurs in the

context of amicable relations between the 'opponents' both pre- and post-encounter (Pellis 1988). Predatory aggression may be included under the rubric of aggression on the basis that it involves harm to the opponent. However, it is very different from both offensive and defensive attack in being aimed almost exclusively at non-conspecifics, and in being absent in many mammal species. While paradigms involving attacks by predators on animals of prey species, e.g. mouse- or frog-killing by rats, and insect-killing by mice (Karli 1956, Brain 1979) have sometimes been used to measure aggression, this is becoming increasingly rare. There is an emerging consensus that predation is very different from offensive and defensive attack on grounds of its core motivations and its relationship to aversive emotions and emotional arousal (see Blanchard et al 1999 for review), not to mention that human predation on prey animals is seldom regarded as constituting a social problem. For all these reasons, the study of predation is seldom grouped with work on other forms of aggression.

Offensive and defensive aggression

These comments will focus on offensive and defensive aggression, as reflecting two fundamental divisions of 'serious' aggression. The distinction between offensive and defensive aggression is based on a number of aspects of behaviour, including antecedent conditions, organismic variables, response topography and typical outcomes (Blanchard & Blanchard 1977, Brain 1979, Blanchard et al 1999). In terms of antecedents, offensive aggression involves response to challenge over adaptively important resources, whereas defensive aggression is attack in defence of the subject's own bodily integrity. Defensive attack may be seen to either attacking non-conspecifics, typically predators, or to attacking conspecifics. It is embedded in a larger pattern of defensive behaviours and, depending on species and circumstances, may or may not occur in a particular instance of defence against attack. It thus constitutes one component of a larger defence pattern, whereas offensive aggression stands alone.

With reference to the behaviours involved, within-species offensive and defensive aggression involve potentially damaging attack targeted towards specific areas on the body of a conspecific opponent. The targets for these two types of aggression are different. For rats and mice, conspecific offensive attack is targeted toward the back and flanks of the opponent while defensive attack is targeted at the snouts of both conspecifics and predators (Blanchard et al 1977a, 1980, Blanchard & Blanchard 1977). These patterns appear to be quite similar in wild and laboratory rats and mice, although some non-attack components of the defence pattern (notably freezing) have been altered by domestication (see Blanchard 1997 for review). In hamsters, the rump (lower back) and lower flanks are the targets of offensive attack (Pellis & Pellis 1988), but targets for defensive

TABLE 1 Target sites for conspecific offensive attack

<i>Attack site (%)</i>	<i>Rat</i>	<i>Mouse</i>	<i>Hamster</i>
Head	7.24	1.82	0.21
Back	88.62	78.67	78.27
Ventrum	0.00	10.29	19.65
Limbs	4.14	8.88	1.35
Genitals	0.00	0.00	0.52
Tail	0.00	0.34	0.00

attack have not been described. All of these targets apply to unanaesthetized conspecific opponents, animals that are able to display behavioural defences, and the defences of the opponent may have a considerable influence on target sites for attack (Blanchard et al 1977b).

These target sites are important for an understanding of both conspecific offensive aggressive and conspecific defensive behaviours, in that conspecific defensive behaviours are organized to protect the target site for offensive attack by making it unavailable for biting; in turn these defences strongly influence the offensive tactics used to gain access to these sites. In rats and mice defence against attacking conspecifics includes flight, freezing (a lot in laboratory rats, some in mice), manoeuvres to protect the specific targets of offensive attack, and defensive threat and attack. The target site-protecting manoeuvres include postures in which the defender faces the attacker, often in an upright defensive stance from which it may pivot easily, to continue to remove its back and flanks from the attacker, and lying on the back. Offensive attack behaviours consist of movements enabling the attacker to thwart these defensive behaviours, such as a 'lateral' approach to an upright defender, that involves moving forward and around it to bite at the flanks and back (Blanchard & Blanchard 1977, Blanchard et al 1979, Pellis & Pellis 1988).

The problem of 'animal cruelty': bites and wounds

The dynamics of these patterns make it comparatively easy to differentiate offensive and defensive attack in laboratory rodents on a purely behavioural basis, without prior knowledge of the antecedent conditions and history of the animal. They may make it possible to differentiate these patterns, and even to measure the intensity of attack, without permitting the actual damaging component of attack, the bite, to occur. Can offensive aggression be measured through ancillary behaviours such as piloerection of the subject or spacing by the opponent, or defensive attack by its

accompanying threat behaviours (defensive upright postures, defensive vocalizations)? Animal research on evaluation of aggression by analysis of non-damaging elements is very much needed, as public abhorrence of what is seen as animal cruelty is an important reason for reductions in experimental work in this area.

An additional contribution to the problem of perception of ‘cruelty’ may include analysis and dissemination of information on the actual consequences of ‘bites’. These represent the only component of attack in rodents (and most other mammalian species) that is capable of producing substantial tissue damage to the opponent. However, bites are not wounds. In recent hamster studies we noted that bites, measured directly by observation, were much more common than were actual wounds, evaluated on the same day, after the animal was sacrificed and completely denuded of hair. A follow-up study in mice confirmed this, that only about 1 bite in 10 actually cuts or tears the skin. The others appear to constitute a pinch—doubtless startling and sometimes painful, but different than what is commonly accepted as the consequence of being bitten. A more appropriate label for these, when cuts are not involved, might be ‘toothpinch’ or ‘pinch-vocalization’ when the defending animal vocalizes in response.

Aggressive and defensive motivations: unravelling a complex interaction

As an adaptive behaviour, aggression is facilitated by circumstances predicting that it will be successful (e.g. location in subject’s own territory, weak opponent); and inhibited when it is likely that the animal will lose (e.g. following defeat: Scott 1966, Huhman et al 2003). Losing involves a strong potential for body harm, and the emotional response to this possibility, defensiveness, exerts a strong inhibitory influence on the expression of offensive aggression. Because defence is a particularly salient neurobehavioural system in rodents, genetic, pharmacological and experiential manipulations that alter offensive attack may work through defence as easily, and with as much potency, as through a direct effect on aggression itself. (Notably, this is not true of defensive aggression, e.g. Blanchard et al 1980, potentially providing an additional means of differentiating the two.)

These effects on defence may come from many sources. In addition to conspecific defeat, and response to predators or other threat features of the situation (e.g. novelty), defensiveness can be changed by genetic or pharmacological manipulations, strongly but indirectly impacting offensive aggression. Individual differences factors impacting human aggression may also operate through inhibitory systems (Brennan et al 1997). The effect of defensiveness on offensive aggression may be very situation-specific, depending on the level of threat

initially engendered by the situation and opponent; the capability of the opponent to retaliate; and whether general defensiveness or specific aspects of defence have been enhanced or reduced by relevant manipulations. If the situation or manipulations used produce defensive attack, there is also the question of differentiating this from offensive aggression. At present, there are relatively few guidelines for such analyses, although studies specifically directed at analysis of antiaggression drugs have at least recognized some of the problems involved (e.g. Olivier et al 1994).

The problem of fear–aggression interactions is particularly damaging in view of a strategy increasingly used to avoid animal cruelty issues—measurement of aggression by a single measure, latency to attack. The behavioural inhibition associated with enhanced defence is virtually guaranteed to enhance latency to first attack. One analytic strategy may be to measure other fear-affected latencies, e.g. to copulation with a strange but receptive female, or eating in a novel situation. If they also increase, increased latency to attack cannot be interpreted as reduced aggressiveness. However, this is only a partial solution, and aggression research badly needs an algorithm for differentiating effects on aggressive motivations from changes in defensiveness. While it is probably too early to think about standardizing animal aggression protocols, a less formalized group of ‘attention points’ for designing and analysing such studies would be useful.

The fit between animal and human aggression

While attention to the above issues would undoubtedly improve animal aggression research, there is a remaining and substantial problem concerning its relationship to aggression in people. Animal–human behavioural correspondences always involve tricky issues, but these are particularly acute in the case of aggression. First, there have been a lot of exaggerated claims about the degree to which animal findings are relevant to people, creating a poor atmosphere in which naïve acceptance of such claims is mixed with suspicion regarding the relevance of all such findings. Unfortunately, this situation is reinforced by a lack of communication between researchers of animal and human aggression phenomena.

It should and must be acknowledged that, currently, there is only a limited range of human phenomena to which results of animal aggression research can be directly, legitimately and meaningfully applied. This does not mean that the potential for finding cross-species similarities in aggression is especially limited, but simply that we don’t have an adequate data/analysis basis for evaluating them. What is needed—in addition to a resurgence of both laboratory and field work on aggression in animals—is, first, more research into the dynamics of human aggression and, second, research bridging the human–non-human

mammal gap, to show both the extent and the limitations of using animal models to explain human aggression.

In addition to scientific rigour and creativity, these attempts will also involve a need for great sensitivity on the part of the research community. Aggression is a stigmatized activity, but intentions to control it are regarded with deep suspicion, particularly in the USA with its explicit emphasis on individuality and civil liberties. This constitutes double jeopardy for the researcher trying to understand aggression and to gain some insights into its legitimate and illegitimate functions in contemporary society. While a daunting picture, it nicely illustrates the point that the opposition to research is often directly proportional to its importance. Aggression research is important, and we need to get back to it.

References

- Blanchard DC 1997 Stimulus and environmental control of defensive behaviours. In: Bouton M, Fanselow M (eds) *The functional behaviorism of Robert C. Bolles: learning, motivation and cognition*. American Psychological Association, Washington DC, p 283–305
- Blanchard RJ, Blanchard DC 1977 Aggressive behavior in the rat. *Behav Biol* 21:197–224
- Blanchard RJ, Blanchard DC, Takahashi T, Kelley M 1977a Attack and defensive behavior in the albino rat. *Anim Behav* 25:622–634
- Blanchard RJ, Takahashi LK, Fukunaga KK, Blanchard DC 1977b Functions of the vibrissae in the defensive and aggressive behavior of the rat. *Aggress Behav* 3:231–240
- Blanchard RJ, O'Donnell V, Blanchard DC 1979 Attack and defensive behaviors in the albino mouse (*Mus musculus*). *Aggress Behav* 5:341–352
- Blanchard RJ, Kleinschmidt CF, Fukunaga-Stinson C, Blanchard DC 1980 Defensive attack behavior in male and female rats. *Anim Learn Behav* 8:177–183
- Blanchard DC, Hebert MA, Blanchard RJ 1999 Continuity vs (political) correctness: animal models and human aggression. In: Haug M, Whalen R (eds) *Animal models of human psychopathology*. American Psychological Association, Washington DC, p 297–316
- Brain PF 1979 Differentiating types of attack and defense in rodents. In: Brain PF, Benton D (eds) *Multidisciplinary approaches to aggression research*. Elsevier/North Holland, Amsterdam, p 53–77
- Brennan PA, Raine A, Schulsinger F et al 1997 Psychophysiological protective factors for male subjects at high risk for criminal behavior. *Am J Psychiatry* 154:853–855
- Huhman KL, Solomon MB, Janicki M et al 2003 Conditioned defeat in male and female syrian hamsters. *Horm Behav* 44:293–299
- Karli P 1956 The Norway rat's killing response to the white mouse: an experimental analysis. *Behaviour* 10:81–103
- Keeley L 1996 *War before civilization*. Oxford University Press, Oxford
- Marks IM, Nesse RM 1994 Fear and fitness: an evolutionary analysis of anxiety disorders. *Ethol Sociobiol* 15:247–261
- Olivier B, Mos J, Raghoobar M, de Koning P, Mak M 1994 Serenics. *Prog Drug Res* 42:167–308
- Pellis SM 1988 Agonistic versus amicable targets of attack and defense: consequences for the origin, function, and descriptive classification of play-fighting. *Aggress Behav* 14:85–104
- Pellis SM, Pellis VC 1988 Play-fighting in the Syrian golden hamster *Mesocricetus auratus* Waterhouse, and its relationship to serious fighting during postweaning development. *Dev Psychobiol* 21:323–337
- Scott JP 1966 Agonistic behavior of mice and rats: a review. *Am Zool* 6:683–701

DISCUSSION

Keverne: You showed data illustrating the area of the animal's back which was attacked: were these proportions or absolute numbers?

R Blanchard: Proportions.

Keverne: So did the wild-type animals show the same amount of aggression in total? Were there more attacks by the intruder rather than a different amount of total aggression?

R Blanchard: The surprising thing is that in terms of offensive aggression, when we work with wild rats we see roughly equivalent levels of attack behaviour as we do with laboratory Long Evans rats.

Keverne: On one of your charts there weren't any data for wild-caught animals. Were there no attacks on the head? If so, what does this tell you about alpha-rating males in the wild?

R Blanchard: In the snap-trapped animals we saw head wounds on some, but only a few, and they far fewer than the number of back wounds. This distribution is similar to what we get in groups in laboratory settings, and suggests that the same sort of thing occurs in the wild as in the lab.

C Blanchard: I should mention that these animals were trapped in sugar cane fields in Hawaii. This is fertile breeding ground for wild rats. Every two or three years these fields are burned before the sugar is harvested. These poor rats have no place to go when the fire comes so they run into adjacent areas, and the places we trapped were in the adjacent areas right after the burning took place. These animals would have done a lot more fighting than normal because in their flight they would have run into someone else's territory. Some proportion of the trapped animals would have been the territorial rats and others the invaders. We assume that animals with largely head wounds are likely to have been the territory holders, and those with back wounds the intruders. Overall, however, the head and back wound proportions are fairly close to what you get in laboratory colony situations.

Hinde: You rather dismissed play fighting, and it comes outside your definition of aggression because it isn't 'intended' to hurt. But it is a way of isolating parts of the motor patterns of fighting from the other sorts of motivational bases. It might be interesting from this point of view.

R Blanchard: Indeed it might. The work relevant here is that of Sergio Pellis (Pellis & Iwaniuk 2004) who has been looking precisely at the motor patterns involved in play, and their development. He has looked at their relationship to adult sexual and aggressive behaviour. At least for some species he suggests that the motor systems that seem to be prepared more heavily in play fighting may actually be sexual.

Suomi: The situation may be different in primates. It is premature to dismiss it across all species. Along the same lines, there is another form of behaviour for

which the term 'aggression' has been tagged on, and this is self-injurious behaviour or self-aggression. There the distinction between biting and wounding may be as relevant as in the case you described here.

R Blanchard: One thing we need to understand more clearly is that biting may be inhibited. Whenever a male bites a female who is not receptive, for example, we see clear biting but never wounding. Often biting is inhibited. If we could measure the intensity and the severity of the bite without looking for lesions this would be helpful. I know that in play fighting, certainly, there is inhibition of biting which changes to more injurious biting at a certain age. I accept that it is wrong to totally eliminate play fighting in all species.

Nelson: In terms of developing alternative descriptors, do you know of a lesion or drug that would take out piloerection but not affect attack, for example?

R Blanchard: I should know, but I don't. My concern about piloerection is that we are only just developing techniques of measuring it more precisely with our cameras. When I was working with super 8 mm film or standard videotape, piloerection was very difficult to score. We could do it only by live scoring.

Olivier: I have never seen a drug that wipes out piloerection and allows the animal to still perform aggressive behaviour. It doesn't seem to be a pure autonomic response.

Martinez: You proposed ways of finding alternative models for studying aggression in animals. In humans obviously it isn't possible to put two people together in order to let them fight and kill each other. So we find a way of obtaining some information, using paradigms in which individuals can display their readiness to behave aggressively without real aggression. Do you think this would be possible in animals?

R Blanchard: For example, could I develop a model of aggressive arousal by the use of piloerection? It might be possible, and this is something that is being worked on. Is it going to be the same thing as a real fight? I don't know. One is the question of arousal; the other also involves the motivation, motor patterns and so on. We are always going to have to bring the two into some relationship. We'd like to do this in the human work, too. Doing human ethology of real aggression is one of the most challenging problems and has rarely been done.

Koolbaas: It occurs to me that part of the problem with society is due to the very old definition of aggression, which is inflicting harm on another. This neglects the idea that aggression is a highly functional form of communication with strong inhibitory control for the adverse effects of wounding. Using aggressive behaviour, animals are trying to tell each other something. In my view, we have to make a distinction between the functional form of aggression (as a form of social communication) and violence, which can be considered as the pathological form of uncontrolled aggression. The human studies are mainly involved in violence, the

pathology. However, most of the animal studies are aimed at the functional social communication form.

Olivier: When we tried to develop these anti-aggressive drugs in the 1970s and 80s we thought that there were systems in the brain involved in aggression, and pathology in humans could be due to excessive activity in these systems. We tried to get this concept into human aggression research, but this failed. We wanted to develop drugs for treatment and this failed because psychiatrists can't believe that aggression is a disease. We had to go for depression or anxiety instead. Do you think that in humans aggression and violence are due to the activation of specific neural systems or are they secondary effects? This is the question we never solved.

R Blanchard: The answer is both, but I am committed to the notion that there is a neurobehavioural system for offence which in humans reflects the same sociobehavioural systems in anger. I certainly think that there is a neurobehavioural system for anger. The issue concerns what psychiatric syndromes we have involving anger dis-control. Depression is one.

Olivier: Is it depression which steers aggression or the other way round?

R Blanchard: I don't know. The trouble with the current techniques for psychiatric diagnosis is that they largely focus on syndromes rather than symptoms. It is therefore difficult to parcel this out. We need a better characterization of the specific psychopathologies that are related to anger. This is one of the problems that are understood at the NIH. We need a symptom-based rather than syndrome-based description of psychopathology.

Skuse: I am a child psychiatrist, and I am interested in aggression in relation to social mis-perception. Many children we see who are aggressive appear to show these aggressive responses because they mis-perceive cues that other children are displaying. These might be facial expressions. If someone is looking angry when you are talking to them most of us would probably recognize that we should back off. Among children with autism spectrum disorders in particular, we find the perception of these cues is impaired. This is often how they get into fights. There is not necessarily any innate aggression in many of these encounters, but the situation can escalate to the point that the child has to be removed from a social situation, such as school. Preliminary work of ours suggests that this problem could be so widespread that it underlies many cases of so-called 'conduct disorder' (Gilmour et al 2004). This is one of those wonderful psychiatric definitions of a 'syndrome' that is actually a description of a collection of behaviours, which may have a heterogeneous aetiology.

Suomi: In many of the primate groups we have been observing we have been struck by what appears to be social ineptitude displayed by certain individuals. They apparently are not very good at perceiving social cues and responding appropriately when they receive feedback in a potentially ambiguous situation. Their behavioural output would be described as aggressiveness, but rather than

consider it to be an innate quality, it seems to be more a lack of social recognition and an inability to read signals that other individuals read routinely and accurately.

Skuse: David Amaral at University of California Davis has also been studying social misperception in primates (Amaral & Corbett 2003). He is particularly interested in amygdalotomized animals, and the way that this affects their social behaviour.

Pfaff: In certain streets in New York, eye contact held for milliseconds too long can lead to murder among ‘normal’ individuals.

Skuse: Eye contact is fascinating. It appears to be a very potent stimulus for alerting this amygdala-related circuit that David Amaral is so interested in (Morris et al 2002). We have discovered during studies of normal individuals by functional magnetic resonance imaging (fMRI) that one can get a threat response, as measured by increased skin conductance, just by showing stimuli that are equivalent to eyes, even if these are not eyes that are in a face. Two dots in an abstracted form of threat cue will provoke such a response (J. Morris & D. Skuse, unpublished data). Fear recognition, from another’s face, appears to predict differences in social cognitive competence, at least in males, and has predictable neural correlates (Corden et al 2005). There may be subcortical pathways (Pasley et al 2004) that mediate such responses in humans that are normally controlled by prefrontal cortical mechanisms (Holland & Gallagher 2004). Cortical mechanisms can inhibit this response rather rapidly after it occurs. If this inhibition should be compromised for some reason (for example, because of alcohol intoxication), then inappropriate aggressive (in the sense of defensive) behaviour may result.

Brodakin: IACUCs (Institutional Animal Care and Use Committees) are understandably concerned about injury to animals during the course of aggression testing, although you’ve presented data demonstrating that injury is rare. But I wonder whether studies of ‘pre-bite’ behaviours alone (e.g. piloerection, threat behaviours, or tail rattling) can serve as adequate substitutes for studying bite behaviours. Is it possible that these pre-aggressive threat behaviours may have a somewhat different underlying biology from the actual bite behaviours? Might there be certain individuals whose ‘bark is worse than their bite’ — who do a lot of threatening but don’t progress to attack?

R Blanchard: You have hit on a major point. We are working on systems that are oppositional. The defence systems are opposing the offence systems. The two are always in conflict. If I want to use piloerection as a measure of aggression, I have to use it in an animal that is highly experienced and is clearly primarily offensive and not showing very much in terms of defensive behaviour. Such measures have to be used cautiously.

C Blanchard: If you pre-test Long Evans rats for aggressiveness and then put them all together in a visible burrow system with females, they quickly start

fighting and form a dominance hierarchy within the first couple of days. There is little or no relationship between the latency to first attack and who becomes dominant. The one who *persists* in the individual pretests is usually the one who in a visible burrow system becomes dominant. Thus there are going to be some real problems translating the preattack measures, such as latency to first attack, into other more comprehensive measures of aggression. However, the value of such preattack measures also depends on what you are using them for. Perhaps you are not interested in who is going to become dominant; you are just interested in this first, immediate system and how it may interact with fear or behavioural inhibition.

Brodkein: Some IACUCs allow observation of pre-bite behaviours and one or two bites, but are less comfortable with allowing the aggressive behaviour to go on past the initial attack. But it seems to me that the transition from threat to the initiation of attack (e.g. first bite) is important and very much worthy of study. In clinical psychiatry, patients may get angry and may threaten, but the transition from threatening behaviour to actual harming behaviour of self or others is critically important.

Pfaff: With hamsters the first bite is crucial in terms of the resulting ethogram.

R Blanchard: The first bite is critical, but if you let the encounter run for a bit, you may see that some drugs affect the latency of bite but may not primarily be doing this through offence; they may be acting on defensive behaviour. This is frequently our problem with the initial stage measures.

Moreover, we do feel that some further attack behaviours can be permitted without abuse or cruelty. For example, we need to explain to IACUCs that what is frequently termed a 'bite' is actually measured when one animal contacts another with its snout and the latter vocalizes. In reality most of these 'pinch/vocalizations' do not result in wounds. IACUCs tend to equate the 'bite' measure with bloody wounds, and this is far from the truth. We are suggesting that conspecific aggression is an evolutionary punishment rather than a murderous social strategy.

Ferris: The communication component in the initiation of violence is extremely important. We illustrated this in a simple hamster model. Hamsters rapidly develop dominant-subordinate relationships with a minimum of attacks. Initially, there is intense overt aggression characterized by bites and attacks; however, on subsequent encounters there is little if any fighting. For months afterwards they communicate their social status with no aggression. They communicate through a behaviour called flank marking. They have pheromone-producing glands on their sides that they use to scent mark their environment as a form of olfactory communication. If you remove the flank glands from either the dominant or submissive animal they are unable to communicate. Consequently, whenever they encounter each other they fight. The outcome is always the same — dominant animals do all of the biting and attacking while the submissive animals try to run away. Once the lines of communication are broken the level of

aggression is elevated. This would appear to be true in humans. I canvassed psychiatrists, asking them about where aggression and violence fit in serious mental illness, and most everyone agrees it is secondary to a primary mental illness. As you move across the spectrum of normal behaviour to severe mental illness where do you cross the line? To the clinicians, the tell-tale signs are agitation, impulsivity and the inability to communicate. In this meeting we should keep this cognitive component of communication in the mix, as we try to translate from the animal models to humans.

Pfaff: Applying your thinking to reproductive physiology, hamsters are a species where a non-receptive female can beat up a male to the point of killing him. How many other mammalian species are like this? What about dominance in rhesus monkeys?

Suomi: It depends on the situation, but there are instances where young males who seem to be inappropriately aggressive are targeted by high-ranking adult females, with the apparent intent of driving those young males out of their social group prematurely. These females are often successful. In some cases they kill the young male in the process.

Koolhaas: The approach we take now is to try to define the rules of the game. Aggressive interactions are heavily guided by rules. By analysing action–reaction patterns we aim at defining when the behaviour becomes pathological. We try to identify which individuals, in which situations, don't play the rules of the game anymore. We have individuals who are inclined to develop violent types of aggressive behaviour in which they no longer respond to (submission) signals from the opponent. I think the pathological form is completely different from the normal functional social communication patterns. The task is to find the rules of the game.

Manuck: There is some recent work on Intermittent Explosive Disorder (IED) related to social information processing in aggressive behaviour that may be relevant here (Best et al 2002). IED patients exhibit impaired recognition of facial expressions conveying emotion and show a strong preference for immediate (over delayed) rewards in simulated gambling experiments rigged to render such choices disadvantageous. One speculation is that these deficits arise from dysfunction of inhibitory connections between orbitomedial prefrontal cortex and the amygdala. Since there are two components—impulsivity and a failure to read social cues—do these patients show primarily an inability to process socially relevant information, or are they just too impulsive to do so in certain circumstances?

Skuse: The ability accurately to interpret these cues is distributed non-normally in the general population (Lawrence et al 2005). There are many of us who are pretty poor at it. If we also happen to have impulse control problems, we could be vulnerable to these sorts of outbursts. However, impulse control and the ability

to read social signals are two different processes, and deficits in them do not necessarily coincide (Geurts et al 2004).

Craig: Has ADHD been looked at in terms of the inability to perceive social cues?

Skuse: Not as systematically (e.g. Cadesky et al 2000). Even in autistic children, the work has until now been confined to rather small groups, many of whom have had learning difficulties. Studies of children with autism with normal-range intelligence are lacking. Where it is pretty clear that they do have problems reading social cues, the exact nature of these problems at a neural level, and the extent of their impairment, is not yet known although progress is being made (Insel & Fernald 2004).

Pfaff: James Swanson at the University of California Irvine has studied large samples of ADHD children. He says that in boys but not in girls there is a large degree of co-morbidity between ADHD and other behavioural symptoms that have to do with aggression.

References

- Amaral DG, Corbett BA 2003 The amygdala, autism and anxiety. In: Autism: neural basis and treatment possibilities. Wiley, Chichester (Novartis Found Symp 251) p 177–197
- Best M, Williams JM, Coccato EF 2002 Evidence for a dysfunctional prefrontal circuit in patients with an impulsive aggressive disorder. *Proc Natl Acad Sci USA* 99: 8448–8453
- Cadesky EB, Mota VL, Schachar RJ 2000 Beyond words: how do children with ADHD and/or conduct problems process nonverbal information about affect? *J Am Acad Child Adolesc Psychiatry* 39:1160–1167
- Corden B, Critchley HD, Skuse DH, Dolan RJ 2005 Fear recognition ability predicts individual differences in social cognition and neural functioning. Submitted
- Geurts HM, Verte S, Oosterlaan J et al 2004 Can the Children's Communication Checklist differentiate between children with autism, children with ADHD, and normal controls? *J Child Psychol Psychiatry* 45:1437–1453
- Gilmour J, Hill B, Place M, Skuse DH 2004 Social communication deficits in conduct disorder: a clinical and community survey. *J Child Psychol Psychiatry* 45:967–978
- Holland PC, Gallagher M 2004 Amygdala-frontal interactions and reward expectancy. *Curr Opin Neurobiol* 14:148–155
- Insel TR, Fernald RD 2004 How the brain processes social information: searching for the social brain. *Annu Rev Neurosci* 27:697–722
- Lawrence K, Bernstein D, Pearson R, Mandy W, Skuse D 2005 How good are children and adolescents at recognizing facial expressions of emotion? A normative study. Submitted
- Morris JS, deBonis M, Dolan RJ 2002 Human amygdala responses to fearful eyes. *Neuroimage* 17:214–222
- Pasley BN, Mayes LC, Schultz RT 2004 Subcortical discrimination of unperceived objects during binocular rivalry. *Neuron* 42:163–172
- Pellis SM, Iwaniuk AN 2004 Evolving a playful brain: a levels of control approach. *Int J Comp Psychol* 17:92–118