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APPLICATIONS OF NEUROBIOLOGICAL STUDIES TO FARM ANIMAL WELFARE

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ABSTRACT

Welfare problems arise when individuals fail to cope with their environment or when coping is difficult. Both short-term handling and long-term housing and management effects are of importance in farm animals. Studies of farm animal behaviour show that these animals must have the same sorts of psychological constructs in the brain as those thought to exist in man and laboratory animals. Complex expectancies are used in sophisticated analysis of the environment and hence the same problems concerning uncertainty and frustration exist. Brain-behaviour links are sparsely studied in farm animals but work on catecholamine agonists and opiate-peptide receptor-blockers suggest interactions of stereotyped behaviour with dopaminergic pathways and analgesic opiate peptides. Work on responsiveness of confined sows indicates that a neural gating process resulting in lack of responsiveness may be involved in coping with adversity associated with such confinement.

INTRODUCTION

When considering the responses of farm animals, or any other animals, to their environment it is desirable to distinguish situations which have detrimental effects on the individual from those which do not. The ultimate criterion of what is detrimental is whether individual fitness is reduced but it is often possible to say only that a particular effect on an individual is likely to result in reduced fitness. The term "stress" is of little use if it merely implies "a deviation from the optimum of a particular parameter in response to a stimulus" (Block, 1985) so it is best to use it only when referring to the processes within an individual when environmental factors (stressors) lead to detrimental effects (Broom, 1983a; 1985). The welfare of an individual is its state with regard to its attempts to cope with its environment. An individual which does cope with the conditions in which it lives may do so very easily, using its various regulatory systems, or it may have to spend much time and energy in doing so. Hence welfare may be bad either if the individual fails to cope or if coping is difficult.

Environmental effects which are of importance in farm animal husbandry include both short-term (acute) handling and long-term housing and management effects. Farm animals may be driven from place to place, loaded into vehicles, transported in vehicles, physically abused, mixed with other individuals, subjected to veterinary procedures and exposed to environmental events such as sonic booms. Long-term conditions may involve confinement in a small space, absence of particular environmental stimuli, social isolation or confinement with aggressive conspecifics. The long-term conditions may include frequent or intermittent episodes such as extreme temperature, lack of food, lack of water, contact with predators, or any of the other events listed above.

The first questions about the relevance to farm animal husbandry of work on responses to complex behavioural situations (Warburton, 1986) are whether these animals encounter such situations and whether they are able to have the complex concepts described for man. Some situations are obviously adverse, for example severe injury occurs or the animal is deprived of water for a long period, but the effects of uncertainty and frustration on farm animals may also be severe. Further questions concern whether the neural pathways and transmitters are the same and whether there are the same links between problem situations and the behavioural or physiological symptoms which have been described for man and laboratory animals.

EXPECTANCIES, UNCERTAINTY AND FRUSTRATION

How are expectancies recognised? In some experimental studies, experimenters deduce which sensory inputs are of high or low probability to the subject and recognise an expectancy when there is no response to sensory inputs which are of high probability but there is an obvious response to an input of low probability. In other studies, characteristic behaviour is shown shortly before a predictable event but not at other times and hence expectancy is assumed to exist. There is evidence of both kinds of expectancies in farm animals. Pigs fed regularly at a certain time of day show easily

recognisable behaviour during the hour before feeding. Cattle accustomed to obtaining access to a particular Callan-Broadbent feeding gate when they try to put their head into it show obvious behavioural responses if the gate does not work because it is jammed or because their transponder is missing. Cows which have experienced unpleasant veterinary treatment when entering a crush are often unwilling to enter that crush. This may occur despite no lack of willingness to enter on an earlier occasion and is presumably a consequence of an expectancy of further unpleasant treatment there. Studies of social behaviour often indicate that individual pigs, cattle or poultry recognise other individuals who have previously attacked or threatened them. Since this can occur in the absence of any current threat and may be quite different from initial naive approaches to that same individual, it can be assumed that an expectancy of future attack exists.

More complex expectancies may also exist, for example when mountain sheep graze a meadow and then return to it only after several weeks, by which time it has regrown (Favre, 1975). An expectancy on a different time scale was demonstrated in an experimental study of habituation by domestic chicks. Chicks which had ceased to respond to a light bulb which was illuminated for 10s every 30s showed an orientation reaction when the bulb was extinguished after 5s or when the illumination continued for 15s (Broom, 1968).

Uncertainty may occur after an expected input is not received or in a novel situation in which no precise expectancy exists. Situations where there is a possibility of a predator attack have a considerable effect on the behaviour of sheep. Measurements of heart-rate during the approaches of dogs show that heart-rate increases as the dog draws nearer (Baldock, 1985; Baldock and Sibly, in press). Similarly, hens show behavioural or heart-rate responses when people approach (Duncan and Filshie, 1979). Uncertainty about cues associated with feeding were found to affect pig behaviour in an experiment by Carlstead (1984). When a bell sometimes signalled the

arrival of food and sometimes did not, the pigs showed more aggressive acts per unit time active than when food arrival was reliably signalled by a bell and a light. Many situations where action by a conspecific or by man may occur involve uncertainty and have effects on farm animal behaviour and physiology.

If the levels of most of the causal factors which promote a behaviour are high enough for the occurrence of the behaviour to be very likely, but because of the absence of a key stimulus or the presence of some physical or social barrier, the behaviour cannot occur, the individual may be said to be frustrated. Examples include a hen which is about to lay an egg but which has no materials with which to build a nest, or a hen which is prevented from reaching normally accessible food by a perspex cover. The responses to such frustration included pacing behaviour or excessive, prolonged sitting in the first instance (Wood-Gush, 1969; 1972; Brantas, 1980) and stereotyped pacing or attacks on conspecifics in the second instance (Duncan and Wood-Gush, 1971, 1972). The evidence for frustration implies that the animal has a concept of the action which it wishes to carry out.

All of the examples in this section provide evidence for the existence of the same sorts of psychological constructs in the brain as those thought to exist in man and laboratory animals.

NEURAL PATHWAYS AND TRANSMITTERS IN THE BRAIN

The cerebral cortex is particularly large and elaborately folded in cattle, sheep and pigs as compared with rodents or carnivores. The basic anatomy of the brain is similar but evidence of functioning pathways in the brains of farm animals is sparce. Whilst it seems likely that the hypothalamic-cortical-hippocampal-tegmental arousal-controlling loops are present in ungulates this is not certainly known. The brains of poultry and other birds show close parallels in their basic pathways with those of mammals even though there are anatomical differences. Much also remains to be discovered, or verified, about the roles of the various catecholamines and opiate

peptides in the brains of farm animals. It is likely that the links between the hypothalamic-adrenal pathways and arousal are very similar in farm animals and laboratory animals. Responses to adversity are normally associated with high arousal, but the reverse is not necessarily true; so it would be wrong to equate high arousal with detrimental effects on the individual.

One brain-behaviour link which has been explored in some detail is that associated with stereotypies. Pigs or calves which are kept in close confinement, usually with food available for very little of the time, show abnormal, stereotyped behaviour. A stereotypy is a relatively invariate sequence of movements occurring so frequently in a particular context that it could not be considered to form part of one of the normal functional systems of the animal (Broom, 1983b). These activities have been linked with brain function in several ways. Firstly, Sharman and Stephens (1974) and Fry et al (1976) showed that subcutaneous or intravenous injection of the dopamine receptor agonist apomorphine led to an increase in the incidence of stereotyped sucking, licking and chewing movements in cows, calves, sheep and piglets. Conversely, piglets prevented from carrying out sucking and stereotyped snout rubbing have been found to have modified brain dopamine metabolism. In each of these studies there is some possible contribution of nutritional factors, but they show some correspondence with laboratory studies on the effects on stereotypies of another catecholamine agonist, amphetamine (Lyon and Robbins, 1975). Apomorphine also increased the incidence of stereotypies in pigeons (Deviche, 1985).

As Dantzer (1986) points out, the links between dopamine agonists and behaviour are not easy to interpret. There are complex interactions among the brain neurotransmitters and there are also links with brain opioid peptides. The pentapeptides metenkephalin and leuenkephalin and the much longer chain peptide beta endorphin are involved in analgesia but they also have many other functions. The

enkephalins have an affinity for delta receptors in the brain whilst morphine and beta endorphin have an affinity for mu receptors. These mu receptors are blocked by the drug naloxone. Dry sows, which normally spent long periods engaged in stereotypies, reduced this behaviour but did not change their exploratory behaviour, when naloxone was injected subcutaneously (Cronin et al; 1985). Hence it is possible that stereotypies help in coping with the environment by regulation of arousal and modulation of motivational state (Forrester, 1980; Broom, 1981, 1983) via interactions with dopaminergic pathways and the action of analgesic opioid peptides.

BEHAVIOURAL AND PHYSIOLOGICAL ATTEMPTS TO COPE WITH ADVERSITY

Many of the examples of attempts to cope with adversity described by Warburton (1979; 1986) have parallels in farm animal studies. As described by Ladewig (1986) the adrenal medulla and cortex are active in a wide variety of situations. For example, pigs which are cold or which are chased show increased adrenal cortex activity (Baldwin and Stephens, 1973) and levels of adrenaline were higher in fattening bulls which were kept on a slatted floor or which were involved in active interactions (Unshelm et al, 1978). Adverse conditions may elicit several different kinds of coping attempt in an animal and there are often individual differences in which coping methods are used most. Examples may be taken from studies of dry sows which are confined by tethering or by keeping in small stalls since these results have parallels with studies of learned helplessness in laboratory animals. When sows are first confined they show vigorous activity in the first hour but later they show reduced activity and often develop stereotypies (Cronin et al, 1984). In both tethers and stalls, sows vary in the amount and type of stereotyped behaviour which they show (Dantzer and Mormède, 1981; Broom and Potter, 1984). Behaviour and adrenal activity may be alternative responses to adversity, for Dantzer and Mormède found that the tethered sows which played with a chain had lower cortisol levels than those which did not. Stereotyped behaviour is an active response by sows to confined housing conditions but passive responses also occur. The low levels

of activity shown by many confined sows have been described by Ekesbo (1981). It has also been suggested that confined sows show "apathetic" behaviour, meaning that they are unresponsive to events in their environment (Wiepkema et al, 1983). In experiments to test the responsiveness of stall-housed sows (Broom in press, a,b) all sows were very responsive to food arrival at normal feeding time and to the provision of a few food pellets during the middle of the day when most sows were resting. Behavioural responses were also shown to the filling of a food hopper which would be emptied in the trough the following morning. Stimuli not related to food elicited little response, however. Sows videotaped when a stranger stood quietly in front of them showed little behavioural response and even when the stranger's face was only 25cm from the nose of the sow there was no significant effect on behaviour except more time spent looking at the observer.

In experiments in which sows which had been lying for 20 minutes, but which had their eyes open, had 200ml of water at air temperature dropped on their backs, there was a clear difference between stall-housed and group-housed animals (Table 1).

TABLE 1 Responsiveness of stall-housed and group-housed sows. Behaviour in 20 min. after stimulus presentation.

	Stall-housed	Group-housed	
Mdn. time sit or stand(s)	27.5	349	p=0.094
Mdn number of other activities	2.5	6.5	p=0.004
n	24	12	(2-tailed)

The sows were videotaped before and after stimulus presentation and would have been likely to continue lying for some time. Many stall-housed sows failed to sit or stand during the 20 minutes after water was dropped on them and most showed few other activities such as raise head, vocalise, body shake, sniff ground etc. The group-housed sows

sat up or stood up after a median of 2s and showed many more activities, especially in the first 2 minutes. Hence stall-housed sows were less responsive than group-housed sows but there was much individual variation in response, for example 4/24 stall-housed sows sat or stood for more than 19 minutes and showed 6 or 7 other activities. Similarly, there was variation among group-housed sows for four of these sat or stood for less than one minute. Three of these animals had been housed in stalls before their previous farrowing, so the effects of experience in stalls is being investigated further.

A possible interpretation of these experiments on responsiveness is that some confined sows attempt to cope with their conditions by some neural gating process. This might reduce sensory input by an efferent threshold modifier, or reduce arousal, or attenuate response to input in some other way. The process does not operate where the input is closely associated with food. It could be that such a neural gating effect might operate via the action of analgesic peptides but this need not be so. Whatever the mechanism, lack of responsiveness is an indicator that the animal is having to modify its normal functioning considerably in order to cope with its environment so its welfare is bad.

A final conclusion based on a wide variety of studies of farm animals is that their brain and behaviour mechanisms are sophisticated and deserving of further study and much respect.

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