BIRD BRAINED - THE NEUROLOGY AND NEUROPHYSIOLOGY OF ANXIETY IN BIRDS

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The behaviour of birds is varied and fascinating and has been widely studied. The boundaries of their abilities to learn new songs, new behaviours, remember nesting, feeding and food caching sites continue to be explored by researchers. However, the emotions of birds have not been well investigated. Veterinary behaviourists, psychologists and neurologists are interested in areas of the brain concerned with emotion, learning and memory because anxiety is an unpleasant emotion which can lead to behaviour problems, which need to be distinguished from problem behaviours. This paper will review the neuroanatomy of the avian brain, concentrating on the areas relating to emotion. The neurophysiology of anxiety and how it may affect behaviour will be considered. Lastly, how emotions can be altered in the treatment of behaviour problems will be briefly discussed.

Compared with mammalian brains, the avian brain appears less complex. Once considered to be just a collection of hypertrophied basal ganglia that produced instinctive behaviour (Butler and Cotterill, 2006), the body of research in avian neurology and psychology shows that the avian brain is capable of cognitive feats that equal and in some cases surpass those of some mammals. Bird species have been shown to have episodic memory (used in food caching) (Clayton and Dickinson, 1998); object constancy (Dumas and Wilkie, 1995; Pepperberg et al., 1997); and transitive inference (the ability to infer relationships between others and self by watching or listening to interactions) (Paz-y-Miño et al., 2004). They also have been shown to have a theory of mind (Emery and Clayton, 2001) and the ability to manufacture tools and transfer this information through their social group (cultural transmission) (Hunt and Gray, 2003). However, the emotional lives of birds have not been well studied although in at least one study, birds reacted with “surprise and anger” when their expectations were not met (Pepperberg et al., 1997).

NEUROANATOMY

Overview

The avian brain can be divided into the telencephalon, diencephalon, mesencephalon, metancephalon and myelencephalon. The telencephalic complex, analogous to the telencephalon in mammals, is internalised in the bird brain. It is located deep to the cerebral hemispheres. The telencephalic complex is involved with information processing receiving inputs from optic, retinal, and auditory projections, and project motor pathways to the hindbrain and spinal cord. The hippocampus is between the lateral ventricles on the medial walls of the median fissure. The hippocampus is involved in memory storage.

The diencephalon consists of the thalamus, hyothalamus and epithalamus. The thalamus is a relay station sending sensory input to the telencephalon for processing. The hypothalamus sits below the thalamus and above the pituitary gland. It controls autonomic function, thermoregulation, respiration, reproduction, eating/drinking, reproduction, defensive reactions. The epithalamus

consists of the pineal gland which is very sensitive to light and involved with reproductive function.

The metecephalon contains the cerebellum which regulates motor activities of posture and movement. There is no obvious pons in the bird. Rather there are pontine fibres which have a role in conducting sensory information.

The hindmost part of the brain, the myelencephalon contains the medulla which controls the autonomic vital life process of breathing, heart rate and digestion.

The limbic system

The limbic system is a complex arrangement of brain structures located in the telecephalon and the diencephalon. It controls emotions, emotional responses, hormonal secretions, mood, motivation and sensation pain and pleasure. In mammals, the agreed structures of the limbic system include the amygdala, hippocampus, paraphippocampus, cingulate gyrus, fornix, hypothalamus and thalamus. In birds, not all these structures or their equivalents have been identified. The avian limbic system is thought to contain the hypothalamus, amygdala, cingulate gyrus, thalamus and septal nuclei (Kuenzel, 2000).

Emotions and memory

The limbic system is involved in emotions, memory and learning. It has strong connections to the autonomic nervous system. The connection between the memory processing and emotional areas of the brain and the autonomic nervous system, especially the sympathetic system, aids in the survival of the individual and therefore the species (Kuenzel, 2000). It is important to learn what to be frightened of, to remember this and be able to predict when it might reappear. The emotions that are involved in these processes are those of fear and anxiety. Frustration is associated with anxiety as well.

Fear, anxiety and frustration are of interest to the veterinary behaviourist because they are often the motivators for undesirable behaviours in companion birds. Each emotion is different. Fear is controlled by a neural network that manages the responses of fear and the learning of fear. The amygdala is central to this network. It receives processed input from the cortex and from thalamus. Input from the thalamus arrives faster than information from the cortex resulting in a fear response being activated before the full threat is evaluated (Ohman, 2010).

Anxiety is similar to fear and is an unpleasant emotion. It often occurs without an identifiable triggering stimulus. The amygdala is also active in the anxiety state however; initial input comes from different areas of the brain compared with fear.

Physiologically, anxiety looks the same as fear. When an animal feels fearful or anxious the flight/fight/fiddle/freeze reflex is in action. This means the sympathetic adrenomedullary (SAM) system is working to increase blood pressure, heart rate and slow digestion to ready the animal for action. Usually these situations are resolved quickly – the bird flies away or it fights. However, some situations can continue for some time. When the animal continues to feel anxious or fearful, the Hypothalamic Pituitary Adrenal (HPA) axis is activated with the effect of increasing corticosterone in blood stream. The animal is readied physiologically to continue dealing with the stressful situation.

If the stressful situation continues without resolution, the animal can develop problems due to the

continued activation of the HPA axis. The continued activation leads to changes in the brain. The increased corticosterone from HPA activation feeds back to the hippocampus and has a negative feedback on the on the release of CRH from the hypothalamus. But too much corticosterone damages and can kill the cells in the hippocampus that cause the negative feedback and stop the feedback from happening.

Emotional memories are very strong and have physiological effects when recalled. The amygdala is responsible for determining what memories are stored and where the memories are stored in the brain. It is thought that this determination is based on how huge an emotional response (the amount of adrenaline) an event invokes. Due to direct connections with the thalamus, the amygdala can have effects without input from the cortex. The hippocampus sends memories out to the appropriate part of the cerebral hemisphere for long-term storage and retrieves them when necessary. Long term activation of the HPA axis leads to damage to the hippocampal cells and affects memory.

As the amygdala manages memories with a big emotional response and the hippocampus manages other less emotional memories and can be damaged by long term stress, the chronically anxious animal will struggle to remember calm, non-frightening events.

Anxiety is unpleasant to experience. Individuals will attempt to avoid or relieve anxiety by changing their behaviour. Problems develop for the bird when the behaviours it tries clash with owner expectations about how the bird should behave.

PROBLEM BEHAVIOUR VERSUS BEHAVIOUR PROBLEMS

All companion animals have problem behaviours but only some have behaviour problems.
On the surface, behaviour problems and problem behaviours look alike. In birds, behaviours owner's complain about include being noisy, destructive, biting, aggressive and damaging their feathers (Welle, 2006). However, some of these behaviours are normal parts of bird behaviour. So when are these problem behaviours and when are they behaviour problems? A problem behaviour is a behaviour that the owner finds difficult but which is normal for the bird and is being performed in context. Problem behaviours are generally amenable to training or retraining and/or environmental management. They stem from poor husbandry, poor environmental management and sometimes poor socialisation.

Behaviour problems are very different although the behaviours performed may look very like problem behaviours. For example, it is normal for some bird species to be noisy in the evening as they settle for the night. However, it is not normal for a bird to screech all day. This is a behaviour problem. The behaviour is being performed out of context. Animals with behaviour problems have mental health disorders whereby their responses to everyday events and frustrations are extreme and detrimental to the animal's health and welfare. Behaviour problems occur in response to fear, anxiety and frustration. Fear and anxiety in normal birds are important and protective emotions. Fear and anxiety keep birds on edge and ready to flee from threats. However animals with behaivour problems experience anxiety at higher levels than other animals. For anxious individuals, predicting the outcome of every day events is difficult causing them to be stressed.

MANAGING EMOTIONS

For the bird with a behaviour problem, everyday living is very stressful. Their anxiety leads to them being very aware of changes in their environments and they are predisposed to seeing these as

threatening. Their ability to learn is impaired as their memory retrieval systems are affected by their chronic stress. This is why the behaviour of some birds do not improve with improved environmental management and training regimes. Their brains are effectively not functioning normally. Many of these birds benefit from the addition of medication that alter neurotransmitter levels in their brains. The neurotransmitters most commonly affected by anxiety include serotonin, noradrenaline and gamma amino butyric acid (GABA).

Low levels of serotonin are associated with anxiety, irritability, depression and compulsive disorders (Martin, 2006). Noradrenaline is distributed widely throughout the brain but most noradrenergic neurons can be found in the locus ceruleus. Noradernaline has a role in vigilance and mood (Martin, 2006). GABA is an inhibitory neurotransmitter- it slows the activity of neurons. When GABA levels are increased, there is reduced vigilance, muscle tension and memory formation is inhibited. Low levels of GABA have been associated with fears and phobia and seizures (Martin, 2006).

PSYCHOPHARMACOLOGY FOR BIRDS

As has been shown, the brains of birds showing behaviour problems function differently from birds with simple problem behaviours. As learning and memory is impaired through changes in neurotransmitter levels, treatment and management of behaviour problems often requires medication to help alter neurotransmitter levels. Treatment of all behaviour problems should *always* involve behaviour modification and environmental management.

There are currently no psychopharmacologic agents licensed for use in birds so care should be taken with educating owners as to the expected actions of the medication both positive and negative and how to administer the medication. It is recommended that the owner sign a consent form before the medication is prescribed or dispensed. It also recommended that screening blood, biochemistry and urine tests are conducted before dispensing medication to rule out any disorders that may affect how the medication is metabolised.

Many medications are bitter so compounding and/or disguising the medication in foods or juices may help in medicating the bird.

Medication types commonly used in the treatment of anxiety disorder are tricyclic anti- depressants, selective serotonin reuptake inhibitors and benzodiazepines. Medications found useful by other authors have been summarised in the table below with reported side effects.

CONCLUSION

Anxiety is an unpleasant emotion that can lead to behaviour problems in birds. Chronic anxiety occurs when there are abnormalities in the function of the limbic system. Affected birds have mental health disorders. Treatment of these birds involves managing their emotions with environmental management, behaviour modification and medication.

Medication Class (Side effects/ CI)	Medication (Commercial name)	Dosage	Indications
Tricyclic Antidepressants (SE: Sedation, GIT upset/CI: blood glucose alterations, glaucoma, seizures, cardiac disease, thyroid medication)	Clomipramine (Clomicalm, Anafranil)	3-5mg/kg SID-BID	Compulsive Disorder Compulsive FPD Chronic Anxiety disorder
	Amitriptyline (Endep)	1-5mg/kg BID	Pruritic FPD Chronic Anxiety Disorder
	Nortriptyline	2mg/120mk drinking water	Chronic Anxiety Disorder
	Doxepin (Deptran, Sinequan)	1-2mg/kg BID	Pruritic FPD
Selective Serotonin Reuptake Inhibitor (SE: sedation, anorexia, nausea(?)/CI: seizures, blood glucose alterations, MAO-I drugs)	Fluoxetine (Reconcile, Prozac, Lovan)	1-4mg/kg SID	Compulsive Disorder Compulsive FPD Global Fear Phobia Aggression
	Paroxetine (Paxil)	1-2mg/kg SID-BID	Compulsive Disorder Compulsive FPD Global Fear Phobia Aggression
Benzodiazpene (SE: Sedation, ataxia, muscle relaxation, increased appetite, memory deficits, paradoxical excitement)	Diazepam (Valium, Pamlin)	2.5-4.0mg/kg TID-QID 1.25-2.50mg/120ml water	Fears, Phobias, Anxiety Panic attacks Increase friendliness Acute anxiety Induced FPD

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