

Commentary

## Affective consciousness in animals: perspectives on dimensional and primary process emotion approaches

Behaviourists have long neglected experiential states in animals because of inadequate experimental approaches. As Tinbergen [1] highlighted in his classic *Study of Instinct* (1951, p. 4): ‘Because subjective phenomena cannot be observed objectively in animals, it is idle to claim or deny their existence’. Mendl *et al.* [2]—henceforth MBP—offer a robust *dimensional* strategy for analysing affect-related behavioural functions in animals using novel variations of rigorous behavioural learning approaches. MBP cautiously avoid ontological ambiguities by highlighting that such states ‘may or may not be experienced consciously’. However, if we consider brain stimulation evidence (*vide infra*), the evocation of diverse reward and punishment effects directly from the brain strongly indicates that such states are experienced by animals.

Rather than debating whether *dimensional* or *basic* emotion approaches are better research strategies, MBP wisely advocate a compromise position (for relevant recent discussions, see Zachar & Ellis [3] and Mendl *et al.* [2]). Largely missing from past debates is the explicit recognition that this difficult field of inquiry should not be framed as a zero-sum game. As an advocate for neuroscientific research on shared primary-process affective processes in all mammals [4,5], the need for multi-level approaches seems self evident if information derived from animal models is to have any impact on understanding how affective experiences arise from human brain activities, which is among the most resistant mysteries of MindBrain organization. (Note, I use MindBrain to highlight the complete interpenetration of experience with brain functions, and sometimes reverse the usage to BrainMind, with no change of meaning, but hopefully better contextual emphasis.)

Abundant evidence now indicates that raw affects are ‘ancestral memories’—genetically provided tools for living—that arise, at a primary process level, from homologous lower brain functions in all mammals. Raw emotional affects can now be studied causally by activation of subcortical circuits that arouse instinctual emotional behaviours [4,6]. Although primary ‘rewards’ and ‘punishments’ have typically been defined as ‘objects’ of the world, both obviously achieve their psychological power by arousing brain-affective networks, which are homologous at the primary process level in all mammals. A key breakthrough was that localized brain stimulations that evoke ‘instinctual’—emotional actions also mediate brain reward and punishment processes that control learning (from [7] to [8]). This coalesces in a

*dual-aspect monism* strategy for understanding primary-affective consciousness in animal brains [9]—e.g. instinctual rage behaviours reflect angry feelings.

In discussing uses of dimensional and basic emotion approaches, a focus on levels of control within the Brain-Mind helps clarify why diverse approaches need to cooperate [4,6]. Mammalian brains are evolutionarily layered organs like no other in the body—ancestral progressions remain evident within neuroanatomical and neurochemical organizations. The more ancient medial and caudal brain regions generate raw affects, as indexed by rewarding and punishing properties of artificial brain stimulation, and, to the best of our knowledge (based on brain-imaging and decortication studies), no higher brain ‘read-out’ is needed for them to be felt [10,11].

Such effects encourage us to envision psychobehavioural processes at: (i) *primary process* levels (genetically ingrained ‘instinctual’ organizations); (ii) *secondary processes* (‘cognitive’ elaborations through simple learning, such as fear conditioning); and (iii) *tertiary processes* (interactions of lower affective processes with higher BrainMind functions such as complex perceptions, thoughts, temperaments and perhaps certain moods). Although primary process affects are not learned, they are surely further elaborated by learning and cognitions. It would seem that MBP’s strategy is more relevant for secondary and tertiary, rather than primary process levels of analysis. MBP’s work could be substantially advanced if they included some more direct primary-type measures of affect, such as ultrasonic emotional vocalizations in their rodent studies (see [12]).

The fact that dimensional approaches can now also be deployed effectively in animal models is good news. With MBP’s superb work, top-down higher order dimensional approaches to understanding emotional valence and arousal can now enrich bottom-up subcortical primary process studies of the basic emotions. Although dimensional approaches guiding abundant human research have traditionally analysed linguistic-conceptual processing of emotions, MBP highlight how mood states in animals may be dimensionally conceptualized by analysing instrumental-evaluative learning. With such breakthroughs, we can envision how top-down dimensional and bottom-up neuroaffective analyses can cooperate for integrated multi-level understanding.

It is important to recognize that different basic-emotion approaches do not share a single vision. They rarely use similar research strategies, although facial

analysis has been prominent. Only one type of basic emotion approach focuses on subcortically concentrated emotional networks, which are causally analysable in animal models [4]. Such work helps illuminate primary process affective functions of all mammalian brains. MBP's dimensional analysis can promote *causal* research strategies integrating affective neuroscientific and higher order dimensional approaches. Once investigators begin to view their behavioural data from evolutionary level-of-control perspectives, many perplexing phenomena should become more comprehensible (e.g. why people enjoy scary movies).

Why is all this so important? Understanding the nature of affects in animals can promote better conceptualization of psychiatric disorders, the foundations of human values, as well as the fuller and more realistic understanding of the mentality of fellow creatures [9,13]. I would supplement MBP's insightful analysis with four critical issues for promoting progress.

- Arousal mechanisms of the brain [14] exhibit considerable anatomical and neurochemical diversity, including acetylcholine, dopamine, epinephrine, histamine, norepinephrine and serotonin systems, along with various neuropeptides, from corticotrophin-releasing factor to orexin. Working together, they may simply evoke a single dimensional-type of psychologically experienced arousal. However, several distinct forms of experienced arousal may contribute differentially to different positive and negative affective states.
- Abundant evidence suggests that lower rather than higher brain regions are more important in generating core affective states [5,15]. Abundant human neuroimaging suggests that lower affective brain regions have see-saw relationships with higher mental activities [16], with emotional feelings arising substantially from subcortical brain networks [17,18]. Global mood states may arise from higher order integrations of diverse basic affective states. Since MBP may be 'assessing long-term mood states', basic and dimensional views could be coordinated to facilitate multi-level insights about mood processing in animals.
- Causal understanding of affects requires concurrent neuroscientific and psychological approaches. How might subcortical emotional, homeostatic and sensory networks that mediate 'rewards' and 'punishments' provide input to evaluative functions revealed by dimensional approaches? Clearly, we need empirical strategies to determine how well distinct levels of control within emotional and motivational systems are integrated and discriminated by animals.
- Many dilemmas that impede human- as well as animal-affect research, whether 'basic' or 'dimensional', reside in the ambiguities of language. For progress, we must refine and standardize language-use in cross-species affective studies. MBP used vernacular terms, at times in scare quotes, to describe my work. I prefer specialized terms, capitalized, to designate primary process emotional networks of mammalian brains. Abundant evidence exists for seven distinct Darwinian emotional systems as revealed by behaviours evoked by electrical and chemical stimulation of homologous subcortical

regions of all mammalian brains studied: namely, SEEKING, RAGE, FEAR, LUST, maternal CARE, separation distress PANIC/GRIEF and physical PLAY (capitalized, to highlight their basic nature—i.e. primary processes are defined by brain circuit locations and characteristics and are not equivalent to conceptual, multi-levelled MindBrain wholes typically labelled by vernacular terms). This emotional terminological convention promotes *a priori* predictions about human affective experiences whenever primal emotional networks are artificially aroused. Thereby, we can better understand and predict how pharmacological agents that serve as rewards and punishments for animals are hedonically positive or negative for humans. Dimensional perspectives commonly used in human-research have not yet provided robust cross-species predictions about shared neuro-affective processes of mammalian brains. MBP's research breakthroughs have the potential to fill that gap.

I admire MBP's call for rapprochement between dimensional and basic emotion studies of human and animal feelings. Understanding the affective infrastructures of mammalian BrainMinds will surely require cooperation rather than competition among approaches. Ideological-conceptual biases, endemic in human affect science, have delayed integration (see [3]). Synergistic animal work can help heal such rifts. Let us now envision how bottom-up basic emotion and top-down dimensional approaches can cooperate to generate novel affective predictions. Empirical measures to directly evaluate affect (e.g. emotional vocalizations; [12]) and how well animals can make affective discriminations at different levels of the MindBrain axis are finally conceivable.

MBP are understandably hesitant to ascribe 'conscious' emotions to animals from behaviour-only work, especially since 'consciousness' is intrinsically a hierarchical BrainMind function. However, can we ever understand how affects are constructed in human brains without detailed studies of corresponding brain processes in animal models? Already evidence for primary-process affective *experiences* in other animals, despite widespread agnosticism, is neuroscientifically robust. Most critically, artificial arousals of 'instinctual'-emotional circuits consistently serve as rewards and punishments for learning [4,5,7]. It is theoretically convoluted to explain how external 'rewards' and 'punishments' produce diverse behavioural changes in animals without evoking affective experiences. Of course, the existence of affective *experiences* in animals does not automatically imply they are consciously *aware* of or think about their experiences.

MBP's fascinating work highlights a path to accessing some higher order affective 'mood' processes in animal brains—an especially fine contribution for animal welfare research. The work should stimulate long-overdue *scientific* discussions of what we can and cannot know about the affective lives of other animals and how that impacts understanding our own nature as well as identifying emotional endophenotypes for advancing biological psychiatry [13].

Evidence from cross-species affective neuroscience needs to be fully considered by all interested in the primary-process nature of animal and human minds. But our

historical theoretical conundrums may slow progress. Whether situating human emotional feelings on theoretically generated maps of multi-dimensional affective space (arousal-valence) reflects biologically dictated brain functions or simply research-promoting conceptual acts remains unresolved. Despite historical resistances (see [19]), the existence of diverse emotional-affective networks in animal brains is empirically definitive. Although our understanding of these systems is far from complete, MBP have clarified how higher evaluative consequences of affects/moods can be rigorously studied.

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