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Modulation of behavior in communicating emotion

Commentary on ***King*** *on Animal Grief*

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Abstract: King discusses many examples where two animals, as they bond, behave in ways we interpret as expressing love for one another. If one of the bonded animals then dies, signs of loving are replaced by signs we interpret as expressing grief by the animal who remains. I propose a pathway for emotional communication between an animal and an observer that can have a central role in these and other observations by King and in our overall ability to interpret observed behavior in relation to emotion. This pathway provides evidence of emotion in an observed animal by communicating evidence of emotion's effects on the behavioral activities of the observed animal. Initial findings from humans including those from music support and can begin to fill in the details for such a pathway.

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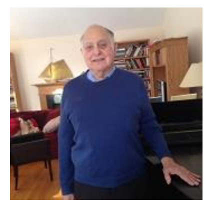

Communicating Information About Emotional State. As Scherer (1995) pointed out, Darwin (1872, 1965) argued that it is essential for a human or nonhuman animal to be able to signal their emotional states to other individuals, for example, to avoid a fight or advance toward sexual behavior. Facial expression (Ekman, 1973, 1992) and animal vocalizations that send affective signals (Marler, 1954; Scherer, 1988, 1995) illustrate such signaling.

But King (2003) reminds us that many activities by an animal that do not have the sole purpose of signaling an emotional state can also be interpreted by an observer as indicating emotional state, whether or not the animal intends this communication, or is even aware of being observed. And computer technology is already rapidly developing means to analyze and monitor such signs in humans (Khatchadourian, 2015).

I propose a modulation/demodulation pathway to clarify the steps needed to account for the transmission of information about emotion that King and Khatchadourian discuss.

Communicating spoken words via radio signal. An example from technology illustrates the kind of communication I wish to model. Consider a listener (L) listening on a radio to sounds of words spoken in a studio by a human speaker (S). L cannot hear the actual sounds produced by S, but instead hears a close approximation to these sounds constructed from information carried by a *carrier signal,* here radio waves, passing through the air from a radio wave transmitter to the radio. In a *modulation of carrier stage,* sound waves produced by S talking into a microphone in the studio are used to *modulate* or modify the carrier signal in a known way. At the radio, a *demodulation of carrier stage* reverses the processes used in the modulation stage, creating the sound waves heard by L.

Communicating information about emotion through modulation and demodulation of signaling related to action. Consider an observer (O) observing an individual (A) who can carry out active behavior. O wishes to obtain information about emotional states of A, but since emotional states are internal, O cannot observe A's emotions directly. The channel to be discussed next allows O to observe A's emotions through a pathway involving demodulation of information about A's emotions from signals about A's actions.

Consider whatever signals O uses to observe activities of A as *carrier signals* passing from A to O (CS[A,O]).

Modulation. Damasio (1994, 1999, 2010), building from ideas of James and Lange (1922) and extensive further evidence, proposed that what we call emotion concerns adjustment of body physiology to meet differing challenges to behavior and also to restore depleted capacities whenever this becomes possible. If one adds secondary and background emotions and mixtures that defy verbal description to primary emotions such as fear and joy, normal experience shows no break in emotion. Emotion thus interacts continuously with other brain function as behavior is planned, adjusted, developed, and executed (Gardiner, 2015).

This continuing dialogue between emotion and control of action in observed individual A continuously modulates emotionally the behavior of A, and thus also the carrier signal passing from A to O (CS[A,O]) to produce a new modulated carrier signal CSM(A,O).

Demodulation. To obtain information about A's emotions from CSM(A,O), O must now carry out some form of demodulating reverse engineering based on the belief about how A's emotion can affect A's behavior as now observed.

Rapidly expanding research building on the discovery only a few decades ago of "mirror neurons" and "mirror neuron systems" (MNS) in monkeys (Rizzolati & Craighero, 2004) supports the possibility for such reverse engineering analysis. Mirror neurons in monkeys fire both when the monkey carries out a goal-achieving action and when the monkey observes a similar goal-achieving action by someone else, including humans. Individual neuronal firing has not been directly observed in humans, but imaging and other related studies are demonstrating MNS properties in regions related to observations in the monkey, and also more broadly in the human brain.

MNS systems thus appear to hold and provide access to information that can be used to interpret the meaning of observed actions through a kind of *simulation* (Gallese, 2003) joining MNS and other systems to recreate as closely as possible the functional mental activity (Gardiner, 2008a) in oneself that could create the motor acts observed. There is already evidence that such MNS-related simulation is important to human verbal communication (Fischer & Zwann, 2008; Zarr et al., 2014) as well as to emotional interpretation and communication (Dapretto et al., 2005; Depalma & Lisiewski, 2009; Endicott et al., 2008; Carr et al., 2003; Molnar-Szakacs & Overy, 2006). The modeling now discussed here may help clarify the full communication system in which MNS-related brain function is embedded.

Applications: Human Interpretation of Behavior in Relation to Emotion. King illustrates the interpretation of the influence of emotion on an observed animal's activity. There are many ways to make such an interpretation, but they all require some kind of mental model of the effect of emotion on behavior applied to what is observed, and thus involve demodulation in the most general sense discussed here. This formal modeling can clarify connections to other research showing that emotion affects behavior continuously and that MNS systems may be involved in interpreting observed behavior through internal simulation of related effects on one's own behavior.

King uses both short- and longer-term effects on behavior as evidence of the presence and effects of emotion in animals. Both types of effects must be addressed in models concerning demodulation discussed here.

Dynamics of Bonding and Signs of Love and Grief in Animals. King's examples show great variety in the dynamical growth of bonding and of signs of loving she discusses. This may illustrate varieties in the development of emotional interaction between the animals as they learn to interpret one another's emotional signaling whether transmitted through direct signs or through actions. That bonded individuals then show behavioral signs we interpret as expressing love supports the possibility that the animals come to interpret one another's behaviors similarly and that this maintains their bonding.

When one partner dies or leaves, the signs of love expected by the observing partner leave with them. King's evidence supports her hypothesis that depth of grief is strongly related to extent of love for the deceased or departed partner. The modeling proposed here supports her contention that the absence of signals of love from the departed partner helps to induce the behavior we interpret as expressing grief. By departing, the partner signals end of participation in loving. This purely behavioral signal may well be critical to inducing signs of grieving that follow.

Group demonstrations of grief-related behavior exhibited by horses, as described by King, can be showing similar social-level dynamics.

Conclusion. King provides extensive evidence that animals can interact emotionally in complex ways. As illustrated and discussed here, the ability of animals to read one another's emotions through some kind of demodulation of the effect of emotions on observed actions may help explain such complex behavioral interactions. Animals may interact emotionally not only intentionally, through specific signaling, but also more generally and more continuously by interpreting one another's behaviors. The ability to read one another's emotions from behavior is undoubtedly adaptive, and research is needed to better understand its evolution. The model can also be extended to further clarify the communication of emotion by music (Gardiner, 2008b, 2012, 2015).

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