ESSAY

Love: Neuroscience reveals all

Poetry it is not. Nor is it particularly romantic. But reducing love to its component parts helps us to understand human sexuality, and may lead to drugs that enhance or diminish our love for another, says **Larry J. Young**.

In his *Love's Trinity*, the Victorian poet laureate Alfred Austin sums up the holistic view of love that has long held sway:

Soul, heart, and body, we thus singly name,
Are not in love divisible and distinct,
But each with each inseparably link'd.

Now researchers are attempting to isolate and identify the neural and genetic components underlying this seemingly uniquely human emotion. Indeed, biologists may soon be able to reduce certain mental states associated with love to a biochemical chain of events. This has implications for the evolution of human sexuality, and raises important societal issues given our increasing use of genetic tests to screen for certain behaviours, and of drugs to modulate mental processes.

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Animal models have greatly aided our understanding of the mechanisms that regulate emotions — particularly for evolutionarily conserved states such as fear and anxiety. These advances have led to pharmaceutical therapies for anxiety, phobias and post-traumatic stress disorders. Such models are also beginning to shed light on love.

We are not alone in being able to form intense and enduring social ties. Take the mother–infant bond. Whether or not the emotional connection between a ewe and her lamb, or a female macaque and her offspring, is qualitatively similar to human motherly love, it is highly likely that these relationships share evolutionarily conserved brain mechanisms. In humans, rats and sheep, the hormone oxytocin is released during labour, delivery and nursing. In ewes, an infusion of oxytocin into the brain results in rapid bonding with a foreign lamb.

Long-term bonding between mates is rare in mammals. It may be regulated by the same brain mechanisms as those involved in maternal bonding. For instance, pair bonding in the female monogamous prairie vole is stimulated by oxytocin released in the brain during mating. A female prairie vole rapidly becomes attached to the nearest male if her brain is infused with oxytocin. The hormone interacts with the reward and reinforcement system driven by the neurotransmitter dopamine — the same circuitry that drugs such as nicotine, cocaine and heroine act on in humans to produce euphoria and addiction.

There is intriguing overlap between the brain areas involved in vole pair bonding and those associated with human love. Dopamine-related reward regions of the human brain are active in mothers viewing images of their child. Similar activation patterns are seen in people looking at photographs of their lovers.

The notion that pair bonding in humans may have evolved through a tweaking of the brain mechanisms underlying maternal bonding could explain certain unique characteristics of human sexuality. For example, female sexual desire may have become decoupled from fertility, and the female breast may have become an erotic stimulus for males, to activate ancient maternal-bonding systems. The stimulation of the cervix and nipples during sexual intimacy are potent releasers of brain oxytocin, and may function to strengthen the emotional tie between partners.

Pair bonding in males involves similar brain circuitry to that in females, but different neurochemical pathways. In male prairie voles, for example, vasopressin — a hormone related to oxytocin — stimulates pair bonding, aggression towards potential rivals, and paternal instincts, such as grooming offspring in the nest. Variation in a regulatory region of the vasopressin receptor gene, *avpr1a*, predicts the likelihood that a male vole will bond with a female.

Similarly, in humans, different forms of the *AVPR1A* gene are associated with variation in pair bonding and relationship quality. A recent study shows that men with a particular *AVPR1A* variant are twice as likely as men without it to remain unmarried, or when married, twice as likely to report a recent crisis in their marriage. Spouses of men with the variant also express more dissatisfaction in their relationships than do those of men lacking it. For both voles and humans, *AVPR1A* genetic polymorphisms predict how much vasopressin receptor is expressed in the brain.

The view of love as an emergent property of a cocktail of ancient neuropeptides and neurotransmitters raises important issues for society. For one thing, drugs that manipulate brain systems at whim to enhance or diminish our love for another may not be far away. Experiments have shown that a nasal squirt of oxytocin enhances trust and tunes people into others' emotions. Internet entrepreneurs are already marketing products such as Enhanced Liquid Trust, a cologne-like mixture of oxytocin and pheromones "designed to boost the dating and relationship area of your life". Although such products are unlikely to do anything other than boost users' confidence, studies are under way in Australia to determine whether an oxytocin spray might aid traditional marital therapy.

We don't yet know whether the drugs commonly used to treat disorders from depression to sexual dysfunction affect people's relationships by altering neurochemistry. But both Prozac and Viagra influence the oxytocin system. The quality of patients' relationships should be included in the list of variables assessed in controlled psychiatric drug studies.

The possibility that genetic variation may influence the quality of our romantic relationships also has intriguing implications. Perhaps genetic tests for the suitability of potential partners will one day become available, the results of which could accompany, and even override, our gut instincts in selecting the perfect partner. Either way, recent advances in the biology of pair bonding mean it won't be long before an unscrupulous suitor could slip a pharmaceutical 'love potion' in our drink. And if they did, would we care? After all, love is insanity. ■

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