JSPR

Adult attachment and the brain

James A. Coan

University of Virginia, USA

ABSTRACT

Individuals in adult attachment relationships regulate one another via overt emotional and social behavior. Attachment-related styles of utilizing social support moderate these regulatory effects. In recent years, the social and affective neurosciences have begun to clarify how these processes are instantiated in the brain, including the likely neural mechanisms of long-term felt security following past attachment experiences and the neural circuitry supporting the regulation of emotion by relational partners. In this brief review, I describe the neural systems involved in the formation and maintenance of adult attachment relationships and review the small amount of work to date on the neuroscience of adult attachment style. I then offer my own speculations about how adult attachment relationships conserve the brain's metabolic resources, especially those of the prefrontal cortex.

KEY WORDS: attachment • brain • emotion regulation • relationships

Human adults form interpersonal attachments analogous to, and perhaps derivative of, those they forged with their caregivers as children (Hazan & Shaver, 1987). These adult attachment relationships can confer a number of important potential advantages. Strategies for utilizing the resources associated with attachment relationships manifest as relatively stable trait-like individual differences called attachment styles (Mikulincer & Shaver, 2007). The advantages of attachment relationships include the attenuation of cardiovascular arousal (Grewen, Anderson, Girdler, & Light, 2003), reduced situational and basal glucocorticoid levels (Wiedenmayer, Magarinos, McEwen, & Barr, 2003), reduced threat-related brain activity (Coan, Schaefer, & Davidson, 2006), better health (Robles & Kiecolt-Glaser, 2003), and

---

All correspondence concerning this article should be addressed to James A. Coan, Department of Psychology, University of Virginia, 102 Gilmer Hall, PO Box 400400, Charlottesville, VA 22904, USA [e-mail: jcoan@virginia.edu].

Journal of Social and Personal Relationships © The Author(s), 2010. Reprints and permissions: http://www.sagepub.co.uk/journalsPermissions.nav, Vol. 27(2): 210–217.
DOI: 10.1177/0265407509360900

enhanced longevity (Rohrbaugh, Mehl, Shoham, Reilly, & Ewy, 2008). These advantages orbit a core attachment-related function: social affect regulation (Mikulincer, Shaver, & Pereg, 2003).

Adult attachment is not a unitary construct, especially at the neural level (Coan, 2008). Moreover, the neural bases of individual attachment styles are poorly understood. In this brief review, I will summarize some of the key neural structures involved in the formation and maintenance of adult attachment relationships, and review the small amount of work to date on how individual differences in adult attachment style may be instantiated in the brain. Along the way, I will offer some of my own speculations about how adult attachment relationships help to conserve the brain's metabolic resources, especially those of the prefrontal cortex (PFC).

The neuroscience of attachment

Normative adult attachment

The neural circuits putatively responsible for social bonding and interaction are also commonly associated with, and indeed are virtually inextricable from, those devoted to "ordinary" emotional responding (Coan, 2008; Insel & Fernald, 2004). Social affiliation and pair bonding are commonly linked to dopaminergic projections throughout the nucleus accumbens, PFC, ventral palladium, and ventral tegmentum, regions otherwise implicated in responses to rewards and punishments, emotion regulation, motivation, and personality (Coan, 2008; Panksepp, 1998). Overlap between neural circuits supporting social and emotional processes provide clues as to the function of attachment relationships, but of course do not tell the whole story. Adult attachment relationships rely, for example, on the activity of specific neuropeptides such as vasopressin and especially oxytocin. The density of oxytocin receptors in regions such as the nucleus accumbens appears to determine the degree of monogamy in social animals (Ross et al., 2009), and may be critical to the establishment of trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005).

In humans, as in many species, encounters with potential mates are unconditionally reinforcing. Pleasurable feelings attributable to dopaminergically mediated incentive motivation and endogenous opioid production begin the process of memory consolidation via the hippocampus with assistance by the amygdala, which tags sensory information associated with the encounter as salient, and the ventral tegmental area (VTA), which becomes additionally conditioned to those salient cues. Conditioning in the VTA provides additional incentive motivation to seek or anticipate future encounters with those cues, a process that is itself often experienced as pleasurable. Repeated exposures to the potential mate (assuming things go well) increase feelings of consummatory pleasure, promoting the development of yet more implicit and explicit associations with the potential attachment figure. These cues will later contribute to the dynamics of what attachment theorists call the attachment behavioral system, including distress at signs of separation from the potential mate and feelings of soothing and security after close proximity is restored (Insel, 2003). Importantly, and as elaborated below, individuals in an attachment relationship eventually become inextricable components of each other's emotion regulation system (Coan et al., 2006).

Normative adult attachment and affect regulation

The phenomenon of socially mediated affect regulation awaits a thorough neural explanation, although theory and behavioral research are important guides. At birth, infants are obviously dependent upon their caregivers for their most basic needs: food, shelter from the elements, protection from predators, even thermoregulation. Attachments provide the means of acquiring these provisions. As noted above, social behavior is deeply intertwined with emotion. In early attachment relationships, emotional experience motivates infants to maintain close proximity to their attachment figures, and emotional expression is the primary means through which attachment figures are made aware of the infant's physiological needs. Hofer (2006) has proposed that what begins as the regulation of basic physiological needs *via* expressed (and experienced) emotion gradually transforms into the regulation of emotion *per se*. This sets the stage for the classical notion that attachment figures serve as a *secure base* throughout childhood (Bowlby, 1973, 1982).

Children utilize the secure base as a means of regulating their anxiety as they explore their environments, and as a safe haven to return to if needed. By repeatedly learning that they have a safe place to turn to when distressed, children increase in confidence that the world is a basically safe place, reducing their anxiety overall and allowing them to move without fear further away from the secure base for extended periods of time (Ainsworth, Blehar, Waters, & Wall, 1978). Adult attachment relationships are probably homologues of the infant–caregiver bond, co-opted by natural selection to capitalize on the potential advantages of pair bonding (Fraley & Shaver, 2000). Thus, one should expect adults to experience negative affect attributable to activation of the attachment system when isolated or threatened, as well as a restoration of relatively positive affect upon the resumption of close proximity to, and soothing behavior by, the attachment figure. A wealth of evidence supports this prediction (Mikulincer & Shaver, 2007).

Attachment style

Idealized or normative accounts of adult attachment belie the observation that individuals employ sometimes dramatically divergent strategies for utilizing social resources, including resources provided by attachment figures. These strategies vary as a function of *attachment style*, which is itself thought to result from past experiences combining potential threats with the presence, absence, or specific behaviors, of early attachment figures. Behavioral research suggests that these attachment styles manifest as two independent axes: attachment anxiety and attachment-related avoidance.

Individuals who are generally low in attachment anxiety and avoidance are regarded as *secure*. This group comes closest to the normative story discussed above. Individuals high on both anxiety and avoidance are putatively wary of attachments out of fear of potential harm or loss. Those low in avoidance but high in anxiety are often said to be preoccupied with the status of their attachments, often excessively seeking reassurance. Those low in anxiety and high in avoidance are often regarded as dismissive of attachments and compulsively self-reliant.

Little is known about how attachment styles are instantiated in the brain. The extant database primarily provides glimpses of the *effects* of attachment styles on neural systems supporting emotion and attachment behaviors, without helping very much in explaining those attachment styles per se.

Insecurely attached infants of depressed mothers, for example, tend to show asymmetries in prefrontal activity lateralized to the right (Dawson et al., 2001), an indication that these infants are already showing a tendency toward avoidance or withdrawal as emotion regulation strategies (Coan, Allen, & McKnight, 2006). Using fMRI technology, Gillath and colleagues (Gillath, Bunge, Shaver, Wendelken, & Mikulincer, 2005) asked 20 women to think about, and then stop thinking about, negative relationship scenarios, as brain scans were acquired. Negative relationship scenarios increased activation in the dorsal anterior cingulate in individuals with high attachment anxiety. These individuals also showed lower levels of activation in the orbitofrontal cortex, however, which suggests that individuals suffering from attachment anxiety have difficulty engaging neural systems that might help them regulate their own negative thoughts. In a similar study, brain scans were acquired while participants told “attachment stories” in response to images depicting attachment-related situations (Buchheim et al., 2006). More frequent reports of loss through death, abuse, or abandonment corresponded with greater activation in the amygdala and hippocampus while viewing pictures of traumatic attachment situations, suggesting that past threats to the attachment system may sensitize threat responsive neural systems to potential loss or danger.

Social baseline theory

Social baseline theory (SBT; Coan, 2008) proposes that many mammalian and bird species are hard-wired to assume close proximity to conspecifics, and to utilize social proximity as a baseline affect regulation strategy. If true, then violations of the assumption of proximity should be unconditionally threatening. By contrast, proximity to and positive interaction with conspecifics should be implicitly regulating by decreasing perceived personal costs associated with potentially dangerous situations and environments. All of this is accomplished by the brain’s ability to monitor risk distribution and load sharing.

In *risk distribution*, social species benefit from the probabilistic distribution of risk: the ancient evolutionary strategy of safety in numbers. Examples include not only the likelihood of falling prey, but also the distribution of effort devoted to vigilance for predators, the maintenance of thermal energy (e.g., in species that huddle together, such as penguins), and predation, as when packs of predators target large prey (Krebs & Davies, 1993). *Load sharing* builds on the principle of risk distribution, adding the bonds of trust and interdependence that attachment relationships provide. A trusted companion is not only capable of probabilistically reducing your risk of predation, but will also engage in health- and safety-enhancing behaviors on your behalf, including, for example, the identification and acquisition of resources for you, vigilance for environmental threats to you, and the nurturing of your offspring. SBT suggests that both risk distribution and load sharing underlie socially mediated forms of affect regulation.

SBT and affect regulation

Non-human animals are incapable of regulating themselves by thinking things like "it's only a movie" because they do not have sufficiently powerful PFCs. By comparison, humans have very powerful PFCs, and commensurably powerful self-regulation capabilities. Even humans, however, cannot self-regulate for long periods of time without diminishing their self-regulation capabilities significantly (Galliot & Baumeister, 2007). This decline in self-regulatory capabilities follows the depletion of metabolic resources in the PFC, a cost that impairs other important prefrontally mediated operations (e.g., working memory) as well.

The biological principle *economy of action* suggests that organisms will conserve resources whenever they can, and that indeed they must continuously optimize the ratio of resources acquired to resources expended or they will not survive (cf. Krebs & Davies, 1993; Proffitt, 2006). According to SBT, the PFC represents a valuable and costly resource whose energy expenditures must be similarly managed, and socially mediated affect regulation is a powerful and efficient way to meet this need. SBT suggests social brains throughout the animal kingdom outsource, at lower cost, affect regulation (and problem solving, and memory) to their social networks. This explains why individuals tend to invest less effort in regulating negative affect in the presence of their attachment figure (Coan et al., 2006; Edens, Larkin, & Abel, 1992; Mikulincer & Florian, 1998; Robles & Kiecolt-Glaser, 2003). It is easy to see why this works. In a threatening situation, there may be four problems to solve. If you are alone, you *must* solve all four problems, which may involve a great deal of costly neural processing (and which, inefficiently distributed within your brain alone, might increase the probability of mistakes). If you are with a stranger, you know that at least one problem is taken care of (you no longer need to outrun the bear, for example, just the stranger). If you are with a trusted and interdependent partner, however, you may need to solve only two problems, or one (or, if you have an avoidant attachment style, *five*, making close relationships costly).

An example of the conservation of neural resources by social support is illustrated in a recent fMRI study by Coan et al. (2006). Women were confronted with the threat of shock under three brain scan conditions: alone, holding a stranger's hand, and holding their partner's hand. Women in high-quality relationships showed the least threat-related brain activation – little more than relatively automatic down-regulation of threat perception via the ventromedial PFC. Women in lower-quality relationships apparently perceived more personally relevant problems to solve, incrementally adding activation of the right anterior insula, superior frontal gyrus, and hypothalamus, a suite of activity associated with steadily increasing threat salience and the release of stress hormones. A major shift in perceived personally relevant problems occurred, however, during stranger hand holding, where, in addition to all previously noted activations, superior colliculus, right dorsolateral PFC, caudate and nucleus accumbens all became activated, suggesting additional vigilance and self-regulation efforts were needed. Finally, when women faced the shock alone, to all of the preceding activations were added increased activity in the ventral anterior cingulate cortex, posterior cingulate, supramarginal gyrus, and postcentral gyrus, suggesting that the coordination of threat-related arousal and musculoskeletal activity was needed too. In sum, it appeared that the presence or absence of a social resource, especially an attachment figure, determined (a) the number of problems that needed solving by the threatened individual and (b) the deployment of neural resources commensurate with solving those problems. The human brain utilizes social resources, especially attachment relationships, to economize its activity.

I expect that one of the functions of adult attachment style is to provide the brain with guidance about how personal resources are to be managed in the presence or absence of social resources. Elsewhere (Coan, 2008), I have described the brain as a "Bayesian" bet-making machine, making ongoing decisions about which resources to deploy, and at what level of effort given potential returns. It is likely that adult attachment styles represent "Bayesian" prior probabilities in estimating the utility of attachments and other social resources (see Fruteau, Voelkl, van Damme, & Noë, 2009, for a striking illustration of this possibility). It is likely that neural representations of adult attachment styles will be complex, involving, at the very least, individual differences in prefrontal, amygdalar, hippocampal, dopaminergic, oxytocinergic, and possibly serotonergic systems. Disassembling these processes will require viewing attachment and attachment style as higher-order constructs with many potential constituent processes. This will be greatly assisted by research strategies that emphasize collaboration across psychological, neuroscientific, and biological disciplines. The pursuit of animal models of attachment style, close attention to sex differences, greater attention to clinical manifestations of attachment-related problems, and increased reliance on experimental designs that emphasize person/situation interactions will propel the already rapidly developing science of attachment into the realm of neuroscience.

REFERENCES

Ainsworth, M. D. S., Blehar, M. C., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the Strange Situation*. Hillsdale, NJ: Erlbaum.

Bowlby, J. (1973). *Attachment and loss: Vol. 2. Separation: Anxiety and anger*. New York: Basic Books.

Bowlby, J. (1982). *Attachment and loss: Vol. 1 (2nd. ed.)*. New York: Basic Books.

Buchheim, A., Erk, S., George, C., Kächele, H., Ruchsow, M., Spitzer, M., et al. (2006). Measuring attachment representation in an fMRI environment: A pilot study. *Psychopathology, 39*, 144–152.

Coan, J. A. (2008). Toward a neuroscience of attachment. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (2nd ed., pp. 241–265). New York: Guilford Press.

Coan, J. A., Allen, J. J. B., & McKnight, P. E. (2006). A capability model of individual differences in frontal EEG asymmetry. *Biological Psychology, 72*, 198–207.

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological Science, 17*, 1032–1039.

Dawson, G., Ashman, S. B., Hessl, D., Spieker, S., Frey, K., Panagiotides, H., et al. (2001). Autonomic and brain electrical activity in securely- and insecurely-attached infants of depressed mothers. *Infant Behavior and Development, 24*, 135–149.

Edens, J. L., Larkin, K. T., & Abel, J. L. (1992). The effect of social support and physical touch on cardiovascular reactions to mental stress. *Journal of Psychosomative Research, 36*, 371–382.

Fraley, R. C., & Shaver, P. R. (2000). Adult romantic attachment: Theoretical developments, emerging controversies, and unanswered questions. *Review of General Psychology, 4*, 132–154.

Fruteau, C., Voelkl, B., van Damme, E., & Noë, R. (2009). Supply and demand determine the market value of food providers in wild vervet monkeys. *Proceedings of the National Academy of Sciences of the USA, 106*, 12007–12012.

Galliot, M. T., & Baumeister, R. F. (2007). The physiology of willpower: Linking blood glucose to self-control. *Personality and Social Psychology Review, 11*, 303–327.

Gillath, O., Bunge, S. A., Shaver, P. R., Wendelken, C., & Mikulincer, M. (2005). Attachment-style differences and ability to suppress negative thoughts: Exploring the neural correlates. *NeuroImage, 28*, 835–847.

Grewen, K. M., Anderson, B. J., Girdler, S. S., & Light, K. C. (2003). Warm partner contact is related to lower cardiovascular reactivity. *Behavioral Medicine, 29*, 123–130.

Hazan, C., & Shaver, P. R. (1987). Romantic love conceptualized as an attachment process. *Journal of Personality and Social Psychology, 52*, 511–524.

Hofer, M. A. (2006). Psychobiological roots of early attachment. *Current Directions in Psychological Science, 15*, 84–88.

Insel, T. R. (2003). Is social attachment an addictive disorder? *Physiology and Behavior, 79*, 351–357.

Insel, T. R., & Fernald, R. D. (2004). How the brain processes social information: Searching for the social brain. *Annual Review of Neuroscience, 27*, 697–722.

Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U., & Fehr, E. (2005). Oxytocin increases trust in humans. *Nature, 435*, 673–676.

Krebs, J. R., & Davies, N. B. (1993). *An introduction to behavioural ecology* (3rd ed.). Malden, MA: Blackwell.

Mikulincer, M., & Florian, V. (1998). The relationship between adult attachment styles and emotional and cognitive reactions to stressful events. In J. A. Simpson & W. S. Rholes (Eds.), *Attachment theory and close relationships* (pp. 143–165). New York: Guilford Press.

Mikulincer, M., & Shaver, P. R. (2007). *Attachment in adulthood: Structure, dynamics, and change*. New York: Guilford Press.

Mikulincer, M., Shaver, P. R., & Pereg, D. (2003). Attachment theory and affect regulation: The dynamics, development, and cognitive consequences of attachment-related strategies. *Motivation and Emotion, 27*, 77–102.

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. New York: Oxford University Press.

Proffitt, D. R. (2006). Embodied perception and the economy of action. *Perspectives on Psychological Science, 1*, 110–122.

Robles, T. F., & Kiecolt-Glaser, J. K. (2003). The physiology of marriage: Pathways to health. *Physiology and Behavior, 79*, 409–416.

Rohrbaugh, M. J., Mehl, M. R., Shoham, V., Reilly, E. S., & Ewy, G. A. (2008). Prognostic significance of spouse ***we*** talk in couples coping with heart failure. *Journal of Consulting and Clinical Psychology, 76*, 781–789.

Ross, H. E., Freeman, S. M., Spiegel, L. L., Ren, X., Terwilliger, E. F., & Young, L. J. (2009). Variation in oxytocin receptor density in the nucleus accumbens has differential effects on affiliative behaviors in monogamous and polygamous voles. *Journal of Neuroscience, 29*, 1312–1318.

Wiedenmayer, C. P., Magarinos, A. M., McEwen, B. S., & Barr, G. A. (2003). Mother lowers glucocorticoid levels of preweaning rats after acute threat. *Annals of the New York Academy of Sciences, 1008*, 304–307.