Aisthesis
PRATICHE, LINGUAGGI E SAPERI DELL'ESTETICO
rivista on-line del Seminario Permanente di Estetica
anno VI, numero 2

Aesthetics and Evolution

Nancy E. Aiken

About 2500 years ago Aristotle asked why art evokes emotion. I thought that if we knew *how* art evokes emotion, it might help to answer Aristotle's question. How art evokes emotion is a scientific question because emotions can be studied behaviorally and neurologically. The stimuli that evoke emotions can be matched with the kinds of emotions that have been evoked. If one can discover how art evokes emotion, it may become easier to discern *why* art evokes emotion. Thus, as I untangled the mystery of *how* art evokes emotion, it became obvious *why* art evokes emotion. As our species evolved, *Homo sapiens* became a cooperating, social species. However, at the same time, our ancestors developed big brains and the ability to think and plan for themselves individually. Consequently, two opposing behaviors evolved: cooperation and individualism. Thinking about why people make art from an evolutionary point of view, I have found that art making evolved as a behavior that serves to bind individuals into cooperative group members. This paper summarizes my work that is available with much more detail and explanation in two books: *The Biological Origins of Art* (1998) and *Why Art Matters* (online at www.nancyeaiken.net). The first book is concerned with how art evokes fear. The second book is concerned with how art evokes pleasure and why it evokes emotion. I reached these conclusions keeping in mind the premise that art, being a pervasive human behavior across time and space, must have an evolutionary adaptive purpose; that is, it must be a necessary part of being human.

When people respond to art the response might be pleasurable resulting in a smile and a feeling of rightness or the response might be thrilling resulting in a feeling of excitement. These are the basic emotions of pleasure and fear. It has been suggested that emotion evoked by art is somehow different from emotion evoked by "real" events such as pleasure

from friendly social interaction or fear from having nearly been hit by a car. Nevertheless, emotion evoked by art is the same as emotion evoked by a "real" event; however, it is generally subdued due to its context as art and not as a "real" event (See Aiken [1998a]: 27 (note 9), 102-107). A neuroethologist asks what stimulates the emotion and can it be followed through the sensory system to the behavioral response. In this paper I will demonstrate how art can evoke fear neurobiologically from the stimulus to the response and, with a little less precision, because it is not so well studied, I will do the same for pleasure. I will also discuss why art persists through time and across cultures.

How art evokes fear

An ethological releaser is an unconditioned stimulus that will cause a response more or less predictably every time it is presented. For example, a loud, sudden sound is likely to cause you to startle. You might habituate to it if it is repeated several times in a row, but, given a lapse of time between the loud, sudden sound, you will respond rather predictably with a startle. I have proposed that releasers such as the loud, sudden sound are used in art to evoke emotional response (see Aiken [1998a]: 50-67). A couple of releasers used in visual art to evoke some level of fear are eye spots and zigzag lines. Eye spots are two circles horizontally placed to look like eyes. Eye spots have been researched as releasers of fear (see Aiken [1998a]: 110-113 & Aiken [1998b]). Masks often offer excellent examples of the eye spot releaser (see Coss [1968]: 279 & Aiken [1998a]: 112-113).

Zigzag lines, as sharp and pointed shapes, are likely releasers of fear. Early work indicates that pointed lines have an emotional effect that differs from curved lines. For example, in 1924 Poffenberger and Barrows had subjects match adjectives to lines and found that sad, quiet, and lazy were matched to big curves, merry and playful were matched to small and medium curves and small and medium angles were matched to agitating and furious (Poffenberger & Barrows [1924]: 187-205). More recently, Johanna Uher (now Forester) essentially replicated the Poffenberger and Barrows test with the same results (Uher [1991]). While these tests matched emotion-laden adjectives with curved or zigzag lines, Richard Coss tested the effects of curved versus angled lines on pupil dilation and found a significant difference in dilation (Pupils dilate when fear is felt.) when viewing the different linear qualities (Coss [1965]). Picasso's *Demoiselles d'Avignon* exemplifies the unease and,

even, alarm evoked by the pointed quality of the lines and the eye spots (See Aiken [1998a]: 113-121 for more examples).

Eye spots and curved versus zigzag lines have some research to back up the notion that they are releasers of specific emotions and of their rather obvious use in art, but this is not the case for alarm calls and predator howls used in music to evoke fear. However, research has demonstrated that a threat in alarm calls is recognized across species (Seyfarth & Cheney [1990]). These calls are known to cause gooseflesh or a tingle down the spine which is a pilomotor reflex associated with fear. One study found that music caused gooseflesh (Gray [1955]).

Releasers, as unconditioned stimuli, can evoke emotion when used in art and can also create conditioned stimuli by Pavlovian conditioning which can also evoke emotion in art. While unconditioned stimuli are responded to inherently by all, conditioned stimuli are individualized; thus, individual differences in conditioned learning can cause differences in response to art.

Although a loud sound may be aversive in real life or in art, in real life it might be a car screeching its breaks heading right for you, but in art a loud, screeching sound poses no personal danger. Art is safe and the work of neuroscientist, Joseph E. LeDoux (1992 & 1994) has demonstrated how releasers can evoke fear in the safe environment of art (although his work was not addressing art). A threat stimulus (such as an eye spot) is perceived by the appropriate sensory system and the information is sent to the thalamus where, it would appear, the brain stores information to allow for a rough match between the stimulus and inherent cues for danger (releasers). The thalamus forwards the information to the amygdala and the appropriate sensory area of the cortex with the information arriving at its destinations at about the same time. The amygdala sends its information to the defense coordinator in the periaquaductal gray to set off the visceral alerting response which prepares the individual for fight or flight. This is the fast track for defense. Meanwhile sensory cortex has processed the information sent by the thalamus putting together a clear picture of the information and sends this back to the amygdala. At the same time, the hippocampus is sending contextual information to the amygdala.

When the clear picture is put together with the context, the individual can determine if a threat is actually present. It is at this point that humans can make the conscious association between stimulus and response and call it fear. However, when a threat stimulus is used in

art, the intensity level is usually low and the context is safe, therefore, the effect is fleeting; conscious association seldom occurs. LeDoux points out that the thalamic relay works at a preconscious level, so activating the visceral alerting response leaves us with the remains of a feeling we often are unable to name (LeDoux [1992] & [1994]). This is why Kant called aesthetic response a special response different from other emotional responses (Kant [1951]). The fast track for defense also provides a means for conditioning otherwise neutral stimuli so that they, too, activate the visceral alerting response (See Aiken [1998a]: 102-106 for further discussion).

Why should art evoke fear? Fear is a great motivator. Tyrants have proven over and over again that an enemy at the gate will create enough fear to cause people to give up everything to keep the enemy (real or imagined) out. The school yard bully uses gangster tactics to get what he or she wants. Fearful people will do what the leader wants, but they may plot rebellion. However, if the leader uses artful tactics to create fear, the people will do what the leader wants without realizing they have been manipulated by fear because they do not recognize their response as fear. I call this "closed" coercion because people may make the decisions the tyrant wants, but the people do not recognize the source of their decisions. Of course, decisions made because of closed coercion will be in the best interests of the leader; however, it is possible the decisions may be in the best interests of the followers also.

How art evokes pleasure

Zihlman and Bolter (2004: 37) note that the integrity of non-human mammalian social communities is maintained over time by the «emotional and social bonds that are formed during maturation and the affiliative skills practiced through life» (Zihlman and Bolter [2004]: 37). These emotional and social bonds in mammals are reinforced and cemented by the release of the neuropeptide, oxytocin, for females and arginine-vasopressin for males along with opioids such as the endorphins and enkephalins and dopamine. The release of these brain chemicals makes individuals feel good. They are released during friendly social interaction (Panksepp [1998]: 247, 348, 255; Keverne & Curley [2004]: 777). Keverne and Curley (2004: 777-778) in their study of voles found that not only does oxytocin stimulate maternal behavior but it aides in recognition of offspring. Species that form pair bonds

share other traits such as care of offspring, reduced sexual dimorphism, aggression toward strangers, incest avoidance, and extended families (Carter & Cushing [2004]: 102).

Implications for social behavior found in the studies with voles hold true for humans also. Jaak Panksepp notes that touch and, more dramatically, holding appear to activate the opioid system (Panksepp [1998]: 267 & 272). Panksepp (1998: 249) writes that «brain oxytocin, opioids, and prolactin systems appear to be the key participants in these subtle feelings that we humans call acceptance, nurturance, and love – the feeling of social solidarity and warmth». Not only do these brain chemicals work to provide good feelings, but they appear to deactivate critical assessment of the situation and negative feelings (Bartels & Zeti [2004]: 1162). Holding and touching baby and rocking and rhythmically interacting with baby would activate the appropriate brain chemistry systems flooding care-giver and child with feelings of pleasure and well being.

Thus, a substantial evolutionary infrastructure provides for such human behaviors as pair and social bonding, extended parental care of offspring, extended families, ethnocentrism, and xenophobia. Humans evolved as social animals who need to be part of a group. Probably, this need arose because survival was more likely if there were others of their kind who could come to their aid, help hunt and gather food, help care for children, and help defend the group from predators and other, non-allied, groups of hominids (See www.nancyeaiken.net, chapter 1 for further discussion). Among others, Sarah Blaffer Hrdy argues that humans are «cooperative breeders» as this strategy allowed our ancestors to produce costly, slow-maturing infants. With help from others in the group, more infants could be raised successfully (Hrdy [2009]: 239-245; 276-277).

A mechanism was needed to bond mothers and other caretakers to infants in order to provide the long-term care necessary to raise a human infant. Ellen Dissanayake and Irenaus Eibl-Eibesfeldt propose that our ancestors elaborated ordinary primate facial expressions, gestures, and vocalizations into baby talk to provide the needed attachment. The resulting synchronized, rhythmic vocalizations and movements result in an emotional bond between mother and baby (Eibl-Ebesfeldt [1998] & Dissanayake [2000]: 14-16). Baby talk relies on the mammalian bonding mechanism that bonds other mammals into mating pairs. The mammalian bonding mechanism consists of rhythmic movement which releases dopamine, the opioids, and oxytocin resulting in pleasure and trust, and, thus, bonding (Panksepp [1998]; Young, et. al. [2001]; Keverne & Curley [2004]; Kosfeld, et. al. [2005]).

Dissanayake suggests that the synchronized rhythms, vocalizations, and movements of baby talk became chanting, singing, and dancing – or the temporal arts (Dissanayake [2000]: 9-10, 160). The temporal arts can provide the emotional bonding that promotes social unity and the willingness to work together because the brain chemicals released by the rhythmic activity makes us feel really good and what we are doing feels right (see www.nancyeaiken.net, Chapter 2 for a more thorough discussion). A recent fMRI study of 17 people listening to a piece of classical music, which none of them had heard before, identified brain activity from the midbrain to cortex. The study found that all participants' brains tracked the musical stimulus in similar ways. The authors note that the brain areas stimulated foreshadow those movements that typically accompany listening to music such as clapping, dancing, marching, singing, and head bobbing thus facilitating social coordination (Abrams, et.al. [2013]: 11). Thus, moving together in time to the music is more or less pre-programmed by our brains and activating the mammalian bonding mechanism which makes us trusting and caring for each other.

Pleasure is an even more effective way than fear to get people to follow the leader. Moving together in time provides pleasurable feelings resulting in bonding and trust. Pleasure in the extreme can make "true believers" who will do the bidding of a leader for good or evil (Sargant [1974]: 124, 196-197; www.nancyeaiken.net). However, it should be remembered that both of these ways of getting people to follow the leader were and still are used for the people's benefit; otherwise, the behavior would not be adaptive.

Conditioning by Art

Briefly outlined above are the two mechanisms that provide art with the ability to evoke emotion. (Since this is a brief outline, space does not allow for the more complete discussion in my two books; consequently a review of these longer, more developed works should be enlightening). These are basic neural mechanisms that by arousing emotion provide for individual safety via the defense response and the bonding mechanism which provides for the means of procreating and caring for offspring. These crucial mechanisms operate below the level of conscious thought. *Art, by co-opting them, can manage behavior without arousing rational thought.*

Unconditioned stimuli evoking fear and the mammalian bonding mechanism evoking pleasure, when associated with neutral stimuli, create conditioned responses that evoke the

same emotion. Conditioned responses to both fearful and pleasurable stimuli form individual response to art.

As childhood lengthened for our species, the number of offspring raised to reproductive age had to be reduced. A mother could not have a child a year and raise them all to maturity. Kathryn Coe argues, along with Palmer and Steadman (Coe [1992]: 217-234; Coe [1995]; Palmer & Steadman [1997]: 39-51), that, for humans, cooperative behavior cannot be adequately explained by inclusive fitness theory or reciprocal altruism (for a discussion see Coe [2003]: 18). While the argument is complex, one important point is that a true measurement of reproductive success is not the number of offspring a parent has but the number of one's distant descendants. Based upon that thinking, Coe and I argue that human cooperative behavior results from a parenting strategy aimed, unconsciously, at leaving descendants (Aiken & Coe [2004]: 5-20). For this to occur, each generation had to cooperate with each other in order to protect and nurture the next generation. An important function of art, Coe argues, is to encourage that cooperative behavior (Coe [2003]: 14-17). Survival became less dependent upon reflexes and more dependent upon learning. A fool-proof method of learning evolved. Survival techniques were taught using sounds and visual effects that evoked unconditioned emotional responses and these were paired with the information to be learned creating conditioned emotional memories. These techniques evolved with the increasing malleability of human children so that traditions, technologies, beliefs, language – culture – could be inculcated and the individual would learn to become a cooperative, social being helping others as one would help close kin to survive. Learning by classical conditioning tends not to be forgotten so that art (the vehicle of the conditioning) can affect behavior both immediately and long term. Generally, we are unaware that we have been conditioned and our behavior has been so influenced.

At some point language developed and stories were likely told that would give information vital to the survival and reproduction of individuals within the group. These stories would have been handed down generation after generation in order to preserve the life style that spelled success. Kathryn Coe, Craig T. Palmer, and I argue that traditional children's stories (stories told orally in traditional societies) often contain important information and hearing that information in a story can have an important influence on behavior including having an effect on survival and reproduction. The techniques used in

stories such as metaphor, interesting characters, and, sometimes, fantastic ideas make the information interesting and, thus, memorable (Coe, Aiken & Palmer [2006]).

Traditional stories use many mnemonic devices to make their information memorable from talking animals to mother-to-baby sing-song. These mnemonic devices are used to form associations (classical conditioning) in the minds of listeners so that the information is reliably learned. In an expression of their authority story-tellers often claim to be descendants, and, often they are, of the ancient originators of the story (Coe, Aiken & Palmer [2006]: 28-29). We argue that the aim of the traditional story is to elicit the same behavior over generations in order to help maintain the traditions that have promoted successful survival and reproduction in the past (Coe, Aiken & Palmer [2006]: 30-32).

To support the argument on traditional stories, we described traditional Australian Aborigine stories about the "Dreamtime". These stories basically outline the laws of the ancestors that must be learned and followed in order to succeed in life both socially and physically. These stories describe the way to act in nearly every situation from kin relationships to subsistence strategies, to the ethics of generosity, to obligations and times when one needs to exhibit social restraints. Moreover they tell where the water holes are on the desert which is necessary knowledge for individual survival (Coe, Aiken & Palmer [2006]: 34-36).

It is not difficult to imagine our Paleolithic forbears sitting together and telling similar stories. Their subsistence strategies likely were different from those of Australian Aborigines due to the different environment they inhabited, but their social relationships and the rules they followed for social interactions were likely similar. In the same way our modern stories are different but our social rules are likely similar, e.g. honor and protect your family. So, art, by classical conditioning, can build memories that promote cooperation within the group and ways and means of survival and social behavior that provide each generation with tools for living and raising their offspring.

How Art is Adaptive

Why does this behavior enhance survival and reproductive success? Cooperative behavior has made our species successful. Many researchers have investigated what makes people cooperate with others and have offered four categories of reasons: kin selection, reciprocal altruism, coercion, and group selection. Coe and I discuss these categories giving reasons

why none of them can satisfactorily account for observed human cooperative behaviors (Aiken & Coe [2004]: 7-10). While all of these contribute to cooperative behavior, the ultimate answer lies in our sociality. Humans evolved as social beings and as such we share traits of other social mammals (See Sussman, Garber & Cheverud [2005]: 92-94). The human peculiarities of extremely protracted childhood, which leaves offspring vulnerable requiring extensive care for years, and intellectual capabilities beyond that of other animals, resulting in an unusual reliance on intellect rather than on reflex, created a special need for a mechanism that could provide a fool-proof method of inculcating important information that had proved to be successful to generation after generation and overcome rational thought when necessary to provide for the cooperation needed for success. *This special mechanism is art behavior which evokes emotion creating memories and decisions made under the radar of conscious, rational thought in order to elicit cooperation*.

Artists use releasers and the mammalian bonding mechanism to affect the emotions and, thus, the behavior of other human beings. It seems likely that as some of our ancestors were beginning to make use of such stimuli as loud, sudden sounds and zigzag lines to evoke fear and softly curved lines and soft, cooing sounds to evoke pleasure, all were attending to these stimuli and responding to them.

When the Cro-Magnons arrived in Western Europe (ca. 40,000 B.P.) they brought with them the means and ability to make sophisticated art. They made portable art and wall art. The wall art in caves displayed the ability to depict spatial perspective and motion (Clottes [2008]: 12). Cave art also included sculpture, clay modeling, engraving, and color painting (Clottes [2008]: 13). Paleolithic cave art ranges from geometric abstractions (such as curved lines and zigzags) to stick figured humans to graceful, realistic renderings of animals. Animals depicted generally are not animals that were eaten (Clottes [208]: 20). Jean Clottes argues that the most plausible thesis that best accounts for the facts is that the art was produced by the authority of shamans. Shamanism is very ancient and is the most widespread religion among hunter/gatherers (Clottes [2008]: 22). Lewis-Williams and Pearce argue that the animals depicted in the caves and in portable art were «spirit» animals that permeated pre-existing belief systems. The images are visions that enter or exit or exist as part of the rock surface which constitutes a «membrane» between the people and «an animal-filled spirit realm that lay just out of normal sight» (Lewis-Williams & Pearce [2005]: 82-83). Clottes notes that to venture into the decorated caves was akin to moving

between worlds and was done by a shaman in trance with, perhaps, an apprentice and those who needed healing (Clottes [2008]: 24). Visits in the caves appear to have been infrequent (Clottes [2008]: 21), so it is possible that not many people actually entered the caves. I suspect that fear is too calm a term to describe the experience inside the decorated caves; most likely, terror would be an accurate description of the emotion felt by the visitors brought in by the shamans who would also use dramatic lighting and sounds to heighten the intensity of the emotional effect. Inside the caves it would have been religion experienced literally (Lewis-Williams & Pearce [2005]: 84). Imagine actually visiting the Christian Hell of the Middle Ages. Those who actually experienced the caves could tell others about their visit, and belief would be unquestioned. There must have been an extremely strong need for cooperation with the beliefs and practices of the cultures to go to this extreme. Also it is likely that art appreciation as we know it may not have come about until art was "tamed" by the early Mediterranean civilizations. Although art still awes, it seldom evokes terror as I suspect it did in the Paleolithic and, later, in the Neolithic.

Conclusion

Why do humans make and respond to art? Art uses unconditioned stimuli and the mammalian bonding mechanism to evoke emotional responses. The unconditioned stimuli, releasers and the mammalian bonding mechanism are paired with otherwise neutral stimuli via classical conditioning to provide individualized response to art. Art is a special mechanism peculiar to humans. While other animals come equipped with inherited behaviors that have proved successful for them over their evolutionary history, humans, while also so equipped, have, in addition, the ability to amend natural inclinations and to invent new behaviors. Humans have behavioral flexibility that other animals do not have. As our ancestors began to be able to think consciously and rationally, art behaviors likely evolved at the same time to offset selfishness, lack of concern for others, and lack of cooperation with others. The sociality and cooperation necessary for social living would break down putting individuals, and especially children, at extreme risk. Art behaviors evolved as a means of counteracting our big brain's ability to make rational decisions when the situation could cause a social and cooperative breakdown.

Bibliography

Abrams, D.A., Ryali, S., Chen, T., Chordia, P., Khouzam, A., Levitin, D.J., & Menon, V., 2013: *Intersubject synchronization of brain responses during natural music listening*, "European Journal of Neuroscience", 37 (9), pp. 1-12.

Aiken, N.E., 1998a: *The Biological Origins of Art*, Praeger, Westport, CN & London.

Aiken, N.E., 1998b: *Human cardiovascular response to the eye spot threat stimulus*, "Evolution & Cognition", 4 (1), pp. 51-62.

Aiken, N.E., 2010: *Why Art Matters*, www.nancyeaiken.net.

Aiken, N.E. & K. Coe, 2004: *Promoting cooperation among humans: The arts as the ties that bind*, "Bulletin of Psychology and the Arts", 5 (1), pp. 5-20.

Carter, C.S. & Cushing, B.S., 2004. *Proximate mechanisms regulating sociality and social monogamy in the context of evolution*, in R.W. Sussman & A.R. Chapman (eds.), *The origins and nature of sociality*, Aldine De Gruyter, New York, pp. 99-121.

Clottes, J., 2008: *Cave Art*, Phaidon, New York & London.

Coe, K., 1992: *Art: The replicable unit – An inquiry into the possible origin of art as a social behavior*, "Journal of social and evolutionary systems", 15 (2), pp. 217-234.

Coe, K., 1995: *Voices from our ancestresses: Moral systems and art*, Dissertation Abstracts.

Coe, K., 2003: *The ancestress hypothesis: Visual art as adaptation*, Rutgers University Press, New Brunswick, N.J. & London.

Coe, K, Aiken, N.E., & Palmer, C.T., 2006: *Once upon a time: Ancestors and the evolutionary significance of stories*, "Anthropological Forum", 16 (1), pp. 21-40.

Coss, R.G., 1965: *Mood Provoking Visual Stimuli: Their Origins and Applications*, University of California Industrial Design Graduate Program, Los Angeles.

Coss, R.G., 1968: *The ethological command in art*, "Leonardo", 1, pp. 273-287.

Dissanayake, E., 2000: *Art and Intimacy: How the Arts Began*, University of Washington Press, Seattle & London.

Eibl-Eibesfeldt, I., 1998: *Us and the others*, in I. Eibl-Eibesfeldt & F.K. Salter (eds), *Indoctrinability, ideology, and warfare: Evolutionary perspectives*, Berghahan Books, New York, pp. 21-53.

Gray, R.M., 1955: *The pilomotor reflex in response to music*, Master's thesis, University of Kansas.

Hrdy, S.B., 2009: *Mothers and Others: The Evolutionary Origins of Mutual Understanding*, Belknap Press, Cambridge, Mass. & London.

Kant, I., 1951: *Critique of Judgment*, trans. J.M. Bernard, Hafner, New York.

Keverne, E. & Curley, J., 2004: *Vasopressin, oxytocin and social behavior*, "Current Opinion in Neurobiology", 14, pp. 777-783.

Kosfeld, M., Heinrichs, M., Zak, P., Fischbacher, U., & Fehr, E., 2005: *Oxytocin increases trust in humans*, "Nature", 435 (2), pp. 673-676.

LeDoux, J.E., 1992: *Emotion as memory: Anatomical systems underlying indelible neural traces*, in S. Christianson (ed.), *The handbook of emotion and memory: Research and theory*, Lawrence Erlbaum Associates, Hillsdale (N.J.).

LeDoux, J.E.,1994: *Emotion, memory and the brain*, "Scientific American", 270 (6), pp. 50-59.

Lewis-Williams, D., & Pearce, D., 2005: *Inside the Neolithic mind: Consciousness, cosmos and the realm of the gods*, Thames & Hudson, London.

Palmer, C.T., & Steadman, L.B., 1997: *Human kinship as a descendant-leaving strategy: A solution to an evolutionary puzzle*, "Journal of social and evolutionary systems", 20 (1), pp. 39-51.

Panksepp, J., 1998: *Affective neuroscience: The Foundations of Human and Animal Emotions*, Oxford University Press, New York & Oxford.

Poffenberger, A.T., & Barrows, B.E., 1924: *The feeling value of lines*, "Journal of Applied Psychology", 8, pp. 187-205.

Sargant, W., 1974: *The mind possessed: A physiology of possession, mysticism and faith healing*, Lippincott, New York.

Seyfarth, R.M., & Cheney, D.L., 1990: *The assessment by vervet monkeys of their own and another species alarm calls*, "Animal Behavior", 40, pp. 754-764.

Sussman, R.W., Garber, P.A., & Cheverud, J.M., 2005: *Importance of cooperation and affiliation in the evolution of primate sociality*, "American journal of physical anthropology", 128, pp. 84-97.

Uher, J., 1991: *Die asthetic von zick-zack und welle: Ethologische aspekte der wirkung linearer muster*, Universitat Munchen Ph.D dissertation, Munchen.

Young, L., Lim, M., Gingrich, B., & Insel, T., 2001: *Cellular mechanisms of social attachment*, "Hormones and Behavior", 40, pp. 133-138.

Zihlman, A.L., & Bolter, D.R., 2004: *Mammalian and primate roots of human sociality*, in R.W. Sussman & A.R. Chapman (eds.), *The origins and nature of sociality*, Aldine De Gruyter, New York, pp. 23-52.