
Ethology, Interpersonal Neurobiology, and Play

Insights into the Evolutionary Origin of the Arts



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The author considers the biological basis of the arts in human evolution, which she holds to be grounded in ethology and interpersonal neurobiology. In the arts, she argues, ordinary reality becomes extraordinary by attention-getting, emotionally salient devices that also appear in ritualized animal behaviors, many kinds of play, and the playful interactions of human mothers with their infants. She hypothesizes that these interactions evolved in humans as a behavioral adaptation to a reduced gestation period, promoting emotional bonding between human mothers and their especially helpless infants. She notes that the secretion of opioids, including oxytocin, that accompany birth, lactation, and care giving in all mammals is amplified in human mothers by these devices, producing feelings of intimacy and trust that engender better child care. The same devices, exapted and acquired culturally as arts, she argues, became prominent features of group ritual ceremonies that reduced anxiety and unified participants, which also offered evolutionary advantages. **Key words:** artification; ethology; interpersonal neurobiology; mother-infant play; origins of the arts

FOR MORE THAN FIVE DECADES, I have investigated and pondered the biological basis of the arts. When, where, and how did the arts begin in human evolution? Why did they arise and become an enduring part of the human repertoire on every continent and in every environment and cultural group, and evident even in every toddler and child? Is there a common feature that characterizes all art?

My first (and continuing) point of departure is ethology—the biology of behavior. Because the way of life (behavior) of any animal has evolved to help it survive in a particular environment, ethologists observe animals in their natural habitat. Because the human species has spent more than 99 percent of its time

on earth living as hunter-gatherers, my focus (on the human animal) has been on pre modern or traditional ways of life.

When looking for universal features of the arts, contemporary ideas about arts and aesthetics are misleading. Traditional societies often have no word for art, even though they practice arts in forms such as decorating (bodies and objects), carving, singing, dancing, drumming, chanting, playing instruments, speaking poetically, giving dramatic presentations, enhancing their surroundings—and have words for all these activities. Such societies also have words for beauty, skill, and even aesthetic value, but they do not discourage or prohibit beginners and bunglers from attempts to display them. Nor do they always expect art to be harmonious, spiritual, or even creative—the usual characteristics that Western aesthetics require to call something art.

I wondered whether the common denominator for art should be sought not in one or another quality (noun or adjective) but in what art makers and participants did (a verb). My first question then became: “What do people—ordinary people, including children, as well as artists—do when they engage in art?” Emphasizing behavior—what people do, rather than what art is—was a new and appropriately ethological approach to the subject of art.

My answer has emerged over the years, influenced by what I learned—often accidentally from something I happened to read or hear. Crucial pieces of my thinking about art concern the two subjects covered in this special issue of the *American Journal of Play*: play and interpersonal neurobiology. It began with the former (Dissanayake 1974) and some two decades later incorporated the latter (Dissanayake 1999).

An unexpected new hypothesis (the artification hypothesis) emerged from my work in these two fields. Additionally, in my quest to understand how art began, I discovered a plausible evolutionary explanation for how and why interpersonal neurobiology in humans itself began in the common, ordinary playful interactions between ancestral hominin mothers and infants. No one else has proposed this, which I describe in this article. “Hominin,” here, refers to the group that consists of modern humans, extinct human species, and all our immediate ancestors—that is, members of the genera *Homo Australopithecus*, *Paranthropus*, and *Ardipithecus*. It replaces the older, and more comprehensive label, “hominid,” which today includes all modern and extinct great apes—that is, modern humans, chimpanzees, gorillas, and orangutans plus all their immediate ancestors.

Crucial Components of the Artification Hypothesis

Play

In the 1960s, when I began my investigation of human art making, little had been written about art as a universal biological endowment of evolution except for an influential book by ethologist Desmond Morris. In *The Biology of Art* (1962), he described painting by captive primates, and he traced mark making to play. An ethological study of play in mammals by a German ethologist (Meyer-Holzapfel 1956) described characteristics of animal play that struck me as similar to some characteristics of the arts. First, animal play is not serious, which does not contradict the reminder by many authors that play is serious business but instead makes the point that it is not directly concerned with survival—finding food, seeking a mate, or desperately fighting a foe. A related feature is that play is nonfunctional (but spontaneous and labile) when compared to goal-directed, survival-related behavior. It is autotelic (self-rewarding), generally social, composed of repeated exchanges of tensions and releases, related to exploration and the seeking of stimulation (i.e., an attraction to novelty and surprise), pleasurable, and metaphorical (as when, for example, a suitable toy becomes “prey”).

Although the play of human children does not fit these characteristics in all details and has additional characteristics, the subject of play in human evolution seemed worthy of more thought, especially when I realized that the children of our remote hominin ancestors would surely have played. My first published article (Dissanayake 1974) was an investigation of the similarities between play and art in an evolutionary context. I would not write that article in the same way today, having since incorporated other subjects that at the time I could not have foreseen. Importantly, the evolutionary connection between art and play is now supported and enhanced by much more recent information about another kind of play, the universal human behavior of mother-infant interaction (as it plausibly originated in our remote ancestors) and its neurobiological underpinnings. Later in this article, I will refer again to correspondences between play and artification and between mother-infant interaction and a behavior of artification.

Interpersonal Neurobiology in Mother-Infant Interaction

Studies of what is now called interpersonal neurobiology grew out of the work of developmental psychologists of infancy, stemming from the pioneering work on attachment by British child psychiatrist John Bowlby. Bowlby, incidentally, was the first psychologist of infancy whose perspective was based, like mine,

on ethology (Bowlby 1969). He observed the reactions of young children who for various reasons—illness, death, wartime dispersals, abandonment—had been separated from their mothers, and proposed that there is a positive need for infants to form what he called “attachment” with caretakers. By the age of about eight months, especially in circumstances of uncertainty, children in all cultures do similar things to attract and sustain their mothers’ attention: they cry when separated, lift their arms to be picked up, cling to her body, stay near her, and even when playing happily look at her frequently. They do this whether or not a mother has shown them affection.

Bowlby suggested that the evolutionary value of attachment was that it helps prevent the hunter-gatherer’s helpless baby from wandering off and ensured that, when frightened or alone, it would cry, reach out, move toward, or otherwise try to resume contact with a specific protective figure. This made the human baby less vulnerable to predators and accidents. Many helpless young birds and mammals exhibit similar behaviors.

In the years since Bowlby’s formulations, research with much younger infants has enriched his pioneering work, showing quite remarkable and unexpected early abilities and proclivities for interaction and intimacy. These suggest that attachment—which in Bowlby’s scheme appears at about the time a baby moves around on its own and is concerned primarily with the infant’s physical safety—should be viewed as a late-appearing consequence of a prior, equally innate, and universal adaptive predisposition to engage in relationship and emotional communion, over and above the need for protection.

Infant psychologists Daniel Stern (1971, 1974), Beatrice Beebe (with others, 1977, 1979), Colwyn Trevarthen (1979), and Edwin Tronick (with others, 1979, 1980) were among the earliest investigators of the remarkable abilities of very young infants to engage with their mothers in a mutually improvised interaction (sometimes called “baby talk”), the psychological importance of which had been for years overlooked if not altogether dismissed. Long before the attachment that Bowlby described takes place, this common pastime, which may appear inconsequential, provides enjoyment and intimacy for both participants and significant developmental benefits for the infant.

Further research by a growing number of scientists has demonstrated that in this familiar and ordinary face-to-face play, both mother and baby are doing something quite specialized, based on inborn competencies and sensitivities. Using rhythmic head and body movements, gestures, and facial expressions as well as vocal sounds, the pair create and maintain communicative sequences that

are exquisitely patterned over time. Even newborns show sensitivity to temporal sequence and pattern and engage in behavioral turn-taking as early as eight weeks of age (Beebe 1986). By this age also, they expect social contingency—predictable back-and-forth interactivity (see also “interpersonal sequential dependency” in Miall and Dissanayake [2003, 339]). If a positive ongoing interaction is experimentally manipulated so that one partner’s signals are delayed only a few seconds, the other partner becomes perplexed and distressed. Even though one partner produces the appropriate signals, something seems wrong because they are not coordinated in real-time with the other’s behavior (Murray and Trevarthen 1985, Nadel et al. 1999). This mutual temporal coordination is truly remarkable in a baby so young. It heralds our later social lives, whether in conversation, social play, lovemaking, and—as I will show—music, dance, and other performance arts.

In 1995 neuroscientist and psychiatrist Allan N. Schore published the first of three monumental treatises that brought together hundreds of scientific studies demonstrating the psychobiological underpinnings of social-emotional functioning that develops during right brain-to-right brain communication in the caretaker-infant interaction. This is a far different focus from the (still) reigning neuroscientific emphasis on the development of cognition, language, and memory. Schore’s work also referenced studies of mammalian maternal behavior by neuroscientist Jaak Panksepp, whose *Affective Neuroscience* (1998), systematized the neurology, neuroanatomy, neurochemistry, and functions of the emotional brain. A reader interested in Panksepp’s scientific trajectory (in which he, like Schore, has developed revolutionary theoretical perspectives that are still not widely enough recognized) might wish to consult an interview with him in the winter issue of the *American Journal of Play* (2010), in which he makes clear the influence of ethology in his formative thinking. Among other core emotional systems in all mammals, including of course humans, Panksepp’s work elucidates the brain systems for play and maternal care.

What is Artifying?

As I have described, because of the bewildering cornucopia of ideas about what art is and what art does, I considered ethology the most helpful starting place to examine the arts’ biological origin and original functions. That is, I came to conceptualize art as a behavior (or behavioral predisposition), rather than an object (work of art) or quality (beauty, skill) or cognitive capacity for symbolization.

Ethologically speaking, art is something that people evolved to do (like play, display, court, mate, mourn, establish territory and hierarchy, form families, practice aggression and ethnocentrism, and so forth). Because there is no verbal form of the behavior (e.g., “to art”), I looked for a descriptive label for what artists do. In my earliest thinking, I called the activity “make special” (Dissanayake 1974; 1988), which artists seemed to understand but scientists said sounded simplistic and unclear. I next called it “making the ordinary extra-ordinary” (Dissanayake 1992: 49), then “elaborating” (Dissanayake 2000), and in subsequent publications “artifying,” which embraces all these terms.

Artification and artifying refer to the behavior, observed in virtually all human individuals and societies, of intentionally making parts of the natural and manmade environment (e.g., shelters, tools, utensils, weapons, clothing, bodies, surroundings) extraordinary or special by marking, shaping, and embellishing them beyond their ordinary natural or functional appearance. I used the same term for behaviors that occur in vocal, gestural, and verbal modalities—that is, in what we call song, dance, poetic language, and performances of various types. By their nature, these arts take place in time and are easily conceptualized as behaviors, in contrast to visual arts, which are static—the result of behavior.

The archaeological record reveals that from the Middle Pleistocene (ca. 780,000–127,000 years ago), ancestors of our species recognized some objects, such as unusually shaped, marked, or colored stones, as special (Bednarik 2011; Dissanayake 1988). From at least 250,000 years ago and earlier, they displayed a mental capacity (and motivation) deliberately to make ordinary things extraordinary, as seen in three stone tools that were fashioned with a centrally embedded fossil (illustrated in Dissanayake 1988, 54 and 2000, 133). Other found objects were artified by means of coloring or engraving as well as being set in unusual places. We cannot know the motivations for doing these things, but such actions indicate that the object (or perhaps the occasion or place) was thereby situated in a nonordinary world or awarded a nonordinary status—thus possibly regarded as giving access to, or even hoping to, attract spirits from that world (see my description of ceremonial ritual to come).

Pieces of shaped colored ochre from three hundred thousand years ago suggest that body decoration may have been the earliest visual artification. In recent and contemporary premodern societies, ornaments that come from the bodies of rare, beautiful, powerful creatures—feathers, shells, teeth, carapaces—or the use of colorful minerals and other inorganic substances indicate that the wearer is or has become extraordinary, special.

The extraordinariness of artification is achieved by means of at least five devices or operations: formalization (a term that includes shaping, composing, patterning, organizing, schematizing, and simplifying), repetition, exaggeration, elaboration, and—in some instances—manipulation of the perceiver’s expectation (thereby leading to surprise). These five operations are, interestingly, used by some animals, especially birds, in what ethologists call “ritualized behaviors”—courtship behaviors used by peacocks or birds of paradise are a good example. And notably, artists use the same operations to make things special—thereby drawing people’s attention to the object or behavior, sustaining their interest, and evoking and shaping their emotions. The operations and their effects play a role in other behaviors that I subsequently describe.

Before saying more about art or play, I turn now to a more detailed discussion of the origin that I propose for the behavior of artification in the interpersonal neurobiology of mother-infant interaction.

Evolutionary Origins of the Operations of Artification in Mother-Infant Bonding

In my ethological scheme, artifying arose from a seemingly unlikely source, mother-infant bonding, which I propose was a consequence of two early adaptations in hominin evolution. The first is bipedality—walking upright on two legs (Potts 1996). Over evolutionary time, many anatomical changes were necessary to convert a four-legged creature into an upright bipedal strider. These changes included the reconstruction of the rib cage and the bones of the inner ear, reshaping of the spine, relocation of the opening of the spinal cord, alterations of the lower limbs and feet, reconfigurations of joint surfaces, and the reshaping of body musculature.

A second significant trait, brain enlargement, took place concurrently so that by the time of *Homo habilis*, between 2.0 and 1.5 million years ago, the brain had doubled in size from that of earlier four-legged forms. Another spurt of brain growth and doubling in size occurred around a half million to two hundred thousand years ago (Mithen 1996).

Among the many anatomical concomitants of bipedality was a reshaped pelvis that became shortened from top to bottom and broadened from fore to rear to center the trunk over the hip joints and thereby reduce fatigue during upright locomotion (Klein and Edgar 2002). This reconfiguration secondarily

resulted in a serious obstetric problem (Washburn 1960; Trevathen 1987)—giving birth to an increasingly large-brained baby through a narrowed birth canal. In other words, these conflicting adaptive trends (bipedality and brain expansion) resulted in a life-threatening problem for ancestral mothers and babies that itself required further anatomical adaptations.

We all know that a newborn's skull is compressible—with a fontanelle (or soft spot) aiding passage through the birth canal. Additionally, as birth approaches, hormones soften the cartilage that joins a female's pelvic bone in the middle, so that it will separate slightly during parturition. In addition, changes in the timing of infant brain growth gradually occur so that significant expansion takes place outside the womb: by age four, the modern infant brain is three times larger than at birth (Portmann 1941). Finally, the gestation period in humans has been reduced so that, compared to other primates, babies are born in an immature state. (Actually, selection did not so much shorten the period of gestation as prevent it from increasing as much as it would have otherwise [Chisholm 2003]). It has been estimated that to conform to the general primate fetal developmental pattern, a human baby should be born at around eighteen months (Tomasello 2003) and weigh twenty-five pounds (Falk 2009; Gould 1977; Leakey 1994; Portmann 1941). Obviously, there have been drastic changes.

After only nine months gestation, a newborn human is quite helpless, requiring assiduous care from adults for much longer than any other primate (Falk 2009). Researchers have posited “intense maternal care” or “intensive parenting” as early as 1.8 million years ago (Falk 2004, 2009; Flinn and Ward 2005; Leakey 1994; Rosenberg 1992), and I propose that mother-infant interaction became part of this care. The usual labels for the interaction—“baby talk,” “infant-directed speech,” or “motherese”—do not sufficiently emphasize two of its most important features: its dyadic nature, where both partners influence each other, or its multimodality. Perhaps this is because caretaker vocalizations have been studied primarily with regard to the subject of child language learning. However, frame-by-frame microanalyses of video-taped mother-infant interactions, which show the faces and upper torsos of both partners side by side, reveal that facial expressions and head and body movements are as significant in the interaction as vocalizations (Beebe et al. 1985; Beebe and Lachmann 2014; Murray and Trevathen 1985; Stern 1971). It is important to recognize that in the baby-talk or motherese interaction all three sensory modalities or languages of the engagement (body, facial, vocal) are processed as a whole in the infant's brain (Beebe and Lachmann 2014; Schore 1994; Stern et al. 1985).

Evidence that mother-infant interaction is an evolved adaptation comes from the well-established observation that infants are born ready to recognize, respond to, and coordinate their own behavior with these transformed affiliative signals. They are unresponsive to adult-style discourse that is directed to them but reward extraordinary signals with beguiling wriggles, coos, and smiles. It is important to appreciate that babies are not taught to engage with caretakers in this way. If anything, they are the teachers: by their positive and negative reactions, they let others know which movements, expressions, and sounds they like best (Chisholm 2003). Indeed, they can be said to elicit, shape, and otherwise influence the pace, intensity, and variety of signals that adults direct to them. It seems warranted to propose that mother-infant interaction be recognized as a shared, cocreated, evolved, adaptive communicative behavior that provides benefits to both infant (survival) and mother (reproductive success). That is, like the adaptive anatomical changes that aided the birth of immature infants, it was a behavioral adaptation that after birth aided their subsequent survival.

Although infant-directed sounds, facial expressions, and movements have been well described, no one has pointed out before that they are all derived from common adult vocal, facial, and gestural expressions of social receptivity, affinity, and intimacy described by ethologists such as Eibl-Eibesfeldt (1989) and Grant (1968, 1972). Once pointed out, we all recognize that we give and receive affiliative signals to our friends and associates every day. Looking at something or someone with open eyes expresses interest; raised eyebrows (eyebrow flash) and backward and upward head raising (bob) indicate familiarity and receptivity; head nods show accord; an open mouth or smile shows receptivity, pleasure, liking, or appeasement; a mutual gaze expresses intimacy; a soft voice indicates the absence of a threat or submission (Puts, Gaulin, and Verdolini 2006); and physical gestures such as touching, stroking, patting, hugging, and kissing communicate sympathy and devotion. However, when used with infants, the original function and motivation of these signals—expediting ordinary adult social life—changes. They are simplified or stereotyped, repeated, exaggerated (made more conspicuous), and elaborated (dynamically varied to become louder, softer, faster, slower, larger, smaller, higher, or lower)—that is, they are made more distinct and noteworthy, more likely to attract an infant's attention, sustain her interest, and create and manipulate her emotional response. I suggest that artists use these same operations when artifying.

Although mother and baby enjoy each other's company and loving feelings, a mother's intensified signals of friendly interest, unknown to her, augment

the release of prosocial hormones (endogenous opioids such as oxytocin) that foster maternal behavior in all mammals (Miller and Rodgers 2001; Nelson and Panksepp 1998). Emphasizing these signals also reinforces her brain's neural circuits for affiliation and devotion, creating tender and loving feelings toward her infant, ensuring more attentive care (Carter 1998; Carter, Lederhandler, and Kirkpatrick 1999; Nelson and Panksepp 1998; Panksepp, Nelson, and Bekkedal 1999) and ensuring that she will want to care for a demanding, helpless creature for months and years (see the social biofeedback model of Gergely and Watson 1999). Compared with other Pleistocene mothers who did not make emphatic affiliative signals that instilled and reinforced such devotion, a baby-talking mother was more likely to have reproductive success. By calling forth such signals from its mother and encouraging her to keep making them, an interactive baby (compared with a less responsive one) inadvertently helped ensure maternal care and therefore his or her own survival (Chisholm 2003; Dissanayake 2000).

At the hub of the intricate network of mammalian adaptations for caring for others is oxytocin (Carter, Lederhandler, and Kirkpatrick 1999; Churchland 2011), an ancient hormone from at least seven hundred thousand years ago that predates mammals (Porges and Carter 2011). It is present in all vertebrates, but the evolution of the mammalian brain adapted oxytocin to new jobs in caring for offspring and eventually for wider forms of sociality. Interestingly, oxytocin is critical not only to maternal emotion, but it plays an important role in positive social interactions (Churchland 2011; Panksepp and Biven 2012) that include pair bonding in adults (Bjorklund and Pellegrini 2002 104; Flinn and Ward 2005; Miller and Rodgers 2001; Stringer 2011; Wade 2006), social empathy (Porges and Carter 2012), and ritual behavior (Dissanayake 2008; Freeman 2000; Oubré 1997).

Apart from the importance of mother-infant interaction in human evolution, developmental psychologists today describe a number of psychological (emotional and cognitive) benefits to babies that come from this behavior. Compared with babies who do not have reliable maternal input, they learn to regulate their emotions better, participate in social interactions, become familiar with the sounds of the language they will eventually speak, acquire the culture of their parents, and in other ways develop their minds. The consequences of deficient interaction are starkly evident in a study of children who were brought up from birth in Eastern European orphanages before the fall of the Soviet Union. Although they received adequate physical care, they spent up to twenty hours per day unattended in their cribs. After adoption,

they showed mild neurocognitive impairment, and impulsivity and significant attention and social deficits (Chugani et al. 2001). Much earlier studies of infants in American orphanages who had minimal physical and emotional contact with caretakers revealed the heartbreaking effects of emotional neglect in the first year of life (Spitz 1945).

Pretense and Social Play

Those who study human evolution recognize that the adaptations of upright posture and a large brain characterize the genus *Homo*. They also recognize that the reduced gestation period (with the relatively small size of the neonate brain at birth and its accelerated expansion after birth) and the resulting long period of infant immaturity and dependence on parental care have resulted in a unique and critical developmental stage in humans called childhood (Bogin 1991, 1997; Flinn and Ward 2005; Geary and Bjorklund 2000; Morley 2017). Flinn and Ward have described childhood as “necessary and useful for acquiring the information and practice to build and refine the mental algorithms critical for negotiating the social coalitions that are key to success in our species” (34).

Additionally, the findings of interpersonal developmental psychology make clear that a prominent contribution to this success was the concomitant development of face-to-face interaction between mother and infant and its inherent potential for emotional bonding in adult pairs and groups. The emotional benefits of mother-infant interaction, which include the earliest appearance and exercise of play, are as important as building and refining mental algorithms.

From birth to three or four months of age, a mother uses vocalizations, movements, and facial expressions to regulate the emotional state of her infant—soothing, showing endearment, or modulating distress. But infants gradually become bored with the tranquil, predictable interactions of their early weeks. By four months, they also desire suspense, surprise, and fun, which mothers provide in action games and songs such as peek-a-boo and “This Little Piggy.” The use of repetition in a mother’s vocal utterances and facial and body movements is evident in the earliest interactions, where it regulates the infant and temporally coordinates and emotionally unites the pair. But repetition also makes possible a fifth operation, manipulation of expectation, which in mother-infant interaction occurs when what the baby anticipates is delayed. Sensitivity to regular repetition

leads to prediction of what comes next, and manipulations of the beat induces the pleasurable release of emotion (Kubovy 1999), as when a mother playing peek-a-boo delays the removal of her hands from her eyes to provoke amusement and laughter from her baby or waits to say what the fifth piggy squeals: “Wee, wee, wee, wee, wee, all the way home!”

These games illustrate why mother-infant interaction is often described, thought of, and experienced as playful, or as a kind of play (Stern 1977). It is spontaneous, improvised, and self-rewarding; both partners show that they are enjoying themselves. Play is common in all social animals (Burghardt 2005), including humans, who show with special facial expressions and postures that their play actions are not real behaviors. As infants mature, mothers use expressions of mock surprise (which, incidentally, is like the “play face” that is characteristic of children’s play and that of some higher mammals), make silly sounds, and call their baby’s toes “piggies.”

Early ethologists (e.g., Meyer-Holzapfel 1956) noted that both animal and human play is often based in recognizing and creating an as-if or other world—what has been called a *metareality*—different from or beyond everyday reality. Because play occurs in all higher mammals, we can reasonably assume that young hominins, like other primates, played. Although we do not know when fantasy play (pretense) began in our remote ancestors—evidence for its occurrence in great apes is controversial (Pellegrini and Bjorklund 2004)—it is universal in human children, where it frequently occurs in a social context, prefigured in playful interactions with their caretakers.

Pretend play requires players to take stances that are different from reality (Lillard 1993). Something (say, a stick) is substituted for something else (a wand or a horse to ride). Humans persist in pretend play into adulthood with activities that continue many of the same predilections such as dramatic performance, anthropomorphism of inanimate objects, storytelling, poetry, dance (Morley 2017), mime, dressing up, imaginative drawing, and rhythmic vocal accompaniment to activity (Countryman, Gabriel, and Thompson 2015).

When playing, human children, like other social animals, often alter their ordinary behavior, using devices such as the five operations described earlier. For example, frame markers such as exaggerated voice or movement signal to others that “this is play” (Leslie 1987; Pellegrini and Bjorklund 2004). Actions of play also may be stereotyped, use rhythmic and other kinds of repetition, and be elaborated (Meyer-Holzapfel 1956). Manipulation of expectation also adds to the excitement and fun.

Ceremonial Ritual

Early humans used memory and foresight for practical ends: they made tools for procuring food, fashioned weapons for predation and defense, and concocted remedies for wounds and illness. However, in most if not all traditional societies that anthropologists have described, practical preparation by itself is usually considered insufficient (Guss 1998). When artifacts or occasions are biologically important, individuals everywhere do something more to influence or ensure the outcome they desire. They make the events and things special—extraordinary—even to the point of creating complex physical and mental constructions along with actions that are not obviously relevant to the vital matter at hand. We call these rituals, noting that they are a primary feature of social life in small-scale groups, surrounding people from birth and throughout their lives (Rappaport 1999; Tambiah 1979).

Indeed, the primary occasions for the arts in premodern societies were ceremonial rituals. Visually arresting costumes, masks, and other body ornamentation; altered and embellished artifacts and surroundings; chanting, dancing, singing, drumming, altered language, and dramatic performances transform ordinary bodies, objects, environments, movements, and utterances (Renfrew 2017). In fact, rituals—whatever else they may be—can be considered as “collections of arts,” for without these “transformations of the commonplace” (Danto 1981), it is hard to imagine what would constitute a ceremony.

Although ritual practices occur in every human society, they are not themselves instinctive. Rather, they emerge in highly varied and complex cultural contexts. Yet if examined closely, their individual components can be regarded as extensions and elaborations of the innate—*aesthetic*—operations that originated in ancestral mother-infant playful interaction. That is to say, ordinary faces, bodies, body movements, vocalizations, utterances, surroundings, and materials are transformed and thereby also attract attention, sustain interest, and create or mold others’ emotions.

For example, in the visual arts, ordinary materials are made special by shaping or patterning: tiny snail shells may be pierced and strung into a necklace or affixed to clothing, where they acquire a new significance as personal *décor* and are no longer unnoticed detritus. By rounding their shape and combining them, such salient features as shininess and symmetrically rounded contours become exaggerated *en masse*, becoming additionally salient—noticeable in themselves—as does the ordinary human skin or animal hide on which they

rest. Ordinary human hair is braided or bound rather than remaining wild and shaggy, like animal fur. Color, such as red ocher, is applied to the shell necklace, human hair, or the human body to attract even more attention and become more special.

The same is true for other arts. Whether spoken or written, literary language makes ordinary language special by its form (use of stanzas, rhyme scheme, meter, or rhythm) and vividness or color (use of unusual vocabulary and word order, alliteration, assonance, and other rhetorical and poetic devices). Stories are given shape, emphasis, and elaborate detail that surpass the bare facts of plot. In dance, ordinary body movements of everyday life are configured, patterned, and made vivid through formalization, repetition, exaggeration, and elaboration. In song, the expressive features of the human voice—melody, rhythm, dynamics—are fashioned into conventional intervallic patterns and regulated meter, exaggerated with sustained vowels, and given notable dynamic variation.

The Neurobiology of Ceremonial Participation

Just as mothers do not consciously know that their rhythmic sounds and movements release brain chemicals that generate deep feelings of love for their babies, participants in rituals need not know, nor ever to have known, that their contingent rhythmic actions release the same opioids I described, not only making them feel bonded together in confidence and unity but relieved of anxiety, at least temporarily.

Apart from a study of fire walking in the Anastenaria by anthropologist Dimimtris Xygalatas (2012), I am not aware of any specific studies of participants' neurohormonal secretions during rituals. I suggest that ceremonial participation makes use of the neurobiology of mother-infant interaction. In 2000 neuroscientist Walter Freeman speculated that dancing and singing could induce altered states of consciousness through brain chemicals, like oxytocin, which lead to feelings of trust and therefore receptivity to new knowledge—a conjecture similar to the one I propose here. Other research supports a claim that engaging in ceremonial rituals has similar beneficial effects. For example, participants in musical activities such as singing, dancing, and drumming (which by their nature require coordinating regularized behavior with other individuals) had a higher pain threshold; lower levels of depression, anxiety, and fatigue; and an increase in vigor after the session compared to a control group (Koelsch, Offermanns, and Franzke 2010; Dunbar et al. 2012). These effects are attributed to

the release of endorphins or endogenous opioids like oxytocin, often referred to as “bonding” hormones. Panksepp and Biven (2012: 310) describe additional positive effects of these neurohormones, such as behavioral indications of individual confidence and social comfort.

Even though oxytocin’s primary function in all mammals seems to be its role in maternal nurturing, its contribution (along with other endorphins) to the reduction of the stress hormone cortisol (Heinrichs et al. 2003; Taylor et al. 2008, Uvnäs-Moberg 1999) supports an argument that participation with others in coordinated music making, as in ritual songs and dances, relieves individual anxiety and emotional tensions (Dunbar et al. 2012, Koelsch, Offermanns, and Franzke 2010). Among individuals who coordinate their behavior in time, oxytocin additionally promotes cooperation, trust, and bonding—all obvious adaptive benefits of the ritualized and ritual behaviors that foster and sustain these outcomes (Freeman 1995; Shaver, Hazan, and Bradshaw 1988; Zeifman and Hazan 2008).

Affinitive behaviors and emotions, such as those created and reinforced by the operations of mother-infant interaction (in humans and other mammals) and participation in temporally coordinated and integrated multimodal (facial, vocal, gestural) behaviors, activate the orbitofrontal cortex (OFC) and other reward centers of the brain, such as periaqueductal gray (PAG) (Bartels and Zeki 2004, Carter, Lederhandler, and Kirkpatrick 1999; Miller and Rodgers 2001). Brown and Dissanayake (2009) speculate that the functional properties of OFC provide important insight into the multimodal processing so central to the components of ritual behaviors, whether in mother-infant interactions or in group rituals. In both contexts, one finds entrainment, joint action, emergent coordination, planned coordination, chorusing, turn taking, imitation, complementary joint action, motor resonance, action simulation, and mimesis (Phillips-Silver and Keller 2012).

In three experiments, Scott Wiltermuth and Chip Heath (2009) found that acting in synchrony with others (as opposed to casual, uncoordinated walking or the performance of tasks that required differing degrees of synchrony) led people to cooperate with group members more than did controls. The experiments suggest that cultural practices involving synchrony (e.g., music, dance, and marching) may enable groups to mitigate the “free-rider problem” (i.e., when an individual in a cooperative society might reap its benefits without paying its costs) and more successfully coordinate to take potentially costly social action. Synchronized rituals may therefore have enabled some cultural groups to survive

where others failed (Novak 2006; Sober and Wilson 1998; Wiltermuth and Heath 2009). An interdisciplinary study in New Zealand found that synchrony in music and dance promoted cooperation more powerfully when it was framed as a collective goal (Reddish, Fischer, and Bulbulia 2013). The researchers concluded that their findings supported conjectures by evolutionary scholars that collective music and dance are biocultural adaptations for cooperation. Moreover, “the framing of coordinated behavior with purposes that transcend personal interests produces an even more powerful cooperative response than synchronous interaction in isolation from collective goals” (5). The statement can be usefully applied to individuals in egalitarian societies like those of our ancestors who shared goals of prosperity, fertility, health, safety, victory, and other subjects of collective rituals.

Although research makes clear that collective, synchronous vocal, and body movements promote cooperation and the reduction of stress, the researchers do not take the further step of describing the implications their findings might have specifically for ritual behavior in ancestral humans; nor do they draw specific attention to what I call artification and to the aesthetic operations or components of artification. However, I propose that it is reasonable to base the artification hypothesis on such implications.

The Invention of Religion

Ritual ceremonies are usually viewed as being associated with, even essential to, religion (e.g., Rappaport 1999; Alcorta and Sosis 2005; McCauley 2005), a universal characteristic of our species that is itself a topic of substantial interest to evolutionists. In considering the origin and persistence of religion, evolutionary psychologists have pondered the crucial question of why irrational beliefs and practices persist when they obviously (to a rational scientific mind) do not attract spirits or powers that offer assistance. Many of these scholars propose that religion is a natural by-product of the way the human mind works. That is, humans are born with cognitive biases or propensities—all observable in young children as well as adults—such as intuitive physics (the way objects behave or are perceived), the attribution of cause and effect, common sense dualism, imagination and the ability to build fictive worlds, social attachment, and the need for parents and leaders.

In many writings about the origin and evolution of religion, however, few scholars have appreciated that the practice of the arts (emotion-rich, multimedia clusters of the extraordinary) has been as integral to the evolution of religion as the cognitive biases. For examples of this omission, see scholars such as Guthrie (1993), Hinde (1999), Pyysiäinen (2001), Boyer (2001), Atran (2002), McCauley

and Lawson (2002), Kirkpatrick (2005), and Rossano (2010), although Alcorta and Sosis (2005) recognize the importance of the arts in ritual ceremonies for instilling cooperation and solidarity. Because of the inseparability of religious practice and art-like behavior, it is plausible to suggest that the arts—particularly those that take place in time, such as song, dance, and rhythmic or repetitive movement—arose in human evolution as components of ceremonial behavior rather than as independently evolved activities.

Although artfied rituals may or may not resolve the vital problems of successful hunting or influencing the weather that were their original motivation, they do address and satisfy evolved emotional needs of human psychology. Through their characteristic operations, rituals create and reinforce emotionally satisfying, reassuring, and psychologically necessary feelings of mutuality or intimate relationship with another person (Bowlby 1946; Miller and Rodgers 2001; Dissanayake 2011) and belonging to a group (Hinde 1975; Baumeister and Leary 1995; Dissanayake 2000; Gratier and Apter-Danon 2009). As I have mentioned, they coordinate and unify group members in a reassuring feeling of “oneheartedness” as they also relieve individual and group anxiety by instilling confidence and fostering a sense of control over disturbing circumstances. Further, they provide individuals a sense of meaningfulness or cognitive order (belief) and individual competence insofar as they give emotional force to explanations of how the world came to be as it is and what is required to maintain it. Interestingly, these basic needs resemble the seven social functions of musical participation (Seven Cs) described by Koelsch, Offermanns, and Franzke (2010): contact, social cognition, co-pathy (being empathically affected so that interindividual emotional states become more homogeneous), communication, coordination, cooperation, and cohesion. And of course rituals recall the results of mother-infant interaction as promoted by interpersonal neurobiology.

When anthropologists conceptualize a society’s rituals primarily as part of its symbolic cognitive belief system, they overlook the fact that regardless of the doctrines or meanings conveyed, rituals are constituted of art-like behaviors and, as I have repeatedly pointed out, would not exist without them. In fact, artifications are indispensable. If beliefs and dogma are stated simply as propositions, without artification, people will be less able to remember, accept, internalize, or guide their lives by them.

Early humans found attention-grabbing visual, aural, and gestural artifications to be essential in creating and sustaining their emotional investment, as individuals and as a group, in obtaining the life needs they had evolved to

care about. This was not a conscious choice. Rather, over time, a cultural group that performed artfied ritual practices, thus providing the release of prosocial neurohormones, would become more unified and cooperative and its individuals less anxious compared with groups without artfification—with artifiers, over evolutionary time, gradually achieving greater individual and group survival.

In any case, an ethological approach requires a distinction between religious belief and religious behavior (Feierman 2009; Schiefenhövel and Voland 2009). The difference in the two revives the emphasis on the behavioral and emotional means of instilling and reinforcing a society's beliefs that was described by early twentieth-century anthropologists such as Bronislaw Malinowski ([1935] 1946) and Alfred R. Radcliffe-Brown (1952), who proposed that religion in small-scale societies was less a matter of beliefs than of rites, indeed that belief was an effect of rites (see also Garfinkel 2017; Renfrew 2017; Watkins 2017).

Contemporary neuroscience reveals that belief, like other higher cognitive functions, rests on emotion (Damasio 1994; Kyriakidis 2017). Although literate people can read doctrinal texts and be persuaded to hold particular beliefs, for most of human history, belief was instilled nonverbally in individuals as they participated in song, dance, and other artfied vehicles of entrainment, as I have described, by means of the neurohormonal effects of the aesthetic devices (operations) that were used in these activities.

It is not necessary to claim that the beliefs of our artfying ancestors (or of anyone) be adaptive. It is the inadvertent neurobiological side effects of the behaviors or rites that instill these beliefs—the psychological sense of control and conviction that the matter at hand is being dealt with and the feeling of group unity that reinforces cooperation—in which adaptability resides. Unfortunately, I should mention that, with regard to being evolutionarily adaptive, unifying rituals can have a darker, though still adaptive group function. The neurobiological mechanisms that promote intimacy and intragroup bonding can easily be used to foster outer-directed group violence and xenophobia. Think of such artfied behaviors as patriotic songs, military drills, war cries, and ideological chants that unify insiders as they explicitly identify outsiders as aliens who deserve annihilation.

Summary

The science of ethology, or animal behavior, provides a new and fruitful perspective for viewing the arts as they originated and evolved in our species. In particular, two behavioral systems described by ethologists—ritualized behavior and

play—have contributed to my thinking about ancestral mother-infant interaction and its neurobiological underpinnings, which is the basis of my hypothesis.

I propose that during human evolution, neurobiological substrates for the behavior of caretaking, present in all mammals, were co-opted, extended, and intensified through the biological process of ritualization to become a uniquely human adaptive solution that addressed the unprecedented helplessness of human infants and their need for protracted maternal care after birth.

In a ritualized behavior, first described by ethologists for birds and other animals, ordinary functional vocalizations and movements are gradually altered, over evolutionary time, for a new communicative purpose, becoming stereotyped or formalized, repeated, exaggerated, elaborated, and temporally manipulated to create suspense and surprise. In mothers with infants, familiar, everyday vocalizations, facial expressions, and body movements that ordinarily convey social affiliation and accord between adults were altered by these devices, thereby attracting attention, sustaining interest, and creating and molding emotion in their infant. When patterned in time, the ritualized sequences fostered mutual temporal coordination and a release in both partners of oxytocin and other endogenous opioids, which create feelings of intimacy and trust. This ritualized mother-infant interaction can justifiably be considered an evolutionary adaptation, ensuring that immature infants will be cared for, thereby contributing to their survival and their mothers' reproductive success.

In mother-infant interaction, play—another general mammalian behavioral system described by ethologists—finds its earliest appearance and practice. Although play is too protean to be called a ritualized behavior, it often uses the five devices that characterize ritualized behaviors—stereotypy, repetition, exaggeration, elaboration, and surprise—thereby creating a nonordinary world that is captivating, interesting, pleasurable, and socially unifying. The benefits and satisfactions of play are both pragmatic and social-emotional.

I claim that ritualized mother-infant interaction—and the features that it shares with play—gave rise to the arts. Being innately receptive to the five devices that characterize ritualized behaviors, artists alter ordinary aspects of their everyday world (objects, places, sounds, and actions) deliberately making them extraordinary as if translated to another domain, which is then considered special, imaginary, heightened, or transfigured. I call this universally observable transformative activity *artification*. Unlike most other concepts of art, *artification* considers art as an activity and does not require that the results be skilled or beautiful.

The predisposition in humans to artify can justifiably be called an exaptation, the biological term for a preexisting trait (here, the behavioral predisposition to make the ordinary extraordinary) that evolved in human mother-infant interaction (and was already present in human play) but under new conditions (the desire to affect uncertain life situations by means of group ritual practices that used the five operations of animal ritualization and human artification) acquired another beneficial effect (social-emotional unification of a group and the relief of individual anxiety) without being modified by selection for this effect.

The artification hypothesis cannot be adequately described and defended in a single article. It is a new, complex, and growing contribution to aesthetic philosophy as well as ethology (see Dissanayake 2015; Malotki and Dissanayake 2018). The idea of artification arises from a naturalistic aesthetics that seeks to understand the antecedents of making and experiencing the arts and is not intended to compete at the same level with more circumscribed evolutionary or other explanations of art. Rather, using perspectives drawn from ethology and interpersonal neurobiology, it proposes a new concept of art as an exaptive behavioral predisposition that underlies instances of individual arts, however they are described.

REFERENCES

- Alcorta, Candace S., and Richard Sosis. 2005. "Ritual, Emotion, and Sacred Symbols: The Evolution of Religion as an Adaptive Complex." *Human Nature* 16:323–59.
- Atran, Scott. 2002. *In Gods We Trust: The Evolutionary Landscape of Religion*.
- Bartels, Andreas, and Semir Zeki. 2004. "The Neural Correlates of Maternal and Romantic Love." *NeuroImage* 21:1155–66.
- Baumeister, Roy F., and Mark R. Leary. 1995. "The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation." *Psychological Bulletin* 117:497–529.
- Bednarik, Robert G. 2011. *The Human Condition*.
- Beebe, Beatrice. 1986. "Mother-Infant Mutual Influence and Precursors of Self- and Object Representations." In *Empirical Studies of Psychoanalytic Theories*, Vol. 2, edited by Joseph Masling, 27–48.
- Beebe, Beatrice, and Daniel N. Stern. 1977. "Engagement-Disengagement and Early Object Experiences." In *Communicative Structures and Psychic Structures*, edited by Norbert Freeman and Stanley Grand, 35–55.
- Beebe, Beatrice, Daniel Stern, and Joseph Jaffe. 1979. "The Kinesic Rhythm of Mother-

- Infant Interactions." In *Of Speech and Time: Temporal Speech Patterns in Interpersonal Contexts*, edited by Aaron W. Siegman and Stanley Feldstein, 23–34.
- Beebe, Beatrice, Joseph Jaffe, Stanley Feldstein, Kathleen Mays, and Diane Alson. 1985. "Interpersonal Timing: the Application of an Adult Dialogue Model to Mother-Infant Vocal and Kinesic Interactions." In *Social Perception in Infants*, edited by Tiffany Field and Nathan A. Fox, 217–47.
- Beebe, Beatrice, and Frank M. Lachmann. 2014. *The Origins of Attachment: Infant Research and Adult Treatment*.
- Bjorklund, David F., and Anthony D. Pellegrini. 2002. *The Origins of Human Nature: Evolutionary Developmental Psychology*.
- Bogin, Barry. 1991. "Measurement of Growth Variability and Environmental Quality in Guatemalan Children." *Annals of Human Biology* 18:285–94.
- . 1997. "Evolutionary Hypotheses for Human Childhood." *Yearbook of Physical Anthropology* 40:63–89.
- Bowlby, John. 1946. "Psychology and Democracy." *The Political Quarterly* 17:61–75.
- . 1969–1980. *Attachment and Loss*, 3 vols.
- Brown, Steven and Ellen Dissanayake. 2009. "The Arts Are More Than Aesthetics: Neuroaesthetics as Narrow Aesthetics." In *Neuroaesthetics*, edited by Martin Skov and Oshin Vartanian, 43–57.
- Burghardt, Gordon M. 2005. *The Genesis of Animal Play: Testing the Limits*.
- Carter, Carol Sue. 1998. "Neuroendocrine Perspectives on Social Attachment and Love." *Psychoneuroendocrinology* 23:779–818.
- Carter, Carol Sue, I. Izja Lederhandler, and Brian Kirkpatrick, eds. 1999. *The Integrative Neurobiology of Affiliation*.
- Chisholm, James S. 2003. "Uncertainty, Contingency, and Attachment: A Life History Theory of Theory of Mind." In *From Mating to Mentality: Evaluating Evolutionary Psychology*, edited by Kim Sterelny and Julie Fitness, 125–54.
- Chugani, Harry T., Michael E. Behen, Otto Muzik, Csaba Juhász, Ferenc Nagy, and Diane C. Chugani. 2001. "Local Brain Functional Activity Following Early Deprivation: A Study of Postinstitutionalized Romanian Orphans." *NeuroImage* 14:1290–1301.
- Churchland, Patricia Smith. 2011. *Braintrust: What Neuroscience Tells Us about Morality*.
- Countryman, June, Martha Gabriel, and Katherine Thompson. 2016. "Children's Spontaneous Vocalizations during Play: Aesthetic Dimensions." *Music Education Research* 18:1–19.
- Damasio, Antonio R. 1994. *Descartes' Error: Emotion, Reason, and the Human Brain*.
- Danto, Arthur C. 1981. *The Transfiguration of the Commonplace: A Philosophy of Art*.
- Dissanayake, Ellen. 1974. "A Hypothesis of the Evolution of Art from Play." *Leonardo* 7:211–17.
- . 1988. *What is Art For?*
- . 1992. *Homo Aestheticus: Where Art Comes From and Why*.
- . 1999. "Antecedents of Musical Meaning in the Mother-Infant Dyad." In *Biopoetics: Evolutionary Explorations in the Arts*, edited by Brett Cooke and Frederick Turner, 367–98.

- . 2000. *Art and Intimacy: How the Arts Began*.
- . 2008. "If Music is the Food of Love, What about Survival and Reproductive Success?" *Musicæ Scientiæ*, 12:169–95.
- . 2011. "Prelinguistic and Preliterate Substrates of Poetic Narrative." *Poetics Today* 32:55–79.
- . 2015. "'Aesthetic Primitives': Fundamental Biological Elements of a Naturalistic Aesthetics." *Aisthesis: Pratiche, linguaggi e saperi dell'estetico* 8:5–24.
- Dunbar, Robin I. M., Kostas Kaskatis, Ian MacDonald, and Vinnie Barra. 2012. "Performance of Music Elevates Pain Threshold and Positive Affect: Implications for the Evolutionary Function of Music." *Evolutionary Psychology* 10:688–702.
- Eibl-Eibesfeldt, Irenäus. 1989. *Human Ethology*.
- Falk, Dean. 2004. "Prelinguistic Evolution in Early Hominins: Whence Motherese?" *Behavioral and Brain Sciences* 27:491–541.
- . 2009. *Finding Our Tongues: Mothers, Infants, and the Origin of Language*.
- Feierman, Jay R., ed. 2009. *The Biology of Religious Behavior: The Evolutionary Origin of Faith and Religion*.
- Flinn, Mark V. and Carol V. Ward. 2005. "Ontogeny and Evolution of the Social Child." In *Origins of the Social Mind: Evolutionary Psychology and Child Development*, edited by Bruce D. Ellis and David F. Bjorklund, 19–44.
- Freeman, Walter J. 1995. *Societies of Brains: A Study in the Neuroscience of Love and Hate*.
- . 2000. "A Neurobiological Role of Music in Social Bonding." In *The Origins of Music*, edited by Nils L. Wallin, Björn Merker, and Steven Brown, 411–24.
- Garfinkel, Josef. Forthcoming. "Mask Performance in the Proto-Historic Near East." In *Play, Ritual, and Belief in Animals and Early Human Societies*, edited by Colin Renfrew, Iain Morley, and Michael Boyd.
- Geary, David C. and David F. Bjorklund. 2000. "Evolutionary Developmental Psychology." *Child Development* 71:57–65.
- Gergely, György and John S. Watson. 1999. "Early Socio-Emotional Development: Contingency Perception and the Social-Biofeedback Model." In *Early Social Cognition: Understanding Others in the First Months of Life*, edited by Philippe Rochat, 101–36.
- Gould, Stephen Jay. 1977. *Ontogeny and Phylogeny*.
- Grant, E. C. 1968. "An Ethological Description of Nonverbal Behavior during Interviews." *British Journal of Medical Psychology* 41:177–83.
- . 1972. "Nonverbal Communication in the Mentally Ill." In *Non-Verbal Communication*, edited by Robert A. Hinde, 349–58.
- Gratier, Maya and Gisèle Apter-Danon. 2009. "The Improvised Musicality of Belonging: Repetition and Variation in Mother-Infant Vocal Interaction." In *Communicative Musicality: Exploring the Basis of Human Companionship*, edited by Stephen Malloch and Colwyn Trevarthen, 301–27.
- Guss, David M. 1989. *To Weave and Sing: Art, Symbol, and Narrative in the South American Rain Forest*.
- Guthrie, Stuart Elliott. 1995. *Faces in the Clouds: A New Theory of Religion*.

- Heinrichs, Markus, Thomas Baumgartner, Clemens Kirschbaum, and Ulrike Ehlert. 2003. "Social Support and Oxytocin Interact to Suppress Cortisol and Subjective Responses to Psychosocial Stress." *Biological Psychiatry* 54:1389–98.
- Hinde, Robert A. 1974. *Biological Bases of Human Social Behaviour*.
- . 1999. *Why Gods Persist: A Scientific Approach to Religion*.
- Kirkpatrick, Lee A. 2005. *Attachment, Evolution, and the Psychology of Religion*.
- Klein, Richard G., and Blake Edgar. 2002. *The Dawn of Human Culture*.
- Koelsch, Stefan, Kristin Offermanns, and Peter Franzke. 2010. "Music in the Treatment of Affective Disorders: An Exploratory Investigation of a New Method for Music-Therapeutic Research." *Music Perception* 27:307–316.
- Kubovy, Michael. 1999. "On the Pleasures of the Mind." In *Well-Being: The Foundations of Hedonic Psychology*, edited by Daniel Kahneman, Ed Diener, and Norbert Schwarz, 134–54.
- Kyriakidis, Evangelos. Forthcoming. "Rituals, Games, and Learning." In *Play, Ritual, and Belief in Animals and Early Human Societies*, edited by Colin Renfrew, Iain Morley, and Michael Boyd.
- Leakey, Richard E. 1994. *The Origin of Humankind*.
- Leslie, Alan M. 1987. "Pretense and Representation: Origins of 'Theory of Mind.'" *Psychological Review* 94:412–26.
- Lillard, Angeline S. 1993. "Pretend Play Skills and the Child's Theory of Mind." *Child Development* 64:348–71.
- Malinowski, Bronislaw. (1923) 1946. "The Problem of Meaning in Primitive Languages." In *The Meaning of Meaning: A Study of the Influence of Language upon Thought and of the Science of Symbolism*, edited by Charles Kay Ogden and Ivor Armstrong Richards, 451–510.
- Malotki, Ekkehart, and Ellen Dissanayake. Forthcoming. *Early Rock Art of the American West: The Geometric Enigma*.
- McCauley, Robert N. 2005. Introduction to *Mind and Religion: Psychological and Cognitive Foundations of Religiosity*, edited by Harvey Whitehouse and Robert N. McCauley, xi–xxx.
- McCauley, Robert N., and Thomas E. Lawson. 2002. *Bringing Ritual to Mind: Psychological Foundations of Cultural Forms*.
- Meyer-Holzappel, Monika. 1956. "Spiel des Säugetieres." *Handbuch der Zoologie* 8:1–36.
- Miall, David S., and Ellen Dissanayake. 2003. "The Poetics of Babytalk." *Human Nature* 14:337–64.
- Miller, Warren B. and Joseph Lee Rodgers. 2001. *The Ontogeny of Human Bonding Systems: Evolutionary Origins, Neural Bases, and Psychological Manifestations*.
- Mithen, Steven J. 1996. *The Prehistory of the Mind: The Cognitive Origins of Art, Religion, and Science*.
- Morley, Iain. Forthcoming. "Pretend Play, Cognition, and Life History in Human Evolution." In *Play, Ritual, and Belief in Animals and Early Human Societies*, edited by Colin Renfrew, Iain Morley, and Michael Boyd.
- Morris, Desmond. 1962. *The Biology of Art: A Study of the Picture-Making Behaviour of*

- the Great Apes and its Relationship to Human Art.*
- Murray, Lynne, and Colwyn Trevarthen. 1985. "Emotional Regulation of Interaction between Two-Month-Olds and Their Mothers." In *Social Perception in Infants*, edited by Tiffany Field and Nathan A. Fox, 177–97.
- Nadel, Jacqueline, Isabelle Carchon, Claude Kervella, Daniel Marcelli, and Denise Résébet-Plantey. 1999. "Expectancies for Social Contingency in Two-Month-Olds." *Developmental Science* 2:164–73.
- Nelson, Eric E., and Jaak Panksepp. 1998. "Brain Substrates of Infant-Mother Attachment: Contributions of Opioids, Oxytocin, and Norepinephrine." *Neuroscience and Biobehavioral Reviews* 22:437–52.
- Novak, Martin A. 2006. "Five Rules for the Evolution of Cooperation." *Science* 314:1560–63.
- Oubré, Alondra Yvette. 1997. *Instinct and Revelation: Reflections on the Origins of Numinous Perception.*
- Panksepp, Jaak. 1998. *Affective Neuroscience: The Foundations of Human and Animal Emotions.*
- . 2010. "Science of the Brain as a Gateway to Understanding Play: An Interview with Jaak Panksepp." *American Journal of Play* 2:245–77.
- Panksepp, Jaak, Eric E. Nelson, and Marni Bekkedal. 1999. "Brain Systems for the Mediation of Social Separation-Distress and Social-Reward: Evolutionary Antecedents and Neuropeptide Intermediaries." In *The Integrative Neurobiology of Affiliation*, edited by Carol Sue Carter, I. Izja Lederhandler, and Brian Kirkpatrick, 221–43.
- Panksepp, Jaak, and Lucy Biven. 2012. *The Archaeology of Mind: Neuroevolutionary Origins of Human Emotions.*
- Pellegrini, Anthony D., and David F. Bjorklund. 2004. "The Ontogeny and Phylogeny of Children's Object and Fantasy Play." *Human Nature* 15:23–43.
- Phillips-Silver, Jessica, and Peter E. Keller. 2012. "Searching for Roots of Entrainment and Joint Action in Early Musical Interactions." *Frontiers in Human Neuroscience* 6:1–11.
- Porges, Stephen W., and Carol Sue Carter. 2012. "Mechanisms, Mediators, and Adaptive Consequences of Caregiving." In *Moving beyond Self-Interest: Perspectives from Evolutionary Biology, Neuroscience, and the Social Sciences*, edited by Stephanie L. Brown, R. Michael Brown, and Louis A. Penner, 53–72.
- Portmann, Adolf. 1941. "Die Tragzeit der Primaten und die Dauer der Schwangerschaft beim Menschen: Ein Problem der vergleichend Biologie." *Revue Suisse de Zoologie* 48:511–18.
- Potts, Richard. 1996. *Humanity's Descent: The Consequences of Ecological Instability.*
- Puts, David Andrew, Steven J. C. Gaulin, and Katherine Verdolini. 2006. "Dominance and the Evolution of Sexual Dimorphism in Human Voice Pitch." *Evolution and Human Behavior* 27:283–96.
- Pyysiäinen, Ilkka. 2001. *How Religion Works: Towards A New Cognitive Science of Religion.*
- Radcliffe-Brown, Alfred Reginald. 1952. *Structure and Function in Primitive Society: Essays and Addresses.*

- Rappaport, Roy A. 1999. *Ritual and Religion in the Making of Humanity*.
- Reddish, Paul, Ronald Fischer and Joseph Bulbulia. 2013. "Let's Dance Together: Synchrony, Shared Intentionality, and Cooperation." *PLOS ONE* 8:e71182.
- Renfrew, Colin. Forthcoming. "Play as the Precursor of Ritual in Early Human Societies." In *Play, Ritual, and Belief in Animals and Early Human Societies*, edited by Colin Renfrew, Iain Morley, and Michael Boyd.
- Rosenberg, Karen R. 1992. "The Evolution of Modern Human Childbirth." *American Journal of Physical Anthropology* 35:89–134.
- Rossano, Matthew J. 2010. *Supernatural Selection: How Religion Evolved*.
- Schiefenhövel, Wulf, and Eckhart Voland. 2009. Introduction to *The Biological Evolution of Religious Mind and Behavior*, edited by Eckhart Voland and Wulf Schiefenhövel, 1–7.
- Schore, Allan N. 1994. *Affect Regulation and the Origin of the Self: The Neurobiology of Emotional Development*.
- Shaver, Phillip, Cindy Hazan, and Donna Bradshaw. 1988. "Love as Attachment: The Integration of Three Behavioral Systems." In *The Psychology of Love*, edited by Robert J. Sternberg and Michael L. Barnes, 68–99.
- Sober, Elliott, and David Sloan Wilson. 1998. *Unto Others: The Evolution and Psychology of Unselfish Behavior*.
- Spitz, René A. 1945. "Hospitalism: An Inquiry into the Genesis of Psychiatric Conditions in Early Childhood." *Psychoanalytic Study of the Child* 1:53–74.
- Stern, Daniel N. 1971. "A Micro-Analysis of the Mother-Infant Interaction: Behavior Regulating Social Contact between a Mother and her 3 1/2-Month-Old Twins." *Journal of the American Academy of Child Psychiatry* 10:501–17
- . 1974. "Mother and Infant at Play: The Dyadic Interaction Involving Facial, Vocal, and Gaze Behaviors." In *The Effect of the Infant on its Caregiver*, edited by Michael Lewis and Leonard A. Rosenblum, 187–213.
- . 1977. *The First Relationship: Infant and Mother*.
- Stern, Daniel N., Lynne Hofer, Wendy Haft, and John Dore. 1985. "Affect Attunement: The Sharing of Feeling States between Mother and Infant by Means of Intermodal Fluency." In *Social Perception in Infants*, edited by Tiffany Field and Nathan A. Fox, 249–68.
- Stringer, Chris. 2011. *The Origin of Our Species*.
- Tambiah, Stanley J. 1979. "A Performative Approach to Ritual." *Proceedings of the British Academy* 65:113–69.
- Taylor, Shelley E., Lisa J. Burkland, Naomi I. Eisenberger, Barbara J. Lehman, Clayton J. Hilmert, and Matthew D. Lieberman. 2008. "Neural Bases of Moderation of Cortisol Stress Responses by Psychosocial Resources." *Journal of Personality and Social Psychology* 95:197–211.
- Tomasello, Michael. 2003. *Constructing a Language: A Usage-Based Theory of Language Acquisition*.
- Trevarthen, Colwyn. 1979. "Communication and Cooperation in Early Infancy: A Description of Primary Intersubjectivity." In *Before Speech: The Beginning of Inter-*

- personal Communication*, edited by Margaret Bullowa, 321–47.
- Trevathan, Wenda. 1987. *Human Birth: An Evolutionary Perspective*.
- Tronick, Edward A., Heidelise Als, Lauren Adamson, Susan Wise, and T. Berry Brazelton. 1978. "The Infant's Response to Entrapment between Contradictory Messages in Face-to-Face Interaction." *Journal of the American Academy of Child Psychiatry* 17:1–13.
- Tronick, Edward A., Heidelise Als, and Lauren Adamson. 1979. "Structure of Early Face-to-Face Communicative Interactions." In *Before Speech: The Beginning of Interpersonal Communication*, edited by Margaret Bullowa, 349–72.
- Uvnäs-Moberg, Kerstin. 1999. "Physiological and Endocrine Effects of Social Contract." In *The Integrative Neurobiology of Affiliation*, edited by Carol Sue Carter, I. Ilza Lederhandler, and Brian Kirkpatrick, 245–61.
- Wade, Nicholas. 2006. *Before the Dawn: Recovering the Lost History of Our Ancestors*.
- Washburn, Sherwood M. 1960. "Tools and Human Evolution." *Scientific American* 203:62–75.
- Watkins, Trevor. Forthcoming. "Architecture and Imagery in the Early Neolithic of Southwest Asia: Framing Rituals, Stabilizing Meanings." In *Play, Ritual, and Belief in Animals and Early Human Societies*, edited by Colin Renfrew, Iain Morley, and Michael Boyd.
- Wiltermuth, Scott S., and Chip Heath. 2009. "Synchrony and Cooperation." *Psychological Science* 20:1–5.
- Zeifman, Debra, and Cindy Hazan. 2008. "Pair Bonds as Attachments: Reevaluating the Evidence." In *Handbook of Attachment: Theory, Research, and Clinical Applications*, 2nd ed., edited by Jude Cassidy and Phillip R. Shaver, 436–55.