11

How Attachment Gave Rise to Culture

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Past loves shadow present attachments, and take up residence within them.
—Martha Nussbaum (2001)

Abstract

This chapter reviews advances in evolutionary theory since Bowlby and proposes that our capacity for culture emerged with the evolution of human attachment by means of selection for increased mother-infant cooperation in the resolution of parent-offspring conflict. It outlines the evolutionary-developmental logic of attachment, parent-offspring conflict, and the view of culture as "extended embodied minds." It describes how the embodied mind and its attachments might have been extended beyond the mammalian mother-infant dyad to include expanding circles of cooperative individuals and groups. It argues that because attachment came before and gave rise to culture, no culture could long exist that did not accommodate the attachment needs of its infants. On this view, all the myriad cultural contexts of attachment foster secure-enough attachment—except when they cannot. Theory and evidence show that when mothers and others are unable to buffer their children against environmental risk and uncertainty, insecure attachment can be (or once was) evolutionarily rational. The major source of risk and uncertainty today are the causes and consequences of intergenerational poverty or inequality. It concludes that an attachment theory fully informed by twenty-first century evolutionary theory is fully consilient with normative emic perspectives on the nature of the child and appropriate child care, in both favorable and unfavorable environments.

Introduction

Evolutionary theory is our only scientific theory of life, and attachment theory, as formulated by John Bowlby, is the predominant evolutionary theory of social-emotional-cognitive development. But for attachment theory to mature, it must fully incorporate the cultural contexts of attachment, especially the role of cooperative breeding and alloparenting. I believe that the many advances in evolutionary theory since Bowlby show very clearly that it can.

The most productive of these advances is the emerging "extended evolutionary synthesis" (EES), which is a convergence of ideas from information science, evolutionary-developmental ("evo-devo") biology, and behavioral ecology. Bowlby had limited knowledge of each, which by today's standards were primitive anyway, but he was the first to conceive of emotional development in terms of "control systems" that regulate "feedback" between mother and infant (Bowlby 1969:65). I will argue that the EES provides *a priori* logico-mathematical grounds for rejecting nature-culture, mind-body, and individual-group dualisms and shows how our capacity to cooperate (*cooperārī*, "work together") and develop culture might have evolved from our infant ancestors' ancient mammalian motivation to form attachments.

Because my focus is on the evolution of the development of human attachment, I view "mother" and "attachment" from the perspective of a generic newborn mammal's body. Like all forms of life, infants are complex adaptive systems: they use the information encoded in their genes to act, expressing it in their attempts to adapt to life outside the womb. I begin at the beginning because the human attachment process evolved from the stem mammalian attachment process (e.g., Broad et al. 2006; Royle et al. 2012). All mammalian newborns are motivated to approach species-specific patterns of sign stimuli; in the environment of evolutionary adaptedness of mammals, these stimuli would essentially always emanate from their biological mothers. The primary adaptive function of being close to one's mother is to survive infancy. Parent-offspring conflict theory (Trivers 1974), however, holds that mothers and infants are naturally conflicted. Although mothers share 50% of their genes with each offspring, offspring also share 50% of their genes with their father; thus, mother-offspring conflict is inevitable. Infants are expected to seek more resources (material and socioemotional) than mothers are willing to provide because infants seek to benefit themselves (copies of *both* parents' genes). At the same time, mothers are expected to provide fewer resources than their infants would like because mothers, too, seek to benefit themselves (copies of their genes in current or future offspring). For Trivers, "socialization is a process by which parents attempt to mold each offspring…while each offspring [is expected] to resist…and to attempt to mold the behavior of its parents" (Trivers 1974:260).

At the very least, mammalian mothers must accept or tolerate their infants' proximity-seeking behavior and attempts to nurse. In doing so, mammalian mothers keep their infants alive by regulating their new physiological functions for them. By adjusting their behavior to that of their infants, mammalian mothers help the infant's body learn how to function as it has to as an adult, in terms of temperature maintenance, blood sugar level, arousal level (hypothalamic-pituitary-adrenal [HPA] reactivity), and much more. For a generic mammalian infant, a "mother" would thus be anybody who first does no harm and at least tolerates it long enough for its homeostatic control systems to mature. Corresponding minimalist views of attachment are the "mutual regulation"

model (Tronick 2007), the "biobehavioral synchrony" model (Feldman 2007a, 2014), and the "psychobiological attunement" model (Field 1985), in which "each partner provides meaningful stimulation for the other and has a modulating influence on the other's arousal level" (Field 1985:415; see also Schore 1994, 2013; Polan and Hofer 2008; Beebe and Lachmann 2014; Leclère et al. 2014). A good minimalist definition of secure attachment was provided by Gunnar et al. (1996:200): "secure attachment relationships protect or buffer infants from elevations in cortisol."

The EES views natural selection and development as mechanisms for acquiring information and organisms as matter and energy that have been organized by information. Accordingly, it views "culture" as minds that have been organized by shared information, analogous to the view of culture as cultural models or shared cognitive schemas (Quinn and Holland 1987; D'Andrade 1992; Strauss and Quinn 1997). These minimal definitions of "mother," "attachment," and "culture" help set the stage for the proposition that the bodily connection between infant and mother leads to their cognitive connection.

The Extended Evolutionary Synthesis

The dominant paradigm in evolutionary theory in Bowlby's day was the Modern Synthesis (MS), which unified Darwin's theory of natural selection with population genetics in the 1930s and 1940s. Since Bowlby, the MS has incorporated numerous advances in evolutionary theory, and it remains the dominant paradigm because of its powerfully predictive mathematical models of what gene selection should favor and how gene frequencies change over time. While the EES constitutes a major shift in evolutionary theory, it is a shift in emphasis, not a Kuhnian paradigm shift. Mutation and recombination still generate genetic variability, gene variants are still tested by natural selection, and variants that pass the test are still copied into the next generation more often than those that do not. What the EES is shifting are the old notions that mutation and recombination are the only or even major source of variability, that genes are the only mode of inheritance, and that selection operates in a single mode or at a single level.

Dissatisfaction with the MS goes back to Waddington (1942) and has been building ever since. Tinbergen (1963) expressed his dissatisfaction in the form of his famous "four questions" and Stearns (1982) with his distinction between biology's "adaptationist" and "mechanist" perspectives (Table 11.1). Stearns (1982:238) was dissatisfied with the way the thoroughly adaptationist MS "made a series of simplifying assumptions that had the effect of reducing the objects of study to changes in gene frequencies: the organism disappeared from view, and with it went the phenotype, the ecological interactions of the phenotype with the environment that determine fitness, and the developmental interactions with the environment that produce the phenotype."

Table 11.1 The structure of an evolutionary explanation of human behavior.

Stearns's Perspectives	Tinbergen's Levels of Explanation
Mechanist:	Proximate: What causes the expression of behavior X?
How organisms work Fitness as work	Ontogenetic: What is the developmental/cultural history of behavior X?
Adaptationist:	Phylogenetic: What is the evolutionary history of behavior X?
How evolution works Fitness as measure	Ultimate (natural selection): What is the adaptive value of behavior X?

Flush with the success of its powerfully predictive mathematical models of how gene frequencies change over time, the MS was not very interested in biology's mechanist perspective. The adaptationist perspective focuses on how evolution works and views fitness as a measure: relative reproductive success. The mechanist perspective focuses on how organisms work and views fitness as work: the work they have to do to stay alive, grow, and develop in order to reproduce. If not always explicitly, the EES uses Tinbergen's four questions to bridge the adaptationist-mechanist gap by tracing the developmental pathways from genes to behavior, and back, when behavior changes the focus or strength of selection (Pigliucci and Müller 2010; Stotz 2010, 2014; Sterelny 2013; Pigliucci and Finkelman 2014; Laland et al. 2015).

A major step toward bridging these gaps was the development of life history theory (see also Hawkes et al., this volume). Its key insight was Waddington's: evolution and development are two sides of the same coin. Genotypes "push" phenotypes into one generation; phenotypes "pull" genotypes into the next. Selection operates on flesh, blood, and behavioral phenotypes, not the raw DNA in genotypes. Selection cannot "see" the information represented in genotypes until it has been embodied into a phenotype during development. The life cycles of all sexually reproducing organisms begin with a single-celled zygote, but zygotes must develop into adults before they can reproduce. Development is thus an adaptation for reproduction; life cycles *are* reproductive strategies (Bonner 1965; Stearns 1992; West-Eberhard 2003; Konner 2010) that consist of life history traits (Table 11.2) organized by information about their particular "developmental niche" (Super and Harkness 1986). (More on life history theory later.)

In the EES, information has the quality of "aboutness" or "intentionality" (*intendere*, "to stretch toward, aim at"): it "points at" that which it is about or represents. Evolution and development are both information acquisition mechanisms. In evolution, the information acquired is about an organism's environment of evolutionary adaptedness, represented in its DNA. The laws of aerodynamics, for example, are represented or embodied in the shape of birds' wings, whereas the laws of optics are embodied in eyes. In development, the

Table 11.2 The major dimension of differences in life history strategies (adapted from Pianka 1970; Reznick et al. 2002; see also Hawkes et al., this volume).

Strategy	Current ("Short-fast")	Future ("Long-slow")
	Minimize chance of maximal possible fitness loss (extinction)	Maximize chance of minimum necessary fitness gain (continuation)
Ecology	More variable and/or unpredictable	More constant and/or predictable
Mortality rates	Often catastrophic, non-directed, density dependent	More constant, directed, density independent
Survivorship	Low in early life	High in early life
Population size	More variable	More constant
Intra- and inter-specific competition	More variable, lax	More constant, intense
Selection favors:	Rapid development	Slow development
	Early reproduction	Delayed reproduction
	High reproductive rate	Low reproductive rate
	Low parental investment	High parental investment
	Small body size	Large body size
	Semelparity (large litters)	Iteroparity (small litters or single birth)
	Short life span	Long life span

information acquired is about an organism's developmental niche. The attachment process, for example, enables mammalian infants to acquire information about mothers.

The principal difference between the MS and the EES is that the former is gene-centric whereas the latter is information-centric. The MS holds that with rare exceptions genes are the source of the variability on which selection operates and the only medium of inheritance (Dawkins 1976). In contrast, the EES holds that because selection acts on phenotypes, not genotypes, what matters is the information that organizes the phenotype *regardless* of its source or medium of inheritance—as reflected in the title of the best account of this perspective by Jablonka and Lamb (2005), *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life*.

The four dimensions of evolution are four levels in the evolution of the complexity of life; each emerges from the preceding lower level (Table 11.3). In the beginning, at the bottom level, organisms were (and still are) organized by genetic information. At the next level, some organisms evolved the capacity to be organized by the epigenetic effects of information about their own or their parents' environment, acquired by their own exposure or inherited from

Table 11.3   Information in the four dimensions of evolution (Jablonka and Lamb 2005).

Information	Context	Acquisition Mode	Transfer Mode
4. Symbolic	Cultural environment	"Mind reading"	Cultural environment
3. Behavioral	Social environment	Learning, imitation	Social environment
2. Epigenetic	Physical or social environment	Parents or exposure	Parents or exposure
1. Genetic	Environment of evolutionary adaptedness	Natural selection	DNA

their parents without exposure.[1] At the third level, animals evolved the capacity (nervous systems) to have their behavior organized by information about the behavior of other animals, acquired and inherited from their social environment by learning and imitation, giving rise to animal behavioral traditions. At the top, most recent level, humans evolved the capacity to have their minds organized by the symbolic, cultural information in other minds, acquired and inherited by "mind reading," giving rise to history.

In the EES, information science includes biosemiotics, complex adaptive systems theory, and game theory. Each is reviewed briefly below, after which I will introduce the concepts of group selection and niche construction. This will set the stage for showing how infant attachment motivations give rise to the key EES concepts of the "embodied" and "extended" mind.

Biosemiotics

Biosemiotics ("signs of life") follows from the premise that organisms consist of matter and energy that have been organized by information (Harms 2004; Skyrms 2010; Emmeche and Kull 2011; Deacon 2012; Witzany 2014). This information is acquired from, and points at, two periods and one point in time, which I will call "old," "newer," and "now." "Old" information is about an organism's phylogenetic history, "newer" information is about its ontogenetic history, and "now" information is about its moment-to-moment sensory experience. "Old" information is about what the state of the organism's body *should* be (in order ultimately to reproduce) at a given age in a given circumstance (e.g., its species' optimal[2] body temperature, blood sugar level, or state of arousal). "Newer" information is about what the state of the organism's body *has been* during development. "Now" information is about what the state of the organism's body *is*; that is, what happens to its body

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[1]   Epigenetic inheritance has been identified in 27 human studies (Turecki and Meaney 2016) and over 100 other species, with effects observed (so far) for three generations in humans and 46 in long-term breeding experiments with the silver fox (Jablonka and Raz 2009).

[2]   Best possible, not imaginable.

(consciously or not) as it interacts with its environment. In principle, with information about two periods and one point in time, organisms can "triangulate" on the future.

In biosemiotics, meaning, value, and intention are facts of nature. Meaning exists in nature in the form of intentional information that points at what it means; it is about something in an organism's internal or external environment. Following Peirce (1958), biosemiotics emphasizes the triadic relationship among signs, objects, and interpreters. Signs have meaning only to interpreters. Signs acquire meaning only in terms of what they mean to, or entail for, an interpreter. For instance, even brainless, single-cell bacteria are able to interpret the meaning of the molecular trail left by a decaying organism just by acting on it (without intent: "*if* molecule X, *then* follow them"), implicitly "predicting" that food lies where the sign points. Likewise, mammalian newborns interpret the meaning of signs of mother by approaching (at first with no intent) the source of the signs. Molecule X and signs of mother mean, entail, or "predict" approach behavior because natural selection discovered the natural, "bio-logical" contingency between signs (of molecule and mother) and objects (food source and security).

Value exists in nature in the form of reproductive success; life exists because organisms reproduce. Value exists in nature when a sign points at something of intrinsic value to an organism—any resource that the organism needs to survive, grow, develop, and reproduce (e.g., Chisholm 2012). Bacteria have no feelings; they just act. For infants, detecting contingencies feels good intrinsically; it makes them smile and want to explore, play, and thereby learn how objects, events, and people are connected in ways that naturally feel good (approach) or bad (avoid) (Watson 1972, 1994, 2001; Gergely and Watson 1996; Gergely et al. 2010).[3] Natural selection endowed contingency detection with good feelings as an adaptation for development, for infants to acquire information about their developmental niche.

Complex Adaptive Systems

Evolution is a complex adaptive system, a natural process that keeps itself going by reproduction. According to complex adaptive system theory, "intention" refers to "specific information acting on the dynamics [of the complex adaptive system], attracting the system toward the intended pattern" (Kelso 1995:141). (In terms of attachment, mothers are "attractors" in the "design space," or developmental niche, of infants.) Evolution's "intention" is that life should continue to evolve. Its "intended pattern" is the pattern by which life continues: "The persistence of the whole over time—the global behavior that outlasts any of its component parts—is one of the defining characteristics of complex systems" (Johnson 2001:82).

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[3] See also Gopnik (2000) on "explanation as orgasm."

Complex adaptive systems are hierarchically nested networks of interacting agents that receive signals from their environment and send signals to agents at their own and other levels (Holland 1992b, 1995, 2012; Capra and Luisi 2014). The study of complex adaptive systems "…involves understanding how cooperation, coalitions, and networks of interaction emerge from [agents'] individual behaviors and feed back to influence those behaviors" (Levin 2003:3). Natural selection is the ultimate *bricoleur*: it constructed life, bottom-up, piecing together simple agents into ever more complex wholes. It organized molecules into DNA, then DNA into cells, which opened the door for cell-cell communication, cooperation, coalitions, and networks of interaction, and the emergence of tissues, organs, organ systems, behavior, behavioral control systems (e.g., attachment), societies, and most recently, cultural models or shared cognitive schemas.

Agents at each level set up the environment for the agents at the next level. Agents at the bottom level are the "sensory organs" of the complex adaptive system. They search the environment, both internal and external, for certain kinds of information. If/when they detect a certain kind, they interpret its meaning by sending signals up to agents at the next level. Agents at that level, in turn, search their environment (signs from the preceding level) for certain patterns of information. If/when they detect that pattern, they send signals up to the next level, where the process is repeated until signals reach the top level, which interprets the output of the penultimate level and sends signals back down the hierarchy, effecting top-down control of agents at lower levels and the system (e.g., the body) as a whole.

Each level of complexity is "self-similar" to the level from which it emerged. At all levels agents use the same conditional "if-then" logic to interpret the meaning of the signals they receive. Agents "learn or adapt in response to their interactions with other agents….the actions of a typical agent are conditionally dependent on what other agents are doing" (Holland 2012:24–25). Complex adaptive systems "…change and reorganize their component parts to adapt themselves to the problems posed by their surroundings" (Holland 1995:18). Sometimes permutations and combinations of these conditional "if-then" interactions spontaneously generate a higher, more adaptive level of complexity (e.g., Konner 2010). Game theory shows, in principle, how the "top-down" behavioral control system of shared cultural models or cognitive schemas might have emerged with the evolution of human attachment by means of selection for increased cooperation in the resolution of parent-offspring conflict.

Game Theory

The emergence of game theory after World War II was a major impetus for the EES, as it raised questions about how the logico-mathematical operations

that produce cooperation, in theory, could be embodied, in fact, in the behavioral phenotypes that produce it. Game theory is the study of mathematical models of conflict and cooperation between rational "agents" in which each agent has to choose a behavior in an attempt to obtain some "utility," and the success of one agent's choice depends on those of the others. In the classic iterated prisoner's dilemma game, for example, two players must either "cooperate" with or "defect" from the other to obtain their utility. Game theory has shown that cooperation can emerge (in the iterated prisoner's dilemma game) when the agents are connected by a shared utility or common cause (e.g., Axelrod and Hamilton 1981; Maynard Smith 1982; Axelrod 1984, 1997). Hume provided an early example in his *Treatise on Human Nature* (quoted in Skyrms 2010:21):

> Two men, who pull the oars of a boat, do it by an agreement or convention, tho' they have never given promises to each other. Nor is the rule concerning the stability of possession the less deriv'd from human convention, that it arises gradually, and acquires force by a slow progression, and by our repeated experiences of the inconveniences of transgressing it…

In game theory, the oarsmen are the agents and the utility they seek is what they intend to gain by rowing. Let us assume first that these oarsmen have different intentions. Whatever they are, the "repeated inconvenience" of bumping into each other could serve to draw them together. All they need to do is to detect the contingency between a bump (the signal of asynchrony) and what it feels like (what the signal means) to have their selfish intentions frustrated by the other oarsman. Pure self-interest would then motivate each oarsman to synchronize the timing of their own strokes with that of the other, which would help both to work together to achieve their individually selfish intentions. So it is with mothers and infants, when their intentions conflict. Mother-infant interaction is fundamentally the exchange of information (immaterial signals), the meaning of which can have material effects on their bodies, resolving their conflict and gradually drawing them (and their minds) together.

Alternatively, let us assume that the oarsmen have the same intention. Now, in addition to their self-interested motivation to avoid a collision of oars, they are connected by their shared intention: their motivation to work together to achieve a common good. All they need to do is detect the contingency between their mutually regulated strokes (no collision: synchrony) and the pleasurable feeling (the meaning of not colliding) of realizing their shared intention more quickly or efficiently than either could manage alone or without synchrony. Again, so it is with mothers and infants as they gradually learn that they can trust the other to help them (their group) maintain synchrony (connectedness), which feels better than asynchrony.

Nowak (2006) showed mathematically that there are five processes that can "connect" organisms and favor the evolution of cooperation: kin (shared genes) selection, direct reciprocity, indirect reciprocity, network reciprocity,

and group selection. All five can "connect" infants, mothers, alloparents, and others in expanding circles of group identities. Nowak even concluded that "we might add 'natural cooperation' as a third fundamental principle of evolution beside mutation and natural selection" (Nowak 2006:1563). I suggest that increasing the "connection" between our ancestral mothers and infants would have transformed their natural conflict into "natural cooperation" and opened the door for them to co-construct a new niche, a new unit of selection at a higher level of complexity, the mother-infant group. Put differently, I suggest that our infant ancestors' motivation to "connect" or "attach" to mother-like people gave rise to the *feeling* of belonging to a group (and cultural group selection, as we'll see).

Group Selection

Group or multilevel selection theory maintains that when the cost of a prosocial act to an agent at one level is less than the benefit of that act to its group, group selection trumps the selfish agents at the preceding, lower level (Sober and Wilson 1998; Nowak 2006; Wilson and Wilson 2007; Nowak et al. 2010; Wade et al. 2010; Richerson et al. 2016). Thus, for example, because the cost of synchrony to an individual oarsman is minimal, two connected oarsmen would win a race against two selfish oarsmen. The idea that selection operates at the level of groups is, however, contentious. The MS, being gene-centric, rejects it; the EES, being information-centric, endorses it. The details of the kin selection-group selection debate need not, however, concern us.[4] What is of interest here is the key EES concept of niche construction: how the emergence of more connected mother-infant groups constructed a new niche with new selection pressures.

Niche Construction

According to the MS, environments exert selection on organisms. Under the EES, organisms can also select their environments; they can select (occupy) or construct a new niche by modifying an old one, either way potentially exposing themselves to new selection pressures (Odling-Smee et al. 2003; Stotz 2010; Laland et al. 2016). I speculate that the evolution of increasingly connected maternal and infant bodies would have constructed a new developmental niche with a new selection pressure: group selection for deeper, more intimate cognitive connections between mother and infant through mutual "mind reading."

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[4]   In any event, kin selection and group selection may just be two ways of thinking about the same thing. Their math is equivalent and the choice between them may depend more on particular interests, available data, or philosophical inclination (Nowak 2006; Nowak et al. 2010; Birch and Okasha 2015).

The Embodied Mind

Cognition is embodied when the body affects the brain (Varela et al. 1991; Gallese and Lakoff 2005; Fonagy and Target 2007; Gallese 2007; Johnson 2007; Adams 2010; Niedenthal et al. 2014; Clark 2016). It is embodied in infant brains by the effect of each bout of mother-infant interaction on the infant's body. As evolution embodied the immaterial laws of aerodynamics into wings and those of optics into eyes, the attachment process embodies the immaterial principles and logico-mathematical operations of game theory, biosemiotics, and complex adaptive system theory into infant brains. These "immaterialities" ("pure reason") are embodied in newborns through exteroception and interoception. Exteroception provides the infant with information about its mother. Interoception provides it with information about its *milieu intérieur*—the "feeling of what happens" (Damasio 1999) to its body—when it detects a sign that points at mother. The infant's interpretation of the contingency between mother's behavior and the way it feels at that moment[5] *is* the way it feels; the way it feels points at and means "mother," and vice versa: the contingency between the way the infant feels at a given moment and mother's response points at and means "me." The way it feels "now" is the phenotypic expression of "old," genetic information about the way mammalian infants should feel in that context. The feeling associated with each "now" experience is stored in memory as "newer" information.

Tomasello et al. (2005:680) proposed that the "origin of cultural cognition" was in the evolution of our capacity to share intentions: "Shared intentions, sometimes called 'we' intentionality, refers to collaborative interactions in which participants have a shared goal (shared commitment) and coordinate action roles for pursuing that shared goal." They believe that this capacity evolved from a common great ape's "understanding [of] others as animate, goal-directed and intentional agents" and a human "species-specific motivation to share emotions, experience, and activities with other persons" (Tomasello et al. 2005:675). However, they do not specify what this motivation was. What did selection "see" such that our infant ancestors evolved the "species-specific motive" to share the work of pursuing a shared intention?

I believe that what it "saw" was our infant ancestors' ancient mammalian motivation to form attachments.

Complex Adaptive Nervous Systems

Nervous systems are themselves complex adaptive systems—networks of hierarchically organized neural agents working together to control the body and its movements. They are the embodiment of the conditional, "if-then" logic of biosemiotics, complex adaptive system theory, and game theory. They become

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[5]   Infants can detect contingencies in less than a third of a second (Beebe and Lachmann 2014).

organized through cell-cell communication: if a neuron receives a certain kind of signal, it then interprets its meaning by sending a signal to other neurons. Nervous systems are the embodiment of Hebb's "law" (Hebb 1949): "neurons that fire together, wire together." That is, neurons become connected by communicating within and between levels.

At the bottom of the hierarchy are the most inferior brain regions (spinal cord and brain stem), which generate what Panksepp and Bevin (2012:96) call "intentions-*in*-action," as opposed to "intentions-*to*-act" at the top, the prefrontal cortex (PFC). Intentions-in-action include unmotivated reflexes and the impulsive "acting out" of feelings. Like bacteria, the deeply subcortical brain's interpretation of a stimulus *is* its response to the stimulus. If there's a discrepancy between "now," interoceptive information about the state of the body, and "old" information about what it should be, the deeply subcortical brain interprets the mismatch by activating innate autonomic or motor reflexes for maintaining homeostasis.

The separation between intention and action begins to emerge at the second level, where a higher subcortical region (cerebellum) interprets a stimulus to move, not by doing so, but as an instruction to consult motor memories ("newer" information) before acting. Inserting information about past motor behavior between "if" and "then" makes for more complex, coordinated, and clearer behavioral signals that are more effective because they are easier for mother to interpret.

The third level is the limbic system (amygdala, hippocampus, thalamus, hypothalamus), which is the interface between the subcortical brain and the PFC. The limbic system generates mammalian social emotions and motivations and inserts them as "value judgments" into the information it passes up to the PFC; that is, what this information means (the feeling it entails), first for the infant's immediate survival, then, as it continues to survive, for its growth and development and ultimate reproductive success. The limbic system is the origin of intention: emotions make the body want to do what its "old" mammalian emotions signal it to do. Panksepp identified seven "primordial" motivational systems in the brains of all mammals (Panksepp 1998; Panksepp and Bevin 2012). I will follow his lead in capitalizing their names to emphasize that, unlike everyday emotion terms, they refer to well-defined neuroanatomical structures and functions: SEEKING (wanting, expectancy), FEAR (anxiety, insecurity), RAGE (anger), LUST (sexual excitement), CARE (nurturance), PANIC/GRIEF (loss, sadness), and PLAY (the joy of play and exploration). I focus on SEEKING because it is the body's prime mover, the "generic appetitive force" that drives all the others. According to Panksepp and Bevin (2012:103), SEEKING is

> ...a general-purpose system for obtaining all kinds of resources that exist in the world, from nuts to knowledge, so to speak. In short, it participates in all appetitive behaviors that precede consumption: it generates the urge to search for any

and all of the "fruits" of the environment; it energizes the dynamic eagerness for positive experiences from tasty food to sexual possibilities to political power; it galvanizes people and animals to overcome dangers either by opposing them or by escaping to safety; it invigorates humans and prompts us to engage in the grand task of creating civilizations. But in the beginning, at birth, it is just "a goad without a goal"…that opens up the gateways to engagement with the world, and hence knowledge.

In fact, the goad does have a goal; its adaptive function is just that—to engage the world. Newborns acquire information about people by engaging with their bodies, much as Hume's oarsmen acquire information when their oars collide. Newborns engage mothers and others when their SEEKING systems energize an intention-in-action simply to move, thereby acquiring contingent feedback with which to construct internal motor models of how it feels to engage with them.

Damasio's "somatic marker hypothesis" holds that the limbic system is the source of mental images of past feelings which the PFC can access and "hold in mind" while deciding what to do next (Damasio 1994). He sees the connection between the limbic system and PFC as an "as-if loop" whereby a mental image of a past feeling is inserted into an action plan "as if" it had already been completed. This "as-if loop" makes it possible to evaluate images of the past and future. It enables us "to use a part of our mind's operation to monitor the operation of other parts" (Damasio 2010:28). The feeling tone connected to the imagined future points at or "marks" it as good, bad, or uncertain for the body's fitness, "now" and in increasingly distant futures.

The evolution of our capacity to "monitor" our subcortical emotions (to feel them) gave us a sixth sense, so to speak: our sense of value, the subcortical, inherently subjective feeling of SEEKING (even if we are not always sure what it points at). Natural selection "built the apparatus of rationality (PFC) not just on top of the apparatus of biological regulation (subcortex), but also from it and with it" (Damasio 1994:18), and because of it, Damasio might have added. The entire adaptive point of having a brain is to use it for the good (survival, growth and development, reproduction) of the body. The amygdala plays a critical role in keeping the body alive by looking for signs of danger in the information it receives from the body and inserting "fear" into the signals it sends up to the PFC (Gee et al. 2013; Callaghan and Tottenham 2016b). When it detects danger (risk or uncertainty), it attempts to avoid it by activating the infant's HPA system, initiating the release of cortisol, with its short-term benefit to survival (but potential long-term costs in the form of stress-related disease). Nervous systems are complex adaptive systems, of which the "fundamental attribute" is that "an internal model allows [the system] to look ahead to the future consequences of current actions, without actually committing itself to those actions. In particular, the system can avoid acts that would set it irretrievably down some road to future disaster ("stepping off a fitness cliff")" (Holland 1992b:25).

Because newborns are all intentions-in-action, they are unable to look
ahead to anything. Their optimal developmental strategy is thus to pay particu-
lar attention to downside protection against risk and uncertainty. Continuing
to survive gives them time to construct internal models for looking ahead to
future consequences. Newborns construct internal models of how it feels to en-
gage with mother by applying the scientific method (e.g., Reddy 2008; Gopnik
2009). Each engagement provides the infant with inductive "now" information
about the contingencies between the "feeling of what happens" when mother
responds to its intention-in-action. This information is passed into memory as
"newer" information, adding to what is, in effect, a kind of "correlation matrix
of contingencies," a "database" of experience for the PFC to "analyze" for pat-
terns and construct (deduce) models of experience and expectations.

The PFC is a neurobiological adaptation that enables us, among other things,
to use information about the logical contingencies among beliefs, desires, and
intentions to manage our social relations. (It does the deductive work of in-
ternal working models, theory of mind, mentalizing, intersubjectivity, etc.)
Tomasello et al. (2005:675) argue that sharing intentions ("we" intentionality)
is the "origin of cultural cognition" and the "foundational skill" for theory of
mind "because it provides the interpretive matrix for deciding precisely what
it is that someone is doing," or did, intends to do, or means. A newborn ner-
vous system has the capacity to make primitive meaning because its inter-
pretive matrix came with some information "wired-in," in the form of "old"
information about the environment of evolutionary adaptedness of mammalian
infants. With maturation and repeated interactions with mothers and others, in-
fant nervous systems construct larger, multimodal, cross-temporal interpretive
matrices. As Bowlby observed, each bout of interaction is an iteration of the
feedback cycle that controls infant social-emotional-cognitive development.
Each iteration of this "attachment cycle" (Figure 11.1) embodies information
that the infant nervous system evaluates in terms of its own self-ish SEEKING
for security, and uses to construct beliefs about mother's beliefs, desires, and
intentions regarding the infant (Sroufe and Waters 1977). It goes without say-
ing, of course, that while the attachment cycle itself is universal, the beliefs
that infants construct are inherently specific to their culture.

Attachment and Cooperation

The attachment cycle integrates information from each of the four levels of
complexity in the evolution of life (Table 11.3). First, genetic information es-
tablishes the infant's "set-goal" in the form of "old" information about the way
mammalian infants should feel, i.e., secure (see Figure 11.1, "Felt security").
Second, epigenetic information may be embodied through exposure to stress
or the inheritance of the effects of stress on the infant's parents (e.g., Weaver
et al. 2004; Turecki and Meaney 2016), especially the stress of intergenera-
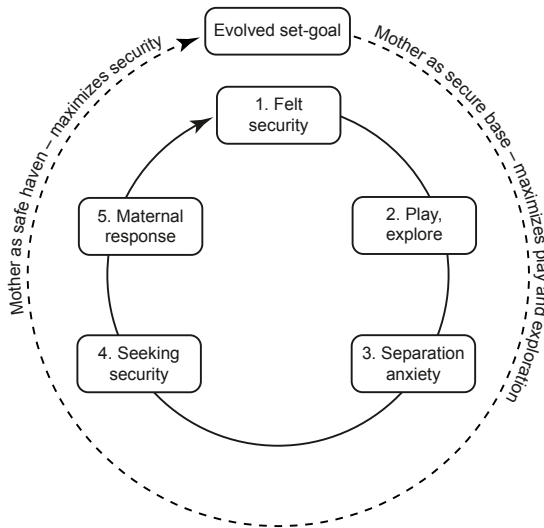tional poverty (McEwen and McEwen 2017). Information about stress (risk

Figure 11.1 Schematic diagram of "attachment as an organizational construct."

and uncertainty) is particularly important to newborn bodies because they are unable to feel the way they should by themselves; they need tolerance and help from mothers or others. Third, behavioral information is embodied through each iteration of the attachment cycle. Information about stress (the feeling of insecurity) is particularly valuable to newborns because the adaptive function of insecurity is to stay alive by SEEKING security. The only way newborns can SEEK security is to signal their needs (intentions-in-action), in the evolution-arily rational expectation that someone will provide a safe haven. (I'll discuss the fourth level of complexity in the following section on "Shared Intentions.")

But there's more to life than safe havens. To acquire information about their developmental niche, infants must explore it. The adaptive function of security is to SEEK information, which, as Panksepp and Bevin (2012:8) pointed out "opens up the gateways to engagement with the world, and hence knowledge." The only way infants can SEEK information is to signal their need for it by the intention-in-action of engaging their world, probing and playing with the people and things around them, in the evolutionarily rational expectation of a secure base to which they can return. Sooner or later, the infant's probes will produce painful contingencies that activate its HPA stress-response system, release cortisol, separation anxiety, and the intention-in-action of SEEKING security. Then comes the nub of the attachment cycle: how its mother (*qua* minimalist mammalian mother) responds to its signal of need.

Each iteration of the attachment cycle provides the infant with an opportunity to detect the contingency between a mother's response to its signal and the feeling of what happens to its body when she does (or does not) respond. Internal models of experience are constructed from "backward" contingencies: they attempt to

explain the past ("after X happened, I felt Y"). Internal models of expectations are constructed from "forward" contingencies: they attempt to predict the future on the basis of the past ("because X happened in the past, I will feel Y if it happens again"). In the stark binary terms of propositional logic, biosemiotics, and complex adaptive systems theory, a mother's response either downregulates the infant's HPA system or it does not; it either makes the infant feel secure or insecure. Each iteration of the attachment cycle provides new "now" information that is stored as "newer" information about its attachment history in its "correlation matrix of contingencies" or "interpretive matrix for deciding precisely what it is that someone is doing," or did, intends to do, or means.

Animal behavioral traditions are maintained by learning. Infants learn their mammalian behavioral traditions, first by learning from the mother's body, then through her mind. Infants begin learning from and about their mothers by detecting the contingencies that "connect" their bodies—the feeling of what happens before, during, and after they come in contact, move, and bump into each other. In the stark binary terms of game theory, each contact (Figure 11.1, "Maternal response") gives mothers an opportunity to "cooperate" with their child or "defect" from it. As with Hume's oarsmen, pure self-interest can motivate each to adjust its movements to the other. In addition, generic mammalian mothers are predisposed to cooperate because they share 50% of their genes with their children and are motivated to care for them. It is in their genetic self-interest to tolerate, at least, the child and its attempts to nurse (see, however, further discussion of parent-offspring conflict below.) By "working together" the mother-infant group achieves a degree of mutual regulation, biobehavioral synchrony, and psychobiological attunement. To paraphrase Hebb, "bodies that move together, wire together." Infants also begin to learn from and about mother in the first few weeks of life through imitation (Meltzoff and Moore 1977; Meltzoff 2005).

Compared to young chimpanzees, young children are "hyper-imitators," prone to "overimitation"[6] (Whiten et al. 2009). This may be due to the human mirror neuron system (Gallese 2007). The capacity for imitation was obviously important in the evolution of our capacity for culture (Tomasello 1999; Richerson and Boyd 2005; Lyons et al. 2007; Burkart et al. 2014). As Whiten et al. (2009:280) stated, "we are such a thorough-going cultural species that it pays children, as a kind of default [adaptive learning] strategy, to copy willy-nilly much of the behavioral repertoire they see enacted before them"—but not by just anyone. Henrich and McElreath (2003) argue that the evolution of culture depended on "biased imitation"—our well-documented propensity to imitate others because of their prestige (higher status, fame), success (power, wealth), similarity ("like me": identity), and/or conformity (proximity: do what people around me are doing).

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[6]   Unlike chimpanzees, children also have a strong tendency to imitate the actions of a model that are extraneous to the goal of the action being modeled.

It is not clear, however, where these imitation biases came from. Because selection operates only on phenotypes, not genotypes, the EES would like to know (a) what phenotypic mechanisms motivate anyone to imitate anyone else, (b) how they develop, and (c) what their phylogenetic precursors might have been. In other words, what did selection "see" such that it evolved into our children's capacity for overimitation? I believe the most parsimonious explanation is that newborn infants imitate mother-like people because they are innately motivated to SEEK the species-specific patterns of sign stimuli and contingencies which point at "mother." Mothers are "attractors" in the design space of generic mammalian newborns because, from the infant's perspective, they have higher status, all the power and resources, are "like me" (belong to my group), and are usually in close proximity. This is a parsimonious explanation because it posits a single adaptive learning strategy—imitate whoever acts like a mother—rather than a number of separate adaptive functions or motivations for imitating different people with different qualities; mothers embody them all. Mother-like people are important for the infant's later cognitive development because their "power" includes epistemic authority; infants cannot help but have "epistemic trust" that a mother is modeling appropriate behavior (Csibra and Gergely 2011).

Shared Intentions

At the top of the four levels of complexity (Table 11.3) is the processing of symbolic (i.e., cultural) information, accomplished in the PFC, the brain's "higher association area." Accounting for twice the total brain volume in humans as in the other apes, the PFC embodies the brain's executive functions and working memory. Within it is the medial prefrontal cortex (mPFC), which, with input from working memory, executes top-down cultural control over our generic mammalian social emotions. With the onset of mPFC myelination at about nine months (Paus et al. 2001), infants begin the transition from intentions-in-action to intentions-to-act. They become able to form forward contingencies—expectations about mother's behavior—based on their "interpretive matrix" of backward contingencies in their attachment history. They develop the ability to "hold in mind" the limbic feeling of what happened to their bodies in the past and form internal models of how it would feel (via Damasio's "as-if loop") if they had executed some intention. If the expected feeling does not match its "old" mammalian information about how it should feel (secure), their mPFC can inhibit that intention.

Chronic early stress (HPA activation) can affect the developing connections between the limbic system and the mPFC, with potentially severe consequences for a child's self-control, exploratory behavior, and HPA reactivity. In theory, if mothers consistently demonstrate their ability and willingness to invest, infants will form positive expectations about future

interactions. If not, they will have negative expectations, in one of two ways. First, in theory, if mothers have been too inconsistent in responding to their signals of need, infants will be insecure (uncertain, anxious, ambivalent, preoccupied) about their mother's ability to meet their needs. Second, if mothers have too often ignored, rejected, or punished their infants' signals of need, they will be insecure about their mothers' motivation and mirror her unwillingness back to her by not signaling, thereby avoiding, not so much her, as the risk of pain from an expected rejection (Main 1981). Indeed, Behne et al. (2005) showed that by the age of nine months, infants can detect the difference between an adult's ability and willingness (motivation, intention) to perform an act.

The nine-month-old's ability to interpret its mother's intentions and generate expectations is the essence of theory of mind (internal working model, mentalizing, etc.). Belief-desire-intention reasoning is practical (Bratman 1987): it is used to program artificial intelligent agents as well as to model successfully reasoning in three- to ten-year-old children (Wahl and Spada 2000). A secure one-year-old, for example, would (a) *believe* that his mother cared for him, (b) so she must *desire* to do so, (c) therefore she *intends* to do so in the future (assuming she is able), and (d) therefore he *expects* her to do so.

Positive expectations maximize the infant's desire to play and explore. An infant will engage its mother and others by SEEKING information through their minds to make the most of its secure base. Positive expectations emerge from the infant's mammalian sense of being connected to mother through mutual regulation, biobehavioral synchrony, and psychobiological attunement. Each good connection leads to the next. Each is associated with the pleasant feeling of "working with" mother, adding to her reputation for cooperation. Positive connections transform the natural parent-offspring conflict into Nowak's "natural cooperation" (Atkinson et al., in preparation), giving rise to the mother-infant group, shared or "we intentionality," and the feeling of consensus, group identity, or "we-ness" with mother. The infant's capacity for "we-ness" emerges, bottom-up, with the maturation of the connections between her limbic system and mPFC, giving her increasing top-down control over her mammalian infant social emotions. In a "self-similar" way, the mother-infant group emerges, bottom-up, from nine months of postnatal mutual regulation, synchrony, and attunement, gradually increasing its top-down control over their individual identities and desires. If we project this model of the ontogeny of "we-ness" backward as an "evo-devo" model of its phylogeny, it is not hard to imagine that early hominin mother-infant groups whose minds were better-connected would have had an evolutionary edge over less-connected mother-infant groups. Better-connected infants would inherit not only their animal behavioral traditions from mother's body, but also her emerging symbolic, cultural traditions through her mind. On this view, natural mother-infant cooperation created a new niche, culture, at a higher level of complexity, the cultural group, and a new selection

pressure, cultural group selection,[7] for mind reading and increasingly well-connected, hypercooperative mother-infant groups.

Negative expectations, on the other hand, maximize the infant's desire for a safe haven, SEEKING security in hope of staying alive just long enough to have a life and avoid a fitness cliff. Building on the pioneering work of Draper and Harpending (1982), Belsky et al. (1991) proposed that the attachment process was an evolved mechanism for entraining alternative reproductive (life history) strategies. It enabled infants to predict the quality of the environment in which they will reproduce from their experience of that into which they were born. Writing in support of their proposal, I argued that it was fully consistent with life history theory (Chisholm 1999b). When mothers are unable to buffer their offspring against environmental risk and uncertainty—above all that of death—it is evolutionarily rational to grow, develop, and reproduce as early as possible to avoid stepping off Holland's "fitness cliff" (Table 11.2). But before looking at the effects of infants' expectations on the development of their reproductive strategies, I need to say a word about how they go from sharing intentions with mother to sharing meanings. In other words, how the infant's expectations draw it into the mother's mind, where it can "read" her intended meanings and learn how to think.

Shared Meanings

Because there is no reason to think unless one is SEEKING a "utility" to think about, emotion is inseparable from cognition. Mammalian emotions were phylogenetically prior to human cognition, gave rise to it, and give rise to it ontogenetically. As Hobson put it, "symbolizing, language and thought are possible only because of the nature of the emotional connection between one person and another, and because of each person's involvement with a shared world" (Hobson 2002:94). Before humans evolved the capacity to think, there "was *social engagement with each other*. The links that can join one person's mind with the mind of someone else—especially, to begin with, emotional links—are the very links that draw us into thought. To put it crudely: the foundations of thinking were laid at the point when ancestral primates began to connect with each other emotionally in the same ways that human babies connect with their caregivers" (Hobson 2002:2, original emphasis).[8]

The link that first connects mothers and infants is bodily: mutual regulation, biobehavioral synchrony, and psychobiological attunement. As Fonagy and Target (2007:428) state:

> Since the mind never, properly speaking, separates from the body, the very nature of thought will be influenced by characteristics of the primary object relation.…

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[7] For cultural group selection theory, see Richerson et al. (2016).

[8] Baron-Cohen (2002) captured Hobson's argument perfectly in the title of his *Nature* review of Hobson's book: "I am loved, therefore I think."

> The origin of symbolic representation is thought to be biologically significant actions tied to survival and adaptation. Such actions are steeped in somatosensory [interoceptive] experiences and salience and are perceptually guided. Thus, implicit in the use of a symbolic representation is the history of bodily and social experience of actions related to the symbol.

Or, in the words of Lakoff and Johnson (1999:555):

> We can only form concepts through the body. Therefore, every understanding that we can have of the world, ourselves, and others can only be framed in terms of concepts shaped by our bodies.

Infants begin life with the intention-in-action of SEEKING information from and about their caregiver's body through physical interactions. To the embodied mind, symbols are material objects, out there in the world, perceived through exteroception *and* they are the material, interoceptive representation of the object in the neural networks that stand for or point at the object (Trevarthen 2009, 2011; Vogeley and Roepstorff 2009; Clark 2016). Roepstorff (2008:2051) reviewed neuroimaging evidence which showed that "once words are understood by a person, they become material instantiations in some form in the brain." For example, action words with specific targets ("the man goes into the house") activate motor areas of the brain; however, when the target of the action is abstract ("the man goes into politics"), motor areas are silent and language areas active. Thus, he suggests that "the overall neural resonance created by words interacts with non-linguistic brain areas involved in representing processes that the word represents" (Roepstorff 2008:2051). In a self-similar way, the "neural resonance" between mother and infant replicates the mother's symbols in the infant's brain. To paraphrase Hebb again, "minds that fire together, wire together," producing the pleasant feeling of being understood. Everyone's first experience of culture is with people who act like mothers. To paraphrase Geertz (1973:5), mothers and infants are "animals suspended in webs of significance they themselves have spun."

The Extended Embodied Mind

Cultures are the extension of embodied minds in which one person's mental state is extended to or constructed in others (Clark and Chalmers 1998; Moll and de Oliveira-Souza 2009; Menary 2010; Kendal 2011; Shea 2012). Preceding Tomasello's concept of "we intentionality"—he even used the term "we-ness"—by 59 years, Bowlby (1946:62) was concerned with "the psychological problem of ensuring persistent co-operative behavior" in groups of any kind. He maintained that "the principal conditions for willing co-operation are thus that there should be a common aim, apprehended to some degree at least as being of value both to the self and to others who are loved, and that the individual or individuals who present this common aim and the plan for achieving

it should do so in such a way that they are respected and trusted" (Bowlby 1946:63). Bowlby believed that the adult motivation to cooperate originated in the infant's desire "to be held in good esteem by the people he values" (Bowlby 1946:65), and that the capacity to value people was the capacity to libidinize,"[9] which "originates in infancy in the child's feeling for his mother" (Bowlby 1946:64). He goes on to describe how the infant's capacity to libidinize mother is the origin of adults' motivation to belong to valued groups and to place emotional value onto group leaders, the group itself, and the group's "policy" (ethos or belief system). I would argue that it's also the origin of the *infant's* capacity to emotionally value groups—groups of alloparents.

The leader of the infant's first group is mother. The infant SEEKS to be held in good esteem by her because he depends on her for his life. His weakness makes him subordinate to her; he needs someone "stronger and/or wiser" (Bowlby 1988a:3). After nine months of good-enough mothering, he begins to develop a sense of group identity, the feeling of "we-ness" about the self-mother group itself. "We-ness" opens the door for "we" intentionality, the feeling of sharing a common aim. Understanding the leader's plans for approaching the group's aim, however, is not easy. It is easier to form feelings of love or pleasure toward a person than toward a plan or policy. It is also easier for infants (and many adults) to identify with a group's leader—and trust that God has a good plan—than to trust the reasons why it is a good plan. People SEEK security in groups more than they seek wisdom because "the group is thought of *as though it were an individual*, and feelings of personal affection are evoked" (Bowlby 1946:61, emphasis added; see also Ein-Dor and Hirschberger 2016).

Like Bowlby, the game theorist Michael Bacharach was concerned with the psychological problem of ensuring persistent cooperative behavior in groups; that is, how "early man managed to function well in groups, by doing things that we are inclined to call 'cooperation'…" (Bacharach 2006:98). He began by emphasizing the huge diversity in the types of game theoretic games that people can play with each other. While cooperation can evolve in the iterated prisoner's dilemma game, Bacharach argues that this cannot explain altruistic or prosocial behavior in other types of games. After a technical explanation of why this is so, he concludes that prisoner's dilemma games "do nothing to explain, *psychologically*, cooperative behavior in common-interest interactions, or in organized interactions" (Bacharach 2006:111, emphasis added). In other words, the iterated prisoner's dilemma cannot explain the emergence of "we-ness" or "group identification":

> ...group identification is the key proximate mechanism in sustaining cooperative behaviour in man. More fully, I conjecture this: dispositions to cooperate in a range of types of game have evolved in man, group identification has evolved

9 Libidinize, or the capacity to form a libido, was restricted in early Freudian theory to the formation of sexual drive, but later expanded to include all expressions of love and pleasure.

in man, and group identification is the key proximate mechanism for the former. The main virtue of this hypothesis over that of altruism and other contenders [for explaining human cooperativeness] is that group identification is a more powerful *explanans* of the diversity of cooperative behaviors we see. Group identity implies affective attitudes which are behaviorally equivalent to altruism in Dilemmas, and it can explain what altruism cannot, notably human success in common-interest encounters (Bacharach 2006:111).

Attempting to cast new light on the evolution of human cooperation, Moffett (2013) conducted a phylogenetic analysis of hunter-gatherer and vertebrate social groups. Reasoning that human groups are characterized by an especially high degree of cooperation and the other vertebrate groups are not, Moffet defined "society" minimally as "cooperation beyond mere sexual activity," so as to include as many vertebrate phyla as possible. He found that "individual-recognition" societies (e.g., nonhuman primates, social carnivores) rarely exceeded 200 individuals, whereas human societies were exponentially larger (millions, if not billions). What made the difference, he suggests, is that we evolved the capacity to have a *concept* of identity. We do not have to recognize individuals because we evolved the capacity to identify people by the signs of the group with which they are identified. This concept of identity enabled our ancestors to construct "nested hierarchies" of group identities (e.g., kinship systems) based on "degrees of intimacy." At the bottom of the hierarchy is the most intimate: the mother-infant group.[10] Then, in order of decreasing intimacy (and rough prehistorical order of emergence) came the nested hierarchy of allomothers, nuclear and extended families, bands, clans, tribes, and so forth, up to more than a billion people in modern states and religions, each exerting a degree of top-down control over the preceding levels. Our cortical capacity for cultural concepts of group identity emerged phylogenetically, and does so ontogenetically, from our mammalian limbic resonance or sense of "we-ness" with mothers and others—Hobson's emotional link that draws us into thought.

Alternative Life Histories

Life History Theory

As argued above, the Belsky-Steinberg-Draper attachment model of the development of alternative reproductive strategies is thoroughly consistent with life history theory. Life cycles (Table 11.2) are reproductive strategies that have been organized by information about an organism's developmental niche. The most telling information is about the probability of dying at a given age (Promislow and Harvey 1990, 1991; Stearns 1992; Charnov 1993). When mortality rates are low and predictable, it is relatively easy for mothers to buffer their children against environmental risk and uncertainty. Under such

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[10] Moffett, a zoologist, mistakenly identifies "married couples" as the most intimate.

conditions, the future or "long-slow" strategy is optimal because it gives organisms time to grow bigger bodies and brains, gain more experience, become more competitive (by cooperating, if they're human), find a good mate, produce a few offspring, and invest heavily in each. This maximizes the probability of the minimum gain necessary for lineage continuation by maximizing offspring "quality" (reproductive value: potential for providing grandchildren). It fosters what Daniel Kahneman refers to as "thinking slow" (Kahneman 2011).

Alternatively, when mortality rates are high or unpredictable, it is harder for mothers or alloparents to buffer children from the causes and consequences of high mortality rates (e.g., intergenerational poverty, inequality). Under such conditions, the current or "short-fast" strategy is evolutionarily rational because it enables organisms to reproduce as early and often as possible. Reproducing early maximizes the chance of reproducing before mortality strikes; reproducing often maximizes the chance that at least one offspring will survive. This minimizes the probability of the maximum possible loss, lineage extinction, by maximizing offspring quantity, even at the cost of future morbidity and shortened lives. It fosters Kahneman's notion of "thinking fast."

Survival, growth, and development are necessary for reproduction but not sufficient. Evolution does not "care" about organisms' quality or length of life; all it cares about is reproduction. To maximize the chance of reproduction under adverse conditions, natural selection favors mechanisms that enable organisms to "make the best out of a bad bargain": available resources from growth and development are reallocated to permit early and/or frequent reproduction. In humans, chronic early adversity (e.g., psychosocial stress, HPA activity) is associated with early puberty in boys (Mendle and Ferrero 2012) and girls (Coall and Chisholm 2003; Chisholm et al. 2005; Chisholm and Coall 2008; Ellis et al. 2009; Belsky et al. 2015). In turn, early puberty is linked to increased risk for obesity, elevated blood pressure, heart disease, type 2 diabetes, and, in women, breast cancer (Collaborative Group on Hormonal Factors in Breast Cancer 2012; Hanson and Gluckman 2016). Early adversity is also linked to a suite of behavior problems. As Bowlby said of adolescents and young adults who had suffered disturbed early family relations, "persistent stealing, violence, egotism, and sexual misdemeanours were among their less pleasant characteristics" (Bowlby 1951:380). The same traits also comprise the "absent father syndrome" (Draper and Harpending 1982), the "young male syndrome" (Wilson and Daly 1985), the "male supremacist complex" (Divale and Harris 1976), and "cultures of risk" (Quinlan and Quinlan 2007) and coping (Burbank 2011). Early adversity is also associated with impaired ability to delay gratification (Chisholm 1999a; Coccaro et al. 2015; Sturge-Apple et al. 2016) and increased psychopathology (Del Giudice 2014; Hurst and Kavanagh 2017), in particular borderline personality disorder. Brüne (2016:52) characterizes borderline personality disorder as "unstable interpersonal relationships, fear of abandonment, difficulties in emotional regulation, feelings of emptiness, chronic dysphoria or depression, as well as impulsivity and heightened

risk-taking behaviors." Interpreting borderline personality disorder in terms of life history theory, he describes the lives of sufferers as "fast and furious." Insecure attachment is specifically implicated in its development (Fonagy et al. 2000; Debbané et al. 2016).

The mechanisms by which early adversity affects later health and behavior are not fully understood, but chronic HPA activity can modify the expression of genes involved in neurodevelopment (McGowan et al. 2009; Turecki and Meaney 2016). Early adversity has been linked to enlarged amygdalae (Tottenham et al. 2010) and accelerated amygdala-mPFC connectivity (Gee et al. 2013; Callaghan and Tottenham 2016a, b). In keeping with life history theory's "short-fast" ("fast and furious") reproductive strategy, Callaghan and Tottenham (2016a:79) propose that:

> ...accelerated [fearful] phenotypes emerge because stress experienced early in life may prematurely activate the core circuitry of emotional learning and re-activity. That is, the acceleration of limbic development following early stress may rely on an activity-dependent process. Importantly, we hypothesize that this accelerated development, while meeting immediate [short-term, downside risk protection] emotional demands (i.e., emotional regulation in parental absence), may have long-term consequences…on emotion regulation in adulthood.

Acting out the bodily sensation of fear may be (or once have been) an evolutionarily rational response to chronic risk and uncertainty, but it is not conducive to mind reading, trust, or cooperation.

Cooperative Breeding

Throughout human evolution, the probability of death, and thus the force of selection, has been highest in infancy and early childhood (Jones 2009). Keeping their increasingly needy children alive through the intense selection of their first few years could not have been easy for early mothers. The greater their children's need, the more intensely they would have been selected to meet it. This created a demographic dilemma: the more that mothers worked to keep one child alive, the harder it became to have another and keep it alive as well. The trade-off for rearing quality children was reducing their quantity, making it harder to maintain reproductive rates at replacement level and increasing the threat of lineage extinction (Lovejoy 1981). But our ancestors did increase their reproductive rate: "Humans, who of all apes produce the largest, slowest-maturing, and most costly babies, also breed the fastest" (Hrdy 2009:101). Theory, cross-taxa, and cross-cultural evidence indicate that reducing inter-birth intervals without compromising child survival was possible only because mothers got help with child care.

There is no question that cooperative breeding was critical for the survival of our species (Burkart et al. 2009; Hrdy 2009; Sear 2016), or that grand-mothers in particular radically changed the developmental niche of our infant

ancestors (Hawkes 2004, 2014). Long, slow development gave our ancestors more time to grow big brains, with well-developed association areas, and to develop complex social, emotional, and cognitive skills—but it also increased the cost of rearing them. Cooperative breeding solved the demographic dilemma by spreading this cost among alloparents such that our ancestors were more likely to live long enough to benefit from their enlarging cerebral cortices and "learn more, know more, become more efficient at food procurement, outcompete others for mates, and so forth" (Hrdy 2009:277). For Hrdy (2009:277, original emphasis) "cooperative breeding had to come first" because it was "the *preexisting condition* that permitted the evolution of these traits in the hominin line." Likewise, Hawkes (2014:29) argues that "grandmothering sets up the novel selection pressures on mothers and infants identified by Hrdy."

But why would grandmothers or anyone feel like helping a needy mother? Since selection operates only on phenotypes, not genotypes, the EES would like to know what phenotypic mechanism motivates anyone to cooperate with anyone else. Hrdy's model of the role of cooperative breeding in human evolution as well as Hawkes's of grandmothers in particular, are compelling but say little about the role of the infant in the evolution of cooperative breeding or culture. Recently, Hrdy has argued that our capacity for prosocial, "other-regarding" feelings were "predictable corollaries of [cooperative breeding] and as a byproduct of it, preadapted apes in the hominin line for greater social coordination" (Hrdy 2016a:43). But what was the preexisting, phylogenetic precursor of prosocial emotion? What did selection "see" such that it evolved into Tomasello's "species-specific motivation" to make common cause with one another? I believe that our prosociality was more than a byproduct of cooperative breeding; it was intimately involved in its emergence and that of culture itself.

Parent-Offspring Conflict

Each iteration of the attachment cycle provides mothers an opportunity for parental investment—a chance to respond cooperatively to their infants' signals of need. Whether and how they respond depends on their ability and motivation. When mothers are materially, socially, and emotionally secure, parent-offspring conflict tends to be minimal and constructive. The constructive resolution of conflict builds trust. It repairs the "messiness" of breakdowns in Tronick's mutual regulation model, restores the synchrony in Feldman's biobehavioral model, the attunement in Fields' model, and buffers the infant against HPA hyperreactivity and elevated cortisol in Gunnar's model. However, when mothers are under stress from the causes and consequences of intergenerational poverty or inequality, they may well be less able or willing to invest: more of their interactions are likely to be messy and end badly, leaving the infant and/or mother feeling insecure (hungry, tired, frustrated, confused, sad). Instead of buffering infants against the stress their environment imposes on them, mothers transduce it to their infants.

Conflict is unpleasant and inevitable, but without it there is no reason to co-operate. Likewise, without parent-offspring conflict there would have been no reason for mother-infant cooperation or cooperative breeding. The evolution of our prolonged helplessness escalated our existing ape level of parent-offspring conflict into an early human mother-infant "arms race." Infants would have exerted continuous selection on mothers for their ability and motivation to respond effectively to signals for care and attention. Mothers would have continuously resisted by allocating their limited time and energy to (selecting for) infants with the ability and motivation to send more persuasive signals. The result would be positive feedback between the effects of mothers' selection on infants and vice versa (Chisholm 2003; Kilner and Hinde 2012). When this feedback cycled to the point that mothers could no longer provide enough by themselves, it would have been evolutionarily wise for them to get help with child care. Those with sufficient social skills and/or relationships to recruit or attract alloparental care would be more likely to produce another child before the previous one was independent. Shorter birth intervals, however, opened a new arena for parent-offspring conflict—the "dark side of cooperative breeding" (Hrdy 2009:100). Except for the other cooperatively breeding primates, the callitrichids, only human mothers can have a child before the preceding one is independent. And, like the callitrichids, only human mothers have ever had to decide that one child is a better "investment" than another, and to neglect, reject, and even kill those judged less likely to provide grandchildren (Hrdy 1999, 2009). Understanding a mother's intentions would have been an evolutionarily wise basis for attempting to "mold" her into providing more investment or avoiding its termination with prejudice.

Conclusion

I believe that an attachment theory informed by the EES can readily incorporate the concept of culture and the role of alloparents—those to whom the infant is psychobiologically attuned as if to its biological mother. The key is to focus on the role of the "feeling of what happens" to the body during the acquisition and reproduction of information.

From biosemiotics comes the notion that organisms are matter and energy that have been organized—embodied—by information, and that meaning, value (feelings), and intention are facts of nature represented by signs. This understanding will help us resist mind-body and nature-culture dualism. From complex adaptive systems theory comes the concepts of self-replication and emergence—the idea that complex systems not only reproduce themselves but can acquire information such that higher levels of complexity can emerge, bottom-up, to exert top-down control over lower levels. Evolution is a complex adaptive system; it embodied the information that organized organisms into increasingly complex wholes. Organisms are also complex adaptive systems:

they die, but the information by which they were organized is reproduced, outlasting the matter and energy they embodied. Infants, too, are complex adaptive systems: they acquire the information that organizes their nervous systems into the increasingly complex wholes by which they exert culturally appropriate top-down control over their behavior.

Game theory offers the notion that cooperation can emerge from conflict. I have argued that biology, in the form of (a) mammalian infants' motivation to form attachments and (b) parent-offspring conflict, came before and gave rise to "natural cooperation" and culture: minds that "work together" or "cooperate." This, in turn, opened the door for mothers and infants to co-construct a new niche—a "web of meaning"—a new unit of selection at a higher level of complexity, and for selection to take human evolution in its hypercooperative direction. From life history theory comes the notion that life cycles are reproductive strategies. Evolution is a complex adaptive system that keeps itself going through the acquisition and reproduction of the information that organizes organisms, even when the going gets tough and organisms suffer. Cultures are complex adaptive systems that keep themselves going through the acquisition and reproduction—the extension—of cognitive schemas. As Scheper-Hughes (1992) observed so well, when people suffer from chronic poverty and inequality, cultures of condolence (*condolere*, "to suffer together") are likely to emerge.

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