

# EVOLUTION AND THE SOCIAL MIND

Evolutionary Psychology and  
Social Cognition

*Edited by*

**Joseph P. Forgas**

*University of New South Wales*

**Martie G. Haselton**

*University of California at Los Angeles*

**William von Hippel**

*University of New South Wales*

# 11

## Aligning Evolutionary Psychology and Social Cognition

### Inbreeding Avoidance as an Example of Investigations into Categorization, Decision Rules, and Emotions

DEBRA LIEBERMAN

Introduction

What is a Computational Theory of Mind and Why Should Social-  
Cognitive Scientists Care?

Selection Pressures and the Evolution of Inbreeding Avoidance  
Mechanisms

An Information-Processing View of Inbreeding Avoidance: What  
Would a Well-Engineered System for Inbreeding Avoidance  
Look Like?

Empirical Investigation of Systems for Inbreeding Avoidance

Conclusion

#### INTRODUCTION

As an evolutionary psychologist employing theoretical tools from biology and cognitive science to study human social behavior, I often find I speak a completely different language from those trained in the field of social cognition, despite the similar goals of understanding human sociality. There are (at least) two reasons why translation between these two frameworks has been difficult. First, research in social cognition typically has not considered

important theoretical contributions from evolutionary biology, principles known to organize cognitive processes and behavior in nonhuman animals (e.g., kin selection, parental investment, sexual selection, and reciprocal altruism). For example, despite the fact that humans likely evolved in small kin-based groups and that much of our social interactions would have been with kin of varying degrees, kinship has been an area largely neglected within social cognition (Daly, Salmon, & Wilson, 1997). One area of research that has overlooked the importance of kinship is social categorization and person perception. Researchers interested in the dimensions into which we categorize social targets have focused on the big three—sex, age, and race—yet ignored kinship. Kinship, however, is an important social dimension organizing a variety of different individual and group-level behaviors. For example, tracking kin relations would have enabled inferences such as who is likely to come to the aid of another, who is not likely to be a competitor for a particular mate, or who is likely to band together and form a collective action, among other things. Indeed, recent empirical findings indicate that kinship, much like age and sex, is a dimension implicitly encoded by our psychological architecture (Lieberman, Oum, & Kurzban, 2006).

A second reason for the language divide is that social-cognitive psychologists have not fully adopted a computational theory of mind—a tool that has proved powerful in other areas of cognitive research and, as I hope to demonstrate, in evolutionary approaches to understanding human behavior. I certainly do not believe that social cognition is the only field in need of updating, evolutionary-minded researchers would do well to integrate the robust methodologies developed and debugged by social psychologists. This would allow hypotheses derived from an evolutionary-computational framework to be better tested and then more easily shared across academic boundaries (von Hippel, Haselton, & Forgas, chapter 1, this volume). Evolutionary psychologists should also take note of the phenomena social cognitive psychologists have documented and ask what clues they provide about our species' evolution. Nevertheless, I do see the theoretical contributions flowing primarily from evolutionary science. If evolution can be used to understand the behavior of every other living organism, surely it can be used to understand aspects of human cognition, social or otherwise (Darwin, 1859/2003).

This chapter aims to address these two communication roadblocks separating the fields of evolutionary psychology and social cognition. Specifically, my goal in this chapter is to (1) demonstrate how evolutionary principles can be used to study human social cognition and behavior using categorization and decision-making processes relating to inbreeding avoidance as an example and, in the process, (2) describe what an evolutionary-computational approach to social cognition might look like. In the next section, I briefly discuss what is meant by an evolutionary-computational framework and why it can be of value to the field of social cognition. Then, using my own research on inbreeding avoidance as an example, I walk through the logic of what an evolutionary-computational analysis entails. I start with a review of the evolutionary reasons (i.e., selection

pressures) why inbreeding avoidance mechanisms are hypothesized to exist. Following this, I outline the kinds of information processing procedures (i.e., computational components such as decision rules and categorization processes) required to achieve inbreeding avoidance. In particular, I focus on: (1) how we categorize others according to kinship using cues available in the social world (see Gangestad & Thornhill, chapter 3, this volume for a discussion of cues and signals), and (2) the emotion of disgust and its role in motivating the sexual avoidance of family members. Last, I share some recent empirical findings and make suggestions for the continued investigation of kinship cues and the programs regulating kin-directed behaviors.

### WHAT IS A COMPUTATIONAL THEORY OF MIND AND WHY SHOULD SOCIAL-COGNITIVE SCIENTISTS CARE?

A computational theory of mind (CTM) conceives of the mind as an information processing system (Fodor, 1983). According to Barrett (2005), “CTM views thought as computation: the use of algorithmic rules to systematically map inputs, i.e., information instantiated in neurochemical patterns, onto outputs, i.e. different patterns of information that have been systematically transformed. What makes the patterns in question information is that they ‘stand for’ something: that they, in turn, can be mapped onto something in the world or mind. The mapping operations are computations” (p. 260) This view of the mind allows for the generation of highly detailed models of the cognitive architecture underlying a specific behavior (e.g., the cues/information taken as input, the procedures that transform this information, and the outputs stored or behavioral sequences activated; see Barrett & Kurzban (2006) for a thorough discussion of modularity, a computational view of the mind, and evolution).

An evolutionary approach to the CTM is important because computational systems are highly improbable orderings of matter and their existence requires explanation. The only known causal force likely to generate complex functional design is natural selection (Tooby, Cosmides, & Barrett, 2003). Therefore, an understanding of the selective forces that shaped our computational architecture (e.g., *why* we take certain aspects of the environment as input, *why* certain outputs are generated over others, *why* given outputs effect behavior in the manner they do) is *essential* in the investigation of human social cognition. Without an evolutionary toolbox, computational analyses and neurological investigations can become haphazard and led astray by our folk intuitions, intuitions that might not map directly onto our cognitive architecture. Given their interests in social perception and decision making, it is surprising that social-cognitive psychologists have not taken advantage of these tools to discover the nature of our evolved perceptual systems and the kinds of decision-making processes evolution shaped to direct social behavior.

To help bridge the gap between evolutionary approaches to psychology and

the field of social cognition, I use the topic of my own research, kin detection and inbreeding avoidance in humans, as an example of how social perception and decision making can be investigated using an evolutionary-computational framework. I start with an analysis of the function of inbreeding avoidance, that is, why evolution is hypothesized to have selected for information-processing systems motivating the sexual avoidance of close relatives. Then, I outline the computational architecture of what a well-designed system for inbreeding avoidance might look like. First: Why is inbreeding bad?

## SELECTION PRESSURES AND THE EVOLUTION OF INBREEDING AVOIDANCE MECHANISMS

There are sound biological reasons why psychological mechanisms designed to avoid mating with a close genetic relative are expected to exist. Throughout our species' evolutionary history, the selection pressures posed by deleterious recessive mutations (e.g., Bittles & Neel, 1994) and short-generation pathogens (e.g., Tooby, 1982) would have severely negatively impacted the health and viability of offspring of individuals who were close genetic relatives. As a result, individuals who avoided mating with close genetic relatives and, instead, mated with someone who did not share an immediate common ancestor would have enjoyed greater reproductive success. What follows is a brief discussion of each selection pressure.

### *Deleterious Recessive Mutations*

Because humans are a diploid species, it is possible for harmful mutations to “hide out” in the genome. This is because a fully functional gene inherited from one parent can mask the effects of a dysfunctional and potentially harmful gene inherited from the other. That is, when the functional gene is dominant an individual can display a normal phenotype despite the presence of a recessive deleterious version of the gene. Consequently, deleterious recessives can accumulate in the population until they reach relatively high frequencies. For example, let's say a given negative allele, if dominant, exists in a population at a frequency of 1 in 1,000,000. This same allele, if recessive, would approach a frequency of 1 in 1000—that is, 1000 times more frequent.

The negative consequences of inbreeding occur when the same recessive damaged allele is supplied from both the mother and the father to the resulting offspring. In this case, the deleterious recessive genes are expressed decreasing the health and viability of the individual. According to Bittles and Neel (1994) “all of us are thought to carry in the heterozygous condition ‘several’ rare recessive genes which, if rendered homozygous, would result in a significant medical handicap, ranging from severe defects of vision and hearing to disorders incompatible with survival beyond childhood” (p. 17). The estimated number of

rare lethal genes in a genome is termed lethal equivalents (Cavalli-Sforza & Bodmer, 1971; Crow & Kimura, 1970). Data from a number of studies suggest that each of us possess, on average, somewhere between two (Bittles & Neel, 1994; Carter, 1967; May, 1979) to six (Kumar, Pai, & Swaminathan, 1967) lethal equivalents: alleles that, if homozygous, would cause death before an individual reached reproductive age (Burnham, 1975; Morton, Crow, & Muller, 1956). We are not dead many times over because at the great majority of these loci, we are heterozygous, and the damaging gene is masked by an intact gene.

The effects of inbreeding should be apparent: If two close genetic relatives mate with one another, versus mating with an individual who doesn't share an immediate common ancestor, there is a greatly increased chance that the resulting offspring will be homozygous for many deleterious recessives, leading to decreased chance of survival and reproduction. The more closely related the parents, the greater the likelihood the offspring will suffer a decrease in health and viability, and the selection pressures become very intense whenever two parents are siblings, or parent and child. For this reason, deleterious recessive mutations posed a strong selection pressure against close-kin matings and would have led to the evolution of mechanisms reducing the probability such matings occurred.

### *Pathogens*

A second selection pressure that would have led to the evolution of incest avoidance mechanisms is pathogens (O'Brien, Roelke, & Marker, 1985; Tooby, 1982). The presence of disease-causing agents, such as viruses and bacteria, in and around an organism's body was a constant feature of our evolutionary past. Due to their short generation time, pathogens have the ability to become finely tuned to the biochemistry of their host. The better adapted a pathogen is to its host's microenvironment, the more efficient it becomes at acquiring the necessary resources, evading cells of the immune system, and replicating. As a consequence, they can become extremely detrimental to the health of the host.

The recurrent presence of pathogens in our ancestral environments would have created intense selection pressures for genetic diversity between individuals in a population (Tooby, 1982). This is because the more genetically homogenous the sequence of hosts encountered by a parasitic lineage, the faster an infection is able to spread. Moreover, this selection pressure would have been especially severe the longer-lived the host species—and, compared to the average garden-variety bacterium, humans are very long lived. As a result it is hypothesized that natural selection would have engineered a solution to maintain genetic diversity.

From an evolutionary point of view, the function of sexual reproduction is to introduce genetic variability into offspring sets, and to make organisms genetically different from their neighbors (Ebert & Hamilton 1996; Hamilton, Axelrod, & Tanese, 1990; Tooby, 1982). During the process of reproduction, pathogens are transmitted from parent to offspring. The presence of a unique

internal environment in the offspring renders pathogens that were well adapted to a parental internal environment less suited to the offspring's novel environment. Mating with a close relative then, as opposed to a nongenetically related individual, maintains a more similar microenvironment for pathogens that get transmitted to or among resulting offspring and other members of the social group. This gives pathogens an advantage in moving from host to host. To the extent that incestuous matings led to an increased genetic uniformity in ancestral hunter-gatherer groups, then increased parasite load would have been a second, significant factor selecting against potentially fertile incestuous matings.

In summary, given the selection pressures posed by deleterious recessive mutations and short-generation pathogens, evolution is hypothesized to have selected for reliably developing neural circuitry that was well-engineered for decreasing the probability of close-kin matings. The question is, what would a system designed for avoiding sexual contact (not necessarily all contact) with close genetic relatives look like? This topic is taken up in the next section.

### AN INFORMATION-PROCESSING VIEW OF INBREEDING AVOIDANCE: WHAT WOULD A WELL-ENGINEERED SYSTEM FOR INBREEDING AVOIDANCE LOOK LIKE?

A useful tool for exploring our cognitive architecture is to take the perspective of an engineer and describe the kinds of information processing programs required to perform a specific function. With respect to inbreeding avoidance, what kinds of programs would be required? This question amounts to a description of the computational procedures governing inbreeding avoidance in humans and at first glance at least two kinds of procedures would be needed: (1) procedures for categorizing individuals in the social environment according to genetic relatedness (i.e., kin detection), and (2) procedures that take as input information regarding the relatedness of another individual and regulate sexual attraction/avoidance accordingly (see Lieberman, Tooby, & Cosmides, 2003, for a discussion of this model). These two procedures are discussed in turn.

#### *Procedures for Categorizing Others by Genetic Relatedness*

For an inbreeding avoidance system to be functional there must exist mechanisms for discovering who is likely to be a close genetic relative. Categorization along the dimension of genetic relatedness requires the existence of cues that correlated with relatedness over our species' evolutionary history. There are a number of possible cues kin detection systems might have been designed to take as input. One potential source of information regarding kinship is linguistic and cultural input (e.g., during development you are told who counts as a close genetic relative and how to feel about them). However, these prove problematic since: (1) Kin terms can be used across genetic boundaries blurring the

distinction between types of close genetic relatives and between kin and non-kin (e.g., the term “aunt” or “brother” in the US), (2) there exist asymmetries in relatedness and thus, individuals may not share common “interests” regarding, for example, whom to help and when (e.g., a woman with children of different paternity is motivated to treat each one equally, whereas a particular child is more likely to want to help their full sibling over their half sibling leading to conflicts of interest between parent and offspring; see Trivers, 1974), and (3) systems for categorizing others according to genetic relatedness exist in many other animal species and predate the evolution of language and culture (Hepper, 1991). For these reasons, it is unlikely that evolution used linguistic information as anchor-points for assessing relatedness. Though kin terms do correlate with relatedness (Jones, 2004) and individuals do show greater altruism toward those who share common names (Oates & Wilson, 2002), it is more likely that evolved systems for categorizing kin pattern linguistic terms rather than vice versa.

### *Ecologically Valid Cues to Genetic Relatedness*

Natural selection, rather than relying on linguistic and cultural input, is hypothesized to have shaped kin categorization mechanisms to take advantage of cues that *reliably correlated with genetic relatedness in the ancestral past*. To the extent that different cues reliably correlated with an individual being a particular type of close genetic relative (e.g., mother, father, offspring, or sibling), different categorization mechanisms are expected to exist. For example, because ancestrally a female always gave birth to her own offspring, she could have relied on the process of birth and/or the visual and olfactory cues derived from a newborn to reliably and accurately categorize that child as a close genetic relative (e.g., Porter, Matochik, & Makin, 1983, 1984). However, due to the fact that males of our species could not be 100% certain of their paternity, seeing one’s mate give birth to an offspring would not have solved the problem of assessing degree of relatedness to that offspring. Rather, for males, assessments of paternity might rely on cues signaling the sexual fidelity of their mate. Therefore, there may not be a general kin detection mechanism that relies on the same set of information for detecting *all* types of close genetic relatives. Instead, the advantages of kin selection would accrue most strongly to individuals that possessed specialized detection systems capable of narrowing in on the small subset of states that correlated with an individual being a particular kind of kin. These states may not be signals in the sense that they function to communicate information regarding kinship (see Gangestad & Thornhill, chapter 3, this volume). Rather, they may be stable social arrangements that came into existence due to adaptations serving different functions (e.g., parental care) or as by-products of adaptations that can then be used as anchor-points for kinship categorization. The following discussion focuses on the cues used to detect a particular class of kin, siblings.

### *Cues to Siblingship: The Westermarck Hypothesis and Early Maternal Care*

What cues could evolution have used for categorizing an individual as a sibling? The most likely candidates are cues that reliably carved siblings from, for example, cousins and other individuals that would not have posed as great a threat to reproductive success. Categorization errors would have been costly in two different ways (e.g., see Haselton & Buss, 2000). Using a cue that cast its net too widely and included not only siblings but other, more distantly related kin and non-kin would have excluded potential mating partners. On the other hand, restricting sibling categorization to those meeting too stringent criteria may have excluded actual genetic relatives leading to an increased chance of choosing a genetic relative as a mate and producing offspring that suffered from inbreeding depression. Two cues that appear to walk this fine line are childhood coresidence duration and exposure to one's mother caring for an infant.

**Coresidence Duration.** In 1891, Edward Westermarck, a Finnish social scientist, made the commonplace observation that siblings rarely find one another sexually attractive. He proposed that the early childhood association, a pattern typical among siblings, serves as a cue to relatedness and leads to the development of a sexual aversion later during adulthood (Westermarck, 1891/1921). This has come to be known as the Westermarck Hypothesis. Specifically, Westermarck stated,

Generally speaking, there is a remarkable absence of erotic feelings between persons living very closely together from childhood. Nay more, in this, as in many other cases, sexual indifference is combined with the positive feeling of aversion when the act is thought of. . . . Persons who have been living together from childhood are as a rule near relatives. Hence their aversion to sexual relations with one another displays itself in custom and law as a prohibition of intercourse between near kin.

The cue of coresidence duration is plausible considering our evolutionary history. The nutritional demands of breastfeeding along with the need for protection would have meant that children of the same mother were typically reared in close proximity during early childhood. Also, when hunter-gatherer bands fissioned into smaller units (e.g., due to size or difficult times), nuclear families (including siblings) would have stayed together as a unit (Chagnon, 1992; Lee & DeVore, 1968). This means that in ancestral environments, early childhood would have offered valuable information regarding the relatedness of individuals in prolonged close association.

A number of researchers have tested the Westermarck Hypothesis (see, e.g., Bevc & Silverman, 1993, 2000; Fessler & Navarrete, 2004; Lieberman et al., 2003; Shepher, 1971, 1983; Williams & Finkelhor, 1995; Wolf, 1995). For some, the focus of research has been testing the Westermarck Hypothesis in

populations where genetically *unrelated* individuals were reared together as siblings. Most notable are the anthropological reports on Israeli Kibbutzim (Shepher, 1971, 1983; Spiro, 1958; Talmon, 1964) and on the Taiwanese minor form of marriage (Wolf, 1995). In these two cases cultural institutions inadvertently created a “natural experiment” where children who were not genetically related to one another were reared together from very early childhood. As the Westermarck Hypothesis predicts, lower rates of marriage and sexual interest were found (for the peer groups in Israeli Kibbutzim; Shepher, 1983) as well as greater rates of divorce and extramarital affairs and lower rates of fertility (for Taiwanese marriages where the bride was adopted into her husband’s family as a child; Wolf, 1995).

These cross-cultural studies provide support for the hypothesis that coresidence duration serves as a cue to relatedness. Empirical investigations that have gone beyond sociological measures and sought responses from actual living individuals have also found that longer, uninterrupted periods of childhood coresidence are associated with greater disgust at sexual behavior (Lieberman, Tooby, & Cosmides, in press), a reduced probability of engaging in sexual behavior (Bevc & Silverman, 1993, 2000), and greater moral opposition to sibling incest (Fessler & Naverrete, 2004; Lieberman et al., 2003). However, coresidence duration may not be the best cue available for detecting siblings and, further, may not be used as cue for detecting other categories of genetic relatives (e.g., see Williams & Finkelhor, 1995).

**Maternal Perinatal Association.** Though coresidence would have done a good job carving the social world into siblings versus other kin and non-kin, there may have been an even better cue. The stable association between mother and newborn that exists due to the demands of breastfeeding and care provides a reliable cue from which inferences regarding relatedness may be generated. Seeing one’s mother (i.e., the female from whom one breastfed) breastfeeding another infant would have meant, under ancestral conditions, that the infant in question was at least a half sibling (how cues to shared paternity are assessed is a good question and currently under exploration). Moreover, this cue would have been valid independent of one’s age. That is, no matter whether one is 3, 13, or 23, seeing one’s mother breastfeeding another child is a good cue to relatedness. However, this information would only have been accessible to older siblings. For younger siblings, the arrow of time prevents them from seeing their older sibling breastfed. Thus, for younger siblings, the best cue available for assessing relatedness may very well be coresidence duration. In this way, different decision rules or heuristics may be used to assess siblingship. Indeed, in a recent study by Lieberman et al. (in press), coresidence duration appears to be used as a cue to kinship only when information regarding maternal care during infancy (e.g., breastfeeding information) is absent.

The above discussion shows how an evolutionary analysis can help narrow the sets of cues or information evolution is likely to have used to solve the

recurring problem of inbreeding depression. Coresidence duration and maternal perinatal association are two cues, among others, that are hypothesized to serve as means of categorizing individuals in the social environment into kin versus non-kin. However, this analysis represents the front end of the system. What kinds of procedures take coresidence information as input and how is an estimate of kinship computed? That is, how are specific periods of coresidence translated into estimates of kinship—what is the conversion formula? Further what internal systems take the computed estimates of kinship as input and output motivations of sexual avoidance? To effectively avoid inbreeding, kin detection systems need to hook into decision-making procedures regulating sexual motivation. This is the topic of the next section.

### *Procedures for Regulating Sexual Avoidance: The Emotion of Disgust*

In addition to procedures for categorizing individuals in the social environment by genetic relatedness, procedures for regulating sexual attraction/avoidance are required to prevent inbreeding. What would a well-designed system for motivating sexual avoidance look like? Such a system should be efficient at motivating sexual avoidance, associate sexual aversions with particular individuals in the social environment based on cues to kinship, and have different intensities to match the different probabilities individuals have of being a close genetic relative and the different types of kin that exist (e.g., cousins and siblings).

**The Ability to Motivate Sexual Avoidance.** Programs that were simply indifferent to sexual relations with close genetic relatives would not have solved the problem of inbreeding avoidance because family members can have strong sexual desires and motivations to mate that would not be strongly deterred by a disinterested disposition (e.g., I can be sexually disinterested in a chair, but the chair, unlike an animate being, does not have intentions of its own and thus is unlikely to pursue me sexually). The situation of family members finding one another sexual attractive may arise for at least two reasons: (1) Cues to kinship may not be similar for each individual within a dyad (e.g., the cues fathers use to assess paternity may be different from the cues a child uses to assess who their father is) leading to the possibility that only one person in a dyad has categorized the other as kin and developed a sexual aversion, and (2) depending on the pathogen load of the environment and available mates, incest may have paid as a mating strategy but asymmetrically so for the sexes (e.g., incest might have been beneficial under certain circumstances to the father but still prohibitively costly to the daughter; see Haig, 1999; Tooby, 1977). For these reasons, a program that actively motivated sexual *avoidance* would have out-competed one that was simply disinterested in sex with family members.

**The Association to Relevant Stimuli.** Kinship is a dimension that needs to be discovered anew for each individual generation after generation. For this

reason, the program regulating sexual avoidance must be flexible and easily assigned based on the cues of kinship. That is, the sexual avoidance program is required to accept as input representations of any individual displaying cues to kinship, information that cannot be specified in advance.

*Variation in Intensity.* The intensity of sexual avoidance should be a function of genetic relatedness and the consequences of inbreeding. For example, the intensity of sexual avoidance toward a cousin should be less than the intensity toward a sibling and the intensity of avoidance toward a half sibling should be less than the intensity toward a full sibling. Therefore, rather than having a simple on/off switch, a well-designed program motivating sexual avoidance should output a graded response based on estimates of kinship.

Is there a program that meets the above criteria and appears well suited to perform the function of inbreeding avoidance? Yes—disgust. This is hardly a new idea as Westermarck himself identified disgust as the response to incest (as would any thought experiment involving sex with a parent, for example). Further, Westermarck identifies disgust as governing not only incest but other costly sexual acts.

The objection will perhaps be made that the aversion to sexual intercourse between persons living very closely together from early youth is too complicated a mental phenomenon to be a true instinct, acquired through spontaneous variations intensified by natural selection. But there are instincts just as complicated as this feeling, which, in fact, only implies that disgust is associated with idea of sexual intercourse between persons who have lived in a long-continued, intimate relationship from a period of life at which the action of desire is naturally out of the question. This association is not matter of course, and certainly cannot be explained by the mere liking for novelty. It has all the characteristics of a real, powerful instinct, and bears evidently a close resemblance to the aversion to sexual intercourse with individuals belonging to another species. (Westermarck, 1891/1921, p. 353)

It has been hypothesized that the original function of disgust is to avoid the oral incorporation of various harmful substances (see, for example, Ekman & Davidson, 1994; Izard, 1993; Rozin & Fallon, 1987). Perhaps more specifically, the emotion of disgust evolved to inhibit the ingestion and contact with substances associated with disease-causing agents (e.g., feces, dead organisms, and spoiled food; Curtis & Biran, 2001; see also Schaller, chapter 18, this volume). Disgust could have been co-opted during human evolution to motivate the withdrawal from sexual relations with a close genetic relative (as well as other sexual partners imposing a cost on one's reproductive success). The characteristic trait of disgust to motivate avoidance means that it can be mobilized to deter an unsolicited advance by a close family member. Moreover, it can also function to counteract any sexual desire that may arise due to the fact that one's close genetic relatives may be an attractive member of the opposite sex and possess traits (including accessibility) that feed into sexual attraction systems. Furthermore, disgust varies

in intensity and can be associated with novel stimuli (see Haidt & Bjorklund, in press) making it a good solution for an inbreeding avoidance system. Last, disgust may have been relatively easy to coopt for this new function of sexual avoidance since it is already associated with sexual behavior: Disgust needs to be *down-regulated* before intimate contact (i.e., contact exposing one to the pathogens of another) can occur (Angyal, 1941; as an aside, the ratcheting down of disgust may explain the occurrence of some interesting sexual fetishes). If, instead of down-regulating disgust, a mutation caused its *up-regulation* in response to sexual behavior with specific individuals, inbreeding avoidance would have gained a foothold and slowly, over evolutionary time, become refined into a well-functioning inbreeding avoidance system.

This section illustrated that inbreeding avoidance requires both categorization procedures that assess whether an individual has a probability of being a close genetic relative, and decision rules regulating sexual motivations. The emotion we term disgust is hypothesized to describe, in part, the procedures that take kinship information as input and adjust sexual motivations according to the costs (and benefits) such behavior had in ancestral environments. Disgust, then, is a type of cognitive (i.e., information processing) program (see Oum & Lieberman, in press, for a detailed discussion of emotions as cognitive programs). The model of inbreeding avoidance described above is a simplified version of what has been recently developed (see Lieberman et al., in press). But even this simple model has greatly aided empirical investigations of inbreeding avoidance systems in humans.

### EMPIRICAL INVESTIGATION OF SYSTEMS FOR INBREEDING AVOIDANCE

The model of a human inbreeding avoidance system proposed herein provides an empirical framework within which information hypothesized to serve as cues to relatedness can be tested. The magnitude of the sexual aversion (or attraction) associated with a particular individual should be a function of the exposure to cues correlating with genetic relatedness in our ancestral past. So, for example, longer durations of childhood coresidence should translate into greater sexual aversions toward a sibling. It is therefore possible to reverse engineer the kinds of cues used to detect each type of close genetic relative. This can be done by quantitatively matching individual variation in opposition to incest (i.e., sexual disgust) to individual variation in parameters that may have served as cues to relatedness (e.g., coresidence or maternal perinatal association). Recently, researchers have employed this method to investigate the nature of the cues our mind uses to identify siblings (e.g., DeBruine, 2002; Fessler & Navarrete, 2004; Lieberman, 2003; Lieberman et al., 2003).

Converging lines of evidence for the cues used to categorize individuals as different types of kin can be found by exploring the domain of kin-directed

altruism (see Lieberman et al., in press). Kin selection, like inbreeding avoidance, requires procedures for categorizing kin. To the extent that the same procedures for categorizing kin are used in both domains, cues signaling relatedness are hypothesized to regulate these disparate systems in parallel. Therefore, strong evidence that a particular cue is used to detect siblings would be if variations in this cue predict *both* sexual aversions and altruistic motivations toward that sibling. Using this logic, Lieberman et al. (in press) have found that coresidence duration and MPA are two cues to estimate siblingship. That is, both cues were found to regulate sexual opposition to sibling incest and separately, motivations to help a sibling. Other cues also might be used to assess siblingship including physical resemblance (e.g., DeBruine, 2002; Park & Schaller, 2005) and olfactory cues derived from the catabolism of elements of our immune system (e.g., scents derived from the major histocompatibility complex; Wedekind, Seebeck, Bettens, & Paepke, 1995).

In addition to the exploration of kinship cues, more research is needed on the structure of the emotion programs regulating sexual avoidance (for a discussion on evolution and emotions see Tooby & Cosmides, 1990, 2000). For example, does sexual disgust activate the same set of physiological and psychological features (e.g., components of the immune system and memory for substances ingested) as pathogen-related disgust? Are these systems neurally dissociable? Are there neurological conditions that impair disgust in one domain but not the other (e.g., work on Huntington's disease suggests that individuals are impaired in their ability to detect facial expressions of disgust [Sprengelmeyer et al., 1996]—whether sexual disgust is impaired to the same extent as pathogen-related disgust remains an open question). Just as an engineering perspective can provide a guide-rail for exploring the organization of systems for detecting kin, it can also aid the investigation of emotion programs that evolved to serve a particular function.

## CONCLUSION

The fields of evolutionary psychology and social cognition share the similar goal of understanding the cognitive processes (e.g., categorization and decision-making procedures) regulating social behavior. Greater progress can be made in both disciplines by employing an evolutionary theoretical framework—a framework successfully used to investigate the cognitive processes and behaviors in nonhuman animals. For example, kin selection and parental investment theories provide sturdy guide-rails for generating hypotheses about our cognitive architecture. However, as Daly et al. (1997) have noted, evolutionary concepts such as kinship have been surprisingly absent from the social psychological literature. Yet, as this chapter has demonstrated, kinship is a strong organizing force regulating sexual behavior as well as altruism, two large areas of research in social psychology.

Greater progress can also be made by adopting a computational view of the mind. As this chapter has demonstrated, the generation of a detailed model of what a well-designed system for avoiding inbreeding might look like has led to a research program for investigating the cues mediating kin detection and the programs regulating sexual motivations and kin-directed altruism. The same logic that led to the generation of this model can be used to investigate other areas of interest in social cognition and social psychology in general. The success of such investigations will be wide-spread. For example, not only will evolutionary-computational models in social cognition allow for more careful investigations into the neurological correlates of social behavior, they will also provide a stronger backbone for other fields, such as clinical and school psychology, that look to social cognition for models of human cognition.

As scientists, psychologists share the goal of uncovering how the mind works. Therefore, we would do well to utilize the strengths each discipline in the behavioral and natural sciences has to offer. This would help clear the lines of communication between subdisciplines and result in a more unified science of the mind.

## REFERENCES

- Angyal, A. (1941). Disgust and related aversions. *Journal of Abnormal and Social Psychology*, *36*, 393–412.
- Barrett, H. C. (2005). Enzymatic computation and cognitive modularity. *Mind and Language*, *20*, 259–287.
- Barrett, H. C., & Kurzban, R. (2006). Modularity in cognition: Framing the debate. *Psychological Review*, *113*, 628–647.
- Bevc, I., & Silverman, I. (1993). Early proximity and intimacy between siblings and incestuous behavior: A test of the Westermarck theory. *Ethology and Sociobiology*, *14*, 171–181.
- Bevc, I., & Silverman, I. (2000). Early separation and sibling incest: A test of the revised Westermarck theory. *Evolution and Human Behavior*, *21*, 151–161.
- Bittles, A. H., & Neel, J. V. (1994). The costs of human inbreeding and their implications for variation at the DNA level. *Nature Genetics*, *8*, 117–121.
- Burnham, J. T. (1975). Incest avoidance and social evolution. *Mankind*, *10*, 93–98.
- Carter, C. O. (1967). Risk of offspring of incest. *Lancet*, *1*, 436.
- Cavalli-Sforza, L. L., & Bodmer, W. F. (1971). *The genetics of human populations*. San Francisco: W. H. Freeman.
- Chagnon, N. A. (1992). *Yanomamo: The last days of Eden*. San Diego, CA: Harcourt Brace & Company.
- Crow, J. F., & Kimura, M. (1970). *An introduction to population genetics theory*. New York: Harper & Row.
- Curtis, V., & Biran, A. (2001). Dirt, disgust, and disease: Is hygiene in our genes? *Perspectives in Biology and Medicine*, *44*, 17–31.
- Daly, M., Salmon, C., & Wilson, M. I. (1997). Kinship: The conceptual hole in psychological studies of social cognition and close relationships. In J. A. Simpson & D. Kenrick (Eds.), *Evolutionary social psychology* (pp. 265–296). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Darwin, C. (2003). *The origin of species*. New York: Signet Classics. (Original work published 1859)
- DeBruine, L. M. (2002). Facial resemblance enhances trust. *Proceedings: Biological Sciences*, *269*, 1307–1312.
- Ebert, D., & Hamilton, W. D. (1996). Sex against virulence: The coevolution of

- parasitic diseases. *Trends in Ecology and Evolution*, 11, 79–82.
- Ekman, P., & Davidson, R. J. (1994). *The nature of emotion: Fundamental questions*. New York: Oxford University Press.
- Fessler, D. M. T., & Navarrete, C. D. (2004). Third-party attitudes toward sibling incest: Evidence for Westermarck's hypotheses. *Evolution and Human Behavior*, 25, 277–294.
- Fodor, J. A. (1983). *The modularity of mind*. Cambridge, MA: MIT Press.
- Haidt, J., & Bjorklund, F. (in press). Social intuitionists answer six questions about moral psychology. In W. Sinnott-Armstrong (Ed.), *Moral psychology*.
- Haig, D. (1999). Asymmetric relations: Internal conflicts and the horror of incest. *Evolution and Human Behavior*, 20, 83–98.
- Hamilton, W. D., Axelrod, R., & Tanese, R. (1990). Sexual reproduction as an adaptation to resist parasites. *Proceedings of the National Academy of Science*, 87, 3566–3573.
- Haselton, M. G., & Buss, D. M. (2000). Error management theory: A new perspective on biases in cross-sex mind reading. *Journal of Personality and Social Psychology*, 78, 81–91.
- Hepper, P. G. (1991). *Kin recognition*. Cambridge, UK: Cambridge University Press.
- Izard, C. E. (1993). Organizational and motivational functions of discrete emotions. In M. Lewis & J. M. Haviland (Eds.), *Handbook of emotions* (pp. 631–665). New York: Guilford Press.
- Jones, D. (2004). The universal psychology of kinship: Evidence from language. *Trends in Cognitive Sciences*, 8, 211–215.
- Kumar, S., Pai, R. A., & Swaminathan, M. S. (1967). Consanguineous marriages and the genetic load due to lethal genes in Kerala. *Annals of Human Genetics*, 31, 141–145.
- Lee, R. B., & DeVore, I. (1968). *Man the hunter*. New York: Aldine de Gruyter.
- Lieberman, D. (2003). *Mapping the cognitive architecture of systems for kin detection and inbreeding avoidance: The Westermarck hypothesis and the development of sexual aversions between siblings*. UMI Digital Dissertation, AAT 3103441.
- Lieberman, D., Oum, R. E., & Kurzban, R. (2006). Does the family of fundamental social categories include kinship? *Manuscript under review*.
- Lieberman, D., Tooby, J., & Cosmides, L. (2003). Does morality have a biological basis? An empirical test of the factors governing moral sentiments relating to incest. *Proceedings of the Royal Society: Biological Sciences*, 270, 819–826.
- Lieberman, D., Tooby, J., & Cosmides, L. (in press). The architecture of human kin detection. *Nature*.
- May, R. M. (1979). When to be incestuous. *Nature*, 279, 192–194.
- Morton, N. E., Crow, J. F., & Muller, H. J. (1956). An estimate of mutational damage in man from data on consanguineous marriages. *Proceedings of the National Academy of Science*, 42, 855–863.
- Oates, K., & Wilson, M. (2002). Nominal kinship cues facilitate altruism. *Proceedings of the Royal Society of London, Series B*, 269, 105–109.
- O'Brien, S. J., Roelke, M. E., & Marker, L. (1985). Genetic evidence for species vulnerability in the cheetah. *Science*, 227, 1428–1434.
- Oum, R. E., & Lieberman, D. (in press). Emotion as cognition: An information processing view of the mind. In K. D. Vohs, R. F. Baumeister, & G. Loewenstein (Eds.), *Do emotions help or hurt decision making? Perspectives from psychology and economics*. New York: Russell Sage.
- Park, J. H., & Schaller, M. (2005). Does attitude similarity serve as a heuristic cue for kinship? Evidence of an implicit cognitive association. *Evolution and Human Behavior*, 26, 158–170.
- Porter, R. H., Matochik, J. A., & Makin, J. W. (1983). Evidence for phenotype matching in spiny mice (*Acomys cahirinus*). *Animal Behavior*, 31, 978–984.
- Porter, R. H., Matochik, J. A., & Makin, J. W. (1984). The role of familiarity in the development of social preferences in spiny mice. *Behavioral Proceedings*, 9, 241–254.
- Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review*, 94, 23–41.
- Shepher, J. (1971). Mate selection among second-generation kibbutz adolescents: Incest avoidance and negative imprinting. *Archives of Sexual Behavior*, 1(1), 293–307.
- Shepher, J. (1983). *Incest: A biosocial view*. New York: Academic Press.
- Spiro, M. E. (1958). *Children of the Kibbutz*. Cambridge, MA: Harvard Press.

- Sprengelmeyer, R., Young, A. W., Calder, A. J., Karnat, A., Lange, H., Hömberg, V., et al. (1996). Loss of disgust: Perception of faces and emotion in Huntington's disease. *Brain*, 119, 1647–1665.
- Talmon, G. Y. (1964). Mate selection in collective settlements. *American Sociological Review*, 29, 408–491.
- Tooby, J. (1977). Factors governing optimal inbreeding. *Proceedings of the Institute for Evolutionary Studies*, 77(1), 1–54.
- Tooby, J. (1982). Pathogens, polymorphism, and the evolution of sex. *Journal of Theoretical Biology*, 97, 557–576.
- Tooby, J., & Cosmides, L. (1990). The past explains the present: Emotional adaptations and the structure of ancestral environment. *Ethology and Sociobiology*, 11, 375–424.
- Tooby, J., & Cosmides, L. (2000). Evolutionary psychology and the emotions. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (2nd ed.). New York: Guilford Press.
- Tooby, J., Cosmides, L., & Barrett, H. C. (2003). The second law of thermodynamics is the first law of psychology: Evolutionary developmental psychology and the theory of tandem, coordinated inheritances: Comment on Lickliter and Honeycutt. *Psychological Bulletin*, 129, 858–865.
- Trivers, R. E. (1974). Parent–offspring conflict. *American Zoology*, 14, 249–264.
- Wedekind, C., Seebeck, T., Bettens, F., & Paepke, A. (1995). MHC-dependent mate preferences in humans. *Proceedings of the Royal Society of London: Biological Sciences*, 260, 245–249.
- Westermarck, E. A. (1921). *The history of human marriage*. London: Macmillan. (Original work published 1891)
- Williams, L. M., & Finkelhor, D. (1995). Paternal caregiving and incest: Test of a biosocial model. *American Journal of Orthopsychiatry*, 65, 101–113.
- Wolf, A. P. (1995) *Sexual attraction and childhood association: A Chinese brief for Edward Westermarck*. Stanford, CA: Stanford University Press.