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Introduction: Vision Going Social

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Vision is "knowing what *is* where *by looking" David Marr (1945-1980)*
"There is no such thing as society … only individuals and families" Margaret Thatcher (b. 1925)
"All life is social" Steven A. Frank (2007 b. 1957)

Social psychology and vision science have stood as far apart as any two areas of psychology. At many universities, they are often in separate buildings: social psychology situated in the social sciences, vision research in the natural sciences. Yet, of late, there has been an emerging kinship between them, one that is exciting and propitious. This book provides a glimpse of this, and here we offer reasons for the likelihood of more lasting rewards.

First, it is clear from the chapters in this book and recent publications that vision scientists are using social stimuli, that is, people. Long-recognized are the point-light demonstrations of Gunnar Johansson, showing that simple movement of bright dots placed at the joints of figures against a dark background can provide vivid information about a human figure in motion. Later research has shown that these dots can easily convey gender, personal identity and other characteristics. More recently, vision and neuroscience journals have been studded with pictures of human faces. Vision scientists are abandoning their otherwise-featureless colored patches and sine wave gratings and exploring new visual stimuli. Social psychologists are poaching the field of vision, becoming interested in the basic perceptual processes that are involved in social judgments, and showing that details of the stimulus are important (Langlois and Roggman, 1990; Martin and Macrae, this volume).

Is this just the opportunistic linking of two fields, related more to the availability of cheap computer graphics, or is it something more? Faces have replaced words as the most most-used stimulus in psychology, so it could be just be a fad, of no lasting consequence. Below, I review some trends that indicate a great broadening of the scope of both vision research and social psychology. This in turn indeed suggests more lasting opportunities.

A BRIEF HISTORY OF VISION SCIENCE

The study of vision has a long and illustrious history, but we restrict ourselves to a very short version, summarizing progress only over the past 100 years. There have been many developments in this time, but we mention just a few. Well known at the beginning of the twentieth century, were some very striking errors of vision. Estimates of length, area, color, brightness were dramatically changed by context. These were the classic visual illusions, including the Muller-Lyer, the Ponzo, the Ebbinghaus. These illusions have puzzled scientists to this day, and they grace textbooks of psychology. The elegant demonstrations of the Gestalt psychologists came next, showing compelling properties of the visual system, most importantly the phenomenon of figure ground and perceptual grouping. The visual system had rules of its own that were independent of higher-level processes, such as thinking.

Decades later, these views came to be supported in part by the revolutionary discoveries made by visual neurophysiologists. These scientists found that individual neurons in the visual system were selectively sensitive to patterns of visual input, not just light and dark. Thus, the work of early pioneers was able to show that neurons were sensitive to oriented bars, motion, and color. Some neurons were even selectively sensitive to things of interest to a particular organism: bugs for frogs, faces for humans and monkeys. Refined methods using the tools of psychophysics allowed researchers to make detailed and comparative assessments of the ability of humans, animals, and even individual cells to discriminate between different stimuli, motion, color, and so forth. This provided new methods to establish a causal link between the properties of neurons in animals and human perception.

At a theoretical level, there were many currents and crosscurrents. One broad theme stands out, addressing perhaps the most obvious but elusive question: What does the visual system do? It begins with Barlow's (1961) seminal article, which asks, "What are sensory systems for?" Barlow's answer, which borrowed from the newly emerging field of information theory, was that neurons of the sensory system are part of an efficient coding scheme. Thus, with a minimum number of spikes or impulses, the sensory system delivers *information* from the outside world to the brain. The efficiencies are obtained through redundancies in images, allowing complex recurring patterns to be coded with the fewest possible number of neural signals.

At about the same time, Gibson (1950, 1966) developed his theory of ecological optics. Like Barlow, Gibson claimed that information pickup is the function of the visual system. Gibson's genius was to specify many of the regularities in the optic array that convey useful information about the world. He identified previously unsuspected aspects of the optic array, such as patterns of motion, which delineated the layout of space. Thus, the coding of some simple, seemingly low-level optical variables conveyed very useful information for the organism. Gibson's theory ran parallel to that of Barlow, with both emphasizing the need for information pickup; however, Barlow's theory emphasized neural mechanisms, whereas Gibson's delineated the rich source of information in the optic array. Gibson's emphasis on the coding of real-world properties de-emphasized the role of errors and illusions, hinting that preoccupation with such matters was a distraction and should be subordinated to the main effort.

Drawing heavily on Gibson, David Marr's (1980) most lasting contribution was theoretical. Familiar with the agenda of artificial intelligence, he came to vision with a broader perspective, less steeped in the physiology and psychology of vision. Vision at its simplest, according to Marr, is "knowing *what* is *where* by looking"; but he goes on to say that no single explanation can suffice to explain what constitutes vision. Of the many levels of explanation required, Marr argues, the most fundamental is the computational level—that is, the goal of the computation and the optical information required to arrive at it. Other explanatory levels, such as the formal properties of the computation (algorithmic) and the brain substrates (implementation), are subordinate to this main endeavor.

In the past 40 years, we have come to understand that the anatomical structures comprising the visual system are much larger than previously thought. Previously, the territory we believed to be devoted to vision was largely confined to the striate cortex, which occupies about 10 percent of the brain. Around 1970, however, almost overnight, a handful of neurophysiologists—John Allman, John Kaas, David van Essen—identified about a dozen distinct cortical areas that are visual and that occupy the posterior half of the brain in higher primates. Since then, and with help of high-resolution functional magnetic resonance imaging (fMRI), still more vision-related regions have been identified in both humans and monkeys.

This huge allocation of brain anatomy suggests that vision's role in the brain and mind is tremendous. It is arguably on a par with *all* other functions of the brain: language, thinking, planning, acting, and so on. The exciting implication is that vision must be many things, serving myriad functions, many of which are yet to be discovered.

Marr divides the visual system into a set of sequential stages, each with its own set of properties. At the earliest stage, the brain performs an analysis of the image, extracting statistical regularities with little or no reference to what these images might represent in the world. This is followed by a viewer-centered representation (a 2.5-D sketch) of surfaces. Finally, there is a view-independent stage for the representation of objects, the highest stage for Marr. Marr's theory that there is a sequence of stages is a viable one, but the idea that object recognition represents an ultimate stage has not gone unchallenged.

An alternative view was voiced by Gibson, who was more concerned with how animals, not just humans, deal with the world around them: According to Gibson, categorizing objects without reference to their usefulness to the animal is secondary to thinking about sheer everyday survival. When Gibson defined his theory of affordances 30 years ago, it seemed foreign, strange, and circular to some, but now it almost has the status of a household word in science. As stated by Gibson:

> The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill. The verb *to afford* is found in the dictionary, but the noun *affordance* is not. I have made it up. (Gibson, 1979, p. 127)

Thus for a weary traveler, a flat surface that will support his weight qualifies as "sittable," and for a frightened squirrel, a tree, a chain link fence, and telephone wire all afford travel to safety. Thus, Gibson identifies yet another fundamental role for vision: Its support of action.

These distinctions have anatomical underpinnings. Ungerleider and Mishkin's (1982) division of the visual system into a *what* system (ventral) and a *where* system (dorsal) was a landmark achievement, even if it was to be further refined by Milner and Goodale (1996) into a dorsal system (*how*, for motor behavior) and ventral system (*what*, for object recognition). Milner and Goodale's temporal lobe patient, DF, could hardly identify any object consciously, but showed an astounding ability to grasp complex objects appropriately. This demonstrated that there is indeed a separate nonconscious visuo-motor system that can act automatically outside the range of awareness. Conversely, patients with parietal lobe damage could easily recognize objects but could not make appropriate visuo-motor acts toward them. The parietal lobe, part of Milner and Goodale's dorsal system, is a possible substrate for Gibsonan affordances. This system is so important that it can function outside awareness.

The rise and current supremacy of faces as stimuli in the neurophysiological laboratory is also telling. Vision scientists had long studied cortical neurons' response to oriented bars, gratings, colored patches, moving dots. Each of these could selectively excite a class of cortical neurons with great reliability. Thanks to the pioneering work of Charles Gross, faces were added to this list because some neurons showed astonishing selectivity, firing only when a face appeared in the visual field. More recent studies have confirmed these findings, showing ever-greater selectivity for faces in discrete cortical areas (Tsao et al., 2008). These findings have also been corroborated by human fMRI studies, showing face-specific areas in many areas of the human brain, with further specializations for expression as opposed to identity.

ARGUMENT FOR AN EXPANDED SOCIAL PSYCHOLOGY

Vision's place in psychology has expanded dramatically in scope from a simple cortical image of the retina to the whole brain. There is a role for vision almost everywhere.

There has been a comparable or even greater expansion in fields relating to social psychology. However, this has yet to be fully recognized. From the beginnings of psychology, social psychology has not been linked strongly with mainstream experimental psychology, perhaps reflecting an early distinction between experimental and descriptive social sciences (Dilthey, 1883). Since the cognitive revolution,

italics please

there has been some rapprochement, with social psychologists borrowing to some extent paradigms and concepts from cognitive psychology. But this has not been deemed by all to be entirely successful. Vision scientist and monkey researcher, Nick Humphrey, wrote that "Experimental psychologists in Britain have tended to regard social psychology as a poor country cousin of their subject …" (Humphrey, 1976).

But in this same landmark essay, he made an astonishing case for the central role of social psychology. But, it was advocacy, not for the existing discipline, but a radically expanded one.

> … the higher intellectual faculties of primates have evolved as an adaptation to the complexities of social living. For better or worse, styles of thinking which are primarily suited to social problem-solving colour the behaviour of man and other primates even towards the inanimate world. (N.K. Humphrey, "The social function of the intellect" (1976)

In this piece, Humphrey lays claim for the foundation of a new outlook, one that is intended to turn psychology upside down. Instead of social processes being derived from more basic cognitive processes, he argues it is the other way around. His main point is that (1) social life conferred enormous advantages to fledgling primates, (2) social life requires much more brain power, and (3) the brain mechanisms so evolved here form the foundation of our present intellect.

Although radical at the time, Humphrey's points find greater resonance today. That social life confers advantages to primates (and to other species) is almost self-evident. Of course there are the costs and benefits that have been arbitrated by the winnowing process of Darwinian natural selection. That social life requires more brain power seems likely or at least plausible. Dunbar (1998) has shown that brain size in primates and the size of the social group are strongly correlated. That, brain mechanisms evolved for social processing is the basis of our intellect is interesting and provocative.

In tandem with Humphrey's advocacy were the brilliant essays of Dan Dennett (1971, 1981), who provided an important philosophical underpinning for the study of social beings. He identified the *intentional stance*, part of an epistemological set of distinctions concerning the ways in which observers understand complex systems, including those of animals and people. Dennett argued that for social cognition, a causal system based on physics (the physical stance) or one based on design with purposes (for biological or manmade devices) was essentially useless. Only by adopting the intentional stance, a level of abstraction identifying the beliefs and desires of other minds, could social life as we know it, exist. More recently, psychologist Simon Baron Cohen made this view more accessible to psychologists with his monograph, Mindblindness (1995), drawing on the hypothesized deficits on the intentional stance in autism. See also Brothers, (2001).

It's obvious to those of us who make use of folk psychology in our everyday lives that we adopt the intentional stance, so much so that many academic psychologists have been troubled that our hard-won truths might not pass the "grandmother test." Does our new-found knowledge go beyond what Granny already knew? Mercifully, Granny didn't know about functional brain imaging, so we psychologists of the twenty-first century may rest assured that we do know something new. That aside, what about folk psychology for animals? To the extent that they are social beings, do animals share an awareness of the beliefs and desires of other animals?

Folk tales, from Aesop's fables to Walt Disney, suggest that they do: Folk traditions are replete with stories about the mental lives of animals, attributing Dennett's intentional states to them. Devoted pet owners such as Charles Darwin himself offered anecdotes about animals' awareness of the mental states of others. We have all heard them and we believed them with varying degrees of credulity. Some are clearly suspect but others are not easy to ignore. Thanks to modern technology (portable video cameras and the Internet), rare episodes can't be so easily relegated to the category of tall stories. One widely circulated video available on

YouTube (called the Battle of Kruger) shows remarkable cooperation within a herd of African buffalo, surrounding and then charging a pride of female lions about to devour one of their captured calves. Such behavior is now preserved in one of the most watched YouTube videos in the world. In another video, the buffalo play offense by attacking poorly protected lion cubs, killing one of them (http://www.youtube.com/watch?v=8sdttH2Tq3E). In another video, it is hard to see anything other than a very small gibbon aware of the mental state of tiger cubs as he annoys them by risking his life in pulling their tail and ears (google "monkey taunts tiger").

Putting more flesh to the thoughts of Humphrey and Dennett is the fledgling field of *cognitive ethology*. Differing from the mechanistic ethology of Tinbergen, Lorenz and von AQ1 Fries (Nobel Laureates, 1973), this approach is open to thinking about the intentional stance. In cognitive ethology, the inner lives of animals as they deal with conspecifics, friend and foe, as well as prey and predator, are no longer considered to be taboo anthropomorphisms. Further, well-controlled observations support popular anecdotes suggesting that animals are indeed aware of the mental states of conspecifics; for instance, Emery and Clayton (2004) report that jays will move food that they have cached if they have been observed by other jays.

Although such studies indicate that animals have mental states and thus are likely to contribute to social living, they by themselves do not offer a rich portrait of the social behavior of a whole community. Such studies are inherently difficult because a community has many agents (animals), and most terrestrial animals are sleeping during the day (being nocturnal) or, if they are diurnal, they are under cover. Thus, one can only get glimpses of the social life by chance encounters. This underscores the importance of more serious efforts to live among social animals and to make continuous observations over a period of many years, using as much observational technology and efforts as possible. Fortunately, for us, there are dedicated scientists who have devoted their professional careers to providing information, with the richest detail possible, about the lives of animals and how they interact socially. Some have been filmed for TV nature documentaries and for good reason. The richness and the drama of their social life is astonishing, so much so that humans spend many hours following these stories, much as they might watch other TV miniseries or soap operas.

MEERKAT MANOR

Meerkats (suricatta suricata) is one of the best examples. Not being primates, their social life is less complex and variable, yet their social existence has things that are in common with all primates, including ourselves. They have been featured on a four-year show on the BBC, called Meerkat Manor. Part behavioral ecology, part evolutionary psychology, the work was started by Timothy Clutton-Brock, a zoologist at the University of Cambridge.

Meerkats are very small slender burrowing animals related to the mongoose. They stand approximately 12 inches tall and weigh about 1.6 pounds. They are predators, catching small animals such as worms, millipedes, and scorpions, the poison of which is nontoxic to them. They live in family groups numbering somewhere between 10 and 40 individuals, under the dominance of an alpha female who reserves the exclusive right to bear offspring. If their daughters bear offspring, they are frequently killed or the daughters are banished from the group. They live in the Kalahari desert, which is not technically a true desert, there being some limited rainfall. Yet, there is much less vegetation than in forested areas, and conditions can be harsh. Food, while available, is not plentiful. Thus for a medium-size family, these tiny animals have a territory of approximately 1.5 square miles, which is jealously patrolled to ward off incursions by other meerkat families.

Each member has highly visible individual markings, rendering them identifiable to other family members and conspecifics. Clutton-Brock's outstanding research efforts took full advantage of the desert environment. With increased visibility, an unprecedented record of the activities of a whole family and rival families has been recorded. As a result of this fifteen-year-old continuing study, these animals are arguably the most studied social mammal in the wild.

Meerkats must face a number of challenging problems. I mention a few. First, is ever-present danger, mostly in the form of birds of prey but also from snakes. Mortality from predation is very high, over 20 percent per year. Against the desert, Meerkats are highly visible, particularly to birds who have excellent vision. Meerkats eat bugs and small animals that are buried deep underground. This requires digging deep into the sand so that their heads are buried while other parts of the body are dangerously exposed. Thus an individual Meerkat cannot forage for food and look out for predators at the same time. In addition all Meerkats have to go on very long foraging expeditions during the day, over an extended range, many hundreds of meters away from home. Young Meerkats, emerging from the burrows at three weeks of age, cannot go on foraging trips yet must learn to navigate the above-burrow terrain and eventually learn to forage. Finally, there is always the danger of hostile neighboring meerkat families, occupying neighboring territory.

To deal with the dangers during foraging expeditions, some family members take the posts as sentries. They stand on high ground or trees and, attentively scanning the environment for danger, give warning calls when needed. This comes at considerable sacrifice, for sentries must forgo eating on a sentry day. They appear to take turns insofar as sentry duty is usually for one day only. Similar considerations of individual versus group needs apply to child care. Daughters lactate and feed their alpha female mother's offspring. Adolescent Meerkats spend full days (on a rotating basis) supervising the play of younger siblings just outside the burrow.

Life and death social dramas are played out if a daughter becomes pregnant. This occurs when one of the daughters wanders slightly away from the group, say, during foraging, and meets a roving male from another family. After a brief courtship, mating can occur, often followed by pregnancy. On some occasions, the pregnancy and subsequent birth is tolerated by the alpha female; in other cases it is not. Pregnant daughters make great efforts to gain the favor of the female leader, attempting to groom her and making otherwise supplicating movements. The errant offspring can develop normally if they are tolerated. If not, they are either killed or the daughter-mother is banished, which can lead to starvation and death from predators or exposure.

Meerkat families are territorial. Because food is often scarce there is inevitable conflict between families. If there are territorial infractions (and they are frequent), deadly warfare can be the result and territory in the border zones can be taken or lost. Its noteworthy that these conflicts have some hallmarks of human warfare: war dances, linear formations, and the rushing of each others lines into battle.

This brief description indicates a number of important features of social life that have been highlighted by Humphrey. First, is the obvious advantage of cooperation in this species. Childrearing, babysitting, sentry duty, as well as many other tasks keep the high mortality rate within bounds. Second, all is not smooth; there is plenty of evidence for conflicts between group versus individual interests. In times of warfare or when dealing with a common enemy (snakes), there is extreme group commitment, where individual family members will appear very unselfish and heroic, risking life for the group. At other times, however, there are intra-family conflicts, over food, over who can keep their babies, and so forth. These are mammals, not social insects, and the interplay between individual vs social needs becomes the stuff that makes their life resemble TV soap operas, so much so that Meerkat Manor was a very successful show.

There are many highly social animals, Meerkats being some of the most well studied. Thus, the requirements for social life exist not just in primates, although they may be more advanced here. There must also be brain mechanisms to regulate social life in many animals. The Meerkat colony is only one well-studied example.

CHIMPANZEE POLITICS

Closest to humans among primates are chimpanzees. The wel- known morphological criteria of similarity (teeth, bone structure) have been supported by DNA evidence. This latter evidence places Chimpanzees closer to humans than the other great apes. It indicates that we are the closest to chimpanzees in sharing a common ancestor, perhaps five to seven million years ago. Despite the 99 percent overlap in DNA, large differences can be concealed by this tiny 1 percent difference, explained mainly in terms of regulatory genes that can have huge effects in differently orchestrating sets of otherwise identical genes. Nevertheless, chimpanzees are the closest we have as animals, and if the social life of animals are to inform our own, they would seem to be *the* candidates. The comparison is greatly enriched by the existence of *two* very distinct chimpanzee species, the more familiar chimpanzee *pan troglodyte* and the *pan panicus*, the bonobos. The latter are now the subject of intense interest as they differ significantly from normal chimpanzees, which we will describe below.

Our understanding of Chimpanzee life was advanced significantly thanks to pioneering field work of Jane Goodall, who made many important discoveries in the course of describing the characteristics of their lives in their natural settings. First was her early discovery that chimpanzees were meat eaters, that they launched organized hunting parties for animals such as monkeys. Second was her discovery of their tool use and tool creation, the discovery of these animals fashioning a stick to get the termites in the hole. Third was the strong bonds between individual female animals (both related and unrelated) that were long lasting and which had great importance in regulating behavior, often determining which males would be dominant. Finally, and very shocking to her, was the existence of warfare between groups, where violence to outsiders could be deadly. Later research confirmed this, showing also that lone chimpanzees at the border of their own territory could be easily assaulted and killed by neighboring patrols.

These discoveries were consequential, each one of which was echoed in popular culture as well in the scientific community, overturning, repeatedly, various assumptions, not only about chimpanzees, but about ourselves, especially for those prone to use chimpanzee behavior to draw human lessons.

But, as mentioned before, studying the social life of animals is a very difficult undertaking, particularly when these animals have ranges over many miles and through thick vegetation. Too many interactions are just not visible. The Meerkats, described earlier, have the advantage of being desert animals and are visually evident. This is not possible for chimpanzees and so field work needed to be supplemented by closer observation, where countless daily encounters can be noted and recorded.

The pioneer here was Frans de Waal, who started his career with chimpanzees in the Arnheim Zoo in the Netherlands. Trained in the tradition of Dutch ethology, he became the beneficiary of the then-largest enclosed facility in the world, allowing free range over an outdoor two-acre area that housed approximately 20 chimpanzees. Initially, the many thousands of social exchanges involving vocalizations, displays, and gestures remained mysterious. Only after many months of observations, repeated viewings of videos and sound clips, was it possible for de Waal and colleagues to understand the complex dynamics of the group. Influenced by a political and evolutionary perspective, mindful of the importance of dominance relations in social groups, and explicitly taking Dennett's intentional stance, he gradually was able to piece together a more comprehensive picture of chimpanzee social life. After this, subtle gestures and behavior that were initially missed, were more clearly identified and were used in anticipating outcomes, such as upcoming hostile encounters. Thus, while the observations of human researchers had a subjective quality, they were often validated by their ability to predict future events repeatedly. Although, initially criticized for being anthropomorphic, especially by an older generation of behaviorally trained scientists, the general consensus is that de Waal has captured critical aspects of chimpanzee social life.

One of his first books, *Chimpanzee Politics*, was a riveting day-by-day, sometimes minute-by-minute, description of how various males in the group achieved dominance through often indirect social maneuvering. Although there is an acknowledged alpha male of the community, his power is clearly dependent on various alliances, both male and female within the group. Brute strength on the part of the males was important, but as important was how less-than-maximum force was deployed. Many examples were described. For example, an upstart male undermined the power of the alpha male without direct confrontation. More deviously, he intimidated females (one-by-one) who were friendsof the dominant male. This coercion was successful—eventually leading to the over throw of the dominant male. There were dominance relations within females, but these were more stable and depended on age. While dominant animals afforded greater rewards (food, sex), it appeared that with these privileges came responsibilities, in particular conflict resolution. For example, he recounts the scene of two mothers whose quarreling children are getting out of hand, but the mothers don't intervene, lest this lead to hostility between them. After some time, one of mothers woke the dominant female. "Mama" was mildly disturbed, but she easily broke up the fighting. Similar, breakups of fighting between adults were often witnessed. One pattern seen repeatedly was the calming intervention of the alpha males who broke up fights in the community with impartiality.

Characteristic of male pan troglodyte society is its volatility and occasional shifts in power structure. Male-male hostile encounters are very frequent, with aggressive posturing, occasionally leading to fighting and consequent injuries. At the same time, continuing feuds are punctuated by moments of tender reconciliation between males, often fostered by females, male-male embraces, mutual grooming, and playfulness. These frequent examples of reconciliation are hypothesized mechanisms to dampen hostility that could lead the weakening of a particular chimpanzee group in relation to neighboring rival groups. Thus, de Waal indicates that peacemaking among chimpanzees is as ubiquitous as conflict.

Yet, there are high stakes within chimpanzee male society, and dominant ones have near- exclusive sexual rights with females and are first in line for food. As such, de Waal and others have seen clear links to observations of human politics. Harold Lasswell (1937), pioneer in the psychology of politics dubbed it as the study of "who gets what, when, and how." Machiavellian has been described as the characteristics of primate social life (Byrne and Whitten, 1990). The plots to overthrow kings and princes thus seem to have primate antecedents. De Waal describes in detail the lead-up and the results of a dramatic three-way power struggle where the outcome was the killing of the then-alpha male by his two closest rivals.

These anecdotes are mentioned to indicate to the reader that the social life of chimpanzees is very complicated and it can be a life and death struggle. Humphrey (1976) may indeed be correct, that all of this complex social interaction requires selection pressure to develop more brain power. He argues that in contrast to tool making or tool using, which is more of an incidental activity or at least a routinized one, social life requires constant vigilance, interpretation, and split second quick action.

BONOBOS, PAN ~~PANICUS~~ PANISCUS

Were pan troglodytes our closest and only cousins, we might draw some hasty and possibly unwarranted conclusions. Fortunately, there is another species to consider. Bonobos are a separate species of chimpanzee, having been identified only fairly recently. Their isolation and their distinctiveness was maintained by the wide Congo river, with chimpanzees to the north, bonobos to the south. Bonobos are discriminated from the chimpanzee in having smaller heads, flared nostrils, thinner necks and longer legs. Although called pygmy chimpanzees, they are large, approximately 95 pounds for an adult make, 80 pounds for an adult female. In addition to this size difference, males have very large canines, which are lacking in females. Despite this sexual dimorphism, with its apparent advantage for male dominance, bonobo society is dominated by females (de Waal, 2005).

Female dominance is a further demonstration of the importance of more complex social factors and how they overshadow brute strength. Bonds between females are very strong in bonobo society, clearly offsetting the greater body size and lethality of male canine teeth. In distinction to baboons, where males leave their natal group, females are the ones to leave. In distinction to the volatility and violence associated with the maintenance of male dominance patterns in chimpanzees, female bonobo dominance, similar to that of female chimps, seems to be determined largely by seniority. There is also a male dominance hierarchy, but it is less contentiously established, being determined by the dominance of the mother's position in the female hierarchy. Thus, if the mother of the dominant male dies, her son's social position drops.

Perhaps the most striking aspect of bonobo society is the frequency and the varied forms of sexual behavior and expression. Distinct from all other animals, bonobos can engage in face-to-face sexual intercourse, with a mutuality afforded by gazing at each other's facial expressions. Homosexuality, adult-child sex, as well as extended kissing (French kissing) is common. Because, males are not dominant, there is little of the sexual exclusivity seen in chimpanzee society. Another aspect is the frequency of sex and its casualness. It is much more frequent than in chimpanzee (or in human) society. Some kind of overt sexual behavior can occur almost hourly among bonobos. But it is something that is not an activity apart, as it is in humans or chimpanzees, but it is woven into the fabric of everyday life. As an example, de Waal, describes an incident in which a male seems to be hogging food in the presence of a female. She briefly rubs her genitals against his arm, perhaps disarming him, and proceeds to get her food. This is part of a general use of sex to release tensions. Thus, when coming upon a large cache of sugar cane, which will be the basis of a long feast, bonobos commence with group sexual activities. Only, after a bout of this, with them more calmed down, will they proceed with eating. One curiosity, for those who observe the human male, is that male bonobos show more sexual attraction to older females than younger ones.

CHIMPS VS BONOBOS

Chimps and bonobos offer a stunning contrast in terms of their behavior and invite comparison to humans. A variety of measures suggest that humans and chimpanzees diverged approximately five to seven million years ago, whereas the genetic divergence that led to distinctiveness between modern chimps and bonobos occurred less than one million years ago. Thus, chimps and bonobos are five times more related to each other than they are to human beings. Neither is obviously closer to us genetically, yet differences between them in social behavior, particularly in terms of sex and aggression, is about as wide as we can imagine, wider than our human differences with either of these species. Tiny genetic differences, much smaller than those separating humans and these chimps, must be critical, but the mechanisms by which genes determine these very great differences remain unexplained.

Nevertheless, the comparison between such closely related species can lead to a greater appreciation of larger relationships that exist between conspecifics. One striking example is the relation between dominance, mating patterns, and infanticide. As with Meerkats, infanticide is prominent in chimpanzees. The argument is that it is advantageous in pan troglodytes for the survival of male genes when competition between males is intense and when dominant males have exclusive mating rights. However, there is little need for this in bonobos. Males don't have exclusive mating privileges, and so it follows that there is a lesser advantage for male genes to benefit from infanticide because there is no guarantee that any father would not be eliminating his own offspring.

COGNITIVE REQUIREMENTS FOR SOCIAL LIFE

Our nearest distant ape ancestors have very complex social lives, and they do so without the benefit of language. Now, much later, we humans are the only hominid species remaining. What happened during the past five to seven million years? Paleontological and archeological evidence is fragmentary, and a plausible single narrative is lacking. Our brains are three times larger than those of the great apes. Why do we have such large brains? Tool creation and tool use has been a favorite idea. Yet, the archeological record shows extremely long periods where brain size increased but tool technology did not advance. This is consistent with Humphrey's argument that the greatest advances in human evolution and brain development came with the greater need for social intelligence. But, what kind of social intelligence? We have already seen that chimpanzees and bonobos are both fairly sophisticated, having some of the key hallmarks of human social life.

Having a storehouse of episodic memories about individual events is something that would seem essential for our own lives. For us humans, it is frequently essential for us to know who did what to whom. Not having language, can apes conjure up episodes to guide their future behavior? The question about whether apes have episodic memory has no answer as yet. However, since their complex social life is simpler than ours, it's not inconceivable that it can be conducted without the ability to conjure up past events.

The scope of the mind relevant to human social living is enormous. We can recall social situations of the distant past and can plan and forecast for future events. These can take the form of complex scenarios, casts of characters, plots, and subplots. Thanks to print and other media, our store house of social knowledge, that is, knowledge about people, has exploded. It is likely we have some knowledge of tens of thousands, maybe hundreds of thousands of people, historical figures, literary figures in addition to the many thousands recognized through personal acquaintances. Yet, some of our social life does not depend on such vast knowledge stores in this area. We can also make important social decisions based on very quick judgments (Ambady et al., 2000) with little acquaintanceship of individuals, even doing so with little or no awareness (Bargh and Chartrand, 1999). Whether these particularly automatic routes constitute the main part of animal social cognition or whether animals have more extended cognitive social scenarios is unclear. De Waal's observations, mentioned earlier, suggest that apes have these capacities but these conclusion are based to some extent on anecdotal reports.

We have surveyed several different species, Meerkats, very distant from ourselves, and two species of chimpanzees who are our nearest relatives. Compared to many other animals, the interdependence between conspecifics of these species is very high. What's surprising is that the social behavior between closely related species can vary tremendously. Chimps and bonobos are closely related, yet their social behavior is extremely different. The same holds for Meerkats and close mongoose relatives. The Egyptian mongoose, is almost solitary, clustering in groups whose average size is two or less (Palomares and Delibes, 1993).

The existence of large qualitative differences between closely related species has been a biological mystery for decades. How can closely related species be so different? This is a central question in the new field of evolutionary/developmental (evo devo) biology. Part of the answer lies in the now larger acknowledged size of the units of evolutionary variation. There exist control genes (Kirschner and Gerhart, 2005) or switches in noncoding parts of DNA (Carroll, 2005) that activate huge numbers of other genes such that very large jumps can be made. Genes and switches can control development at a very abstract level, more like a command language than a physical chain of events. As such, there is a single *eyeless* gene conserved over phyla for 500 million years, which leads to an eye no matter whether it be a single-chambered vertebrate eye, with one lens, or a compound eye with many separate facets and lenses. Similar levels of control are likely for brains; a single allele can determine whether a male vole will be monogamous or polygamous. Thus, it's not inconceivable that a finite number of genes can lead to the patterning of a whole constellation of social behaviors that are characteristic for a species. If the insights of evo-devo are applicable to the brain and to social behavior, it is possible that there is a finite number of processes that, when combined appropriately, will allow a species to have its uniquely stable characteristics.

If we are able to understand these hypothetical building blocks, it is possible that the basis of at least some human social characteristics could be better understood. For starters, it is likely that some prosocial behavior could develop out of parenting and pair-bonding mechanisms, present in most mammals, which are then generalized to other settings that would lead to larger-scale social cooperation.

Whatever the combination, it is very likely that we humans have been dealt a genetic deck of cards that is a given and can't be so easily changed. We are not chimps, nor are we bonobos, but we have some characteristics of each, and there is a combination and interaction that defines us as humans. What can't be changed, and what might be defined as human nature are characteristics that are shared by humans across all cultures, modern, premodern and aboriginal. This is presently the subject of intense inquiry by many, including anthropologists and evolutionary psychologists. Yet, it is obvious that, with the long childhood, the almost exclusive monopoly of a given society's influence, culture also has a decisive influence, shaping patterns of thought and possibly perception itself (Park & Kitayama, this volume). There is also the likelihood that, under selection pressure or perhaps by other mechanisms (genetic drift), different cultures have different genetic decks that could be consequential.

WHAT MORE HAVE WE LEARNED FROM ANIMALS?

Even if we remain skeptical about particular claims about intentionality or episodic memory in apes, it is clear that, for many species, the major events in their lives are social. Two broad groups of behaviors, common to our own society pertain: ones that promote pleasure and higher status for individual animals versus ones that promote well-being of others.

Many animals demonstrate the same selfishness we can witness in our own personal and political life: the endless efforts to raise one's status, to achieve dominance. Yet, besides competition, there is plenty of evidence for cooperation and selflessness. Of course, there is the parent-offspring bond, where parents will sacrifice themselves to protect their own. Less obvious, but of great importance, is W.D. Hamilton's concept of inclusive fitness, later popularized as the selfish-gene hypothesis. Aiding one's cousins promulgates the survival of ones own genes (Dawkins, 1976). Yet, warm and affiliative behavior is not restricted to ones kin. Many unrelated animals will exhibit what we regard as sympathy and empathy toward each other, something less directly explainable by selfish genes.

Because each animal is an agent, looking for its share of resources, but also because they are part of a social group, the behavior of social animals can often very hard to predict. At one moment they are fighting, and later they may give succor to the same individual. Because of the importance of social life in many species, it is not unreasonable to assume that parts of the brain, not just in primates, could be devoted to negotiating the complexities of social life.

VISION AND THE SOCIAL WORLD

Nick Humphrey's (1976) essay "On the social origins of the intellect" was prescient, arguing that the benefits and complexity of primate social life led to the unprecedented evolutionary changes in brain size, from monkeys to the great apes, from apes to man. A likely selective pressure was on those structures that can respond adaptively to the delicate balancing between shifting coalitions in a society in which competition needs to be balanced by cooperation. Any individual's relation to any other individual in a given society is potentially relevant, so effective brain mechanisms to understand and also navigate these waters would surely be advantageous for a species. Thus, it is not entirely surprising that humans with their faculty of language and the benefits of cumulative culture became preeminent.

Yet, despite the large differences between, say, chimpanzee and human, it's also clear that there is continuity and that many of the key social processes evident in ourselves are present in chimpanzees and bonobos. An extremely complex social life can proceed without the benefit

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of language. Knowledge of the social world for apes comes almost exclusively from the senses: vision, hearing, touch, and smell, and communications come mainly through actions, gestures, and vocalizations.

Humans of course, with their much larger brains, communicate through spoken language, and this marks an obvious difference between us and the great apes. The sequence of phylogenetic/historic steps leading to our present spoken language ability is poorly understood, but it is likely that it has been in place for a hundred thousand years, perhaps more (Donald, 1991). In contrast, written language for most of humanity has only arrived in the past one hundred years with the advent of mass literacy. Traditional social psychology has benefited from the use of written verbal materials with its use of surveys and questionnaires. Yet, it should be recognized that this particular route toward furthering the understanding of our social lives, particularly as we have inherited basic social mechanisms from our ancestors, very is narrow.

To understand those basic brain mechanisms mediating our social life shared by our biological relatives (both close and distant), we need to consider the widest range of possible information available. All the senses are likely to be important. Hearing is important for primates who are arboreal, and are frequently unseen by their neighbors. Odors, both consciously and unconscious sensed, are increasingly recognized as playing a large role in both animals and humans (see McClintock, 2002). The sense of touch as physical contact is important for parenting and maintaining friendships. We single out vision, not only because it could be the most important, but because it has been the easiest of the senses to study and has received the greatest attention.

Several developments suggest that this endeavor is propitious and is likely repay dividends. First, as mentioned earlier, the notion of vision and visual perception has expanded greatly, and most researchers now agree that visual perception is more than just receiving an image but is clearly related to understanding an image. There is less agreement about what is to be understood, with most researchers preoccupied with object recognition.

Here is where Gibson's approach to perception is likely to provide some guidance. Rather than looking inward to the structure of the visual system or measuring its failures (as in characterizing illusions), he preferred to look outward to the real world, to see what aspects of the world were meaningful for an animal and how such information could be picked up most efficiently (see Nakayama, 1994). Twenty-five years ago, applying these ideas to social psychology, Leslie Zebrowitz MacArthur and Reuben Baron (1983) identified four distinguishing features of this approach:

> … First, it assumes that perception serves an *adaptive* function and that the external world must therefore provide information to guide biologically and socially functional behaviors. Second, it assumes that this information is typically revealed in objective physical *events*—dynamic, changing, multimodal stimulus information as opposed to static or unimodal displays. Third, it assumes that the information available in events specifies, among other things, environmental *affordances,* which are the opportunities for by environmental entities. Fourth, it assumes that the perception of these affordances depends upon the perceivers' *attunement,* that is, the particular stimulus invariants to which the perceiver attends. (McArthur and Baron, 1983) AQ2

A number of developments broadly based on these assumptions and represented in this volume should be mentioned. In, particular, neurophysiological studies of face selectivity amply confirm the *attunements* proposed by Gibson, that specific areas of the brain exist that mediate the detection and discrimination of faces just as there exist areas with neurons that can distinguish motion and color (Tsao and Livingstone, 2008). These attunements are built into the system and are robustly represented. For example, studies on infant monkeys, with enriched environments but deprived of seeing faces for six months, still show normal face processing (Sugita, 2008) after this period. In addition, they can be flexibly deployed, that is, they can pay attention to faces at one moment and ignore them at another.

Very subtle attunements can play a major role in our social life. We humans can draw conclusions about others not only from what they say and not only from their smiles but from many other aspects of their body movements. To fully understand humans, an anthropologist from Mars would need far more than a crash language course because he would also be faced with a problem similar to that initially posed to Frans de Waal observing gestures in the Arnheim Zoo. Although few of us are aware that we are reading subtle body movements, they can be decisive in everyday life. Subtle nonverbal information accompanying a verbal interchange can determine who will get the job, who will get sued (Ambady et al., 2000; Weisbuch & Ambady, this volume). This is perhaps reason why business executives travel so frequently with grueling schedules even in our age of phones, e-mail, and video conferencing. They need all the social channels of information to make key decisions regarding the motives, competence, and trustworthiness of their business partners.

There is no doubt that vision is important for our social life and it is clear that researchers have opened the door to get some first glimpses of pertinent psychological and neural mechanisms. We could be at the threshold of a new scientific adventure, part of a larger effort to understand human beings, making full use of the natural and the social sciences. If so, it is tempting to make some prescriptions and prognostications.

Vision science has a ready-made set of techniques, concepts that are presently being adopted to study elementary social processes. One advantage is experimental control, the ability to precisely manipulate the properties of stimulus so that it can be continuously or randomly varied along a chosen dimension (gender, race, distinctiveness) but not on others. Thanks to new mathematical techniques associated with image synthesis and generation, an essentially infinite metrical space of faces can be created. Such metrical spaces also provide the basis of quantitative theories of representation, such as norm based coding for faces (Rhodes & Jaquet, this volume). Thus, a given face can be seen as a point or vector in a multidimensional space, at a given distance from a neutral origin. This allows one to conduct experiments on high-level social stimuli (faces) using essentially the same concepts and techniques that have been so successful in revealing the underlying mechanisms of color vision. This has also been accomplished for Johanson point-light walkers such that any individual can be continuously morphed into any other individual (Troje, 2002) and varied along chosen dimensions. Thus, adoption of these visual psychophysical techniques is beneficial to social psychology as well as for vision, furnishing social psychology new tools and ideas and in turn widening the scope of traditional vision research.

Yet, it's conceivable that there are even greater rewards, unseen for now, if vision researchers again revisit the functional question: What is the visual system for. Of course vision has many functions and some have been identified. But, if the social brain hypothesis is anywhere near correct, then our ideas regarding the function of the visual system needs to be re-evaluated. Rather than dividing the visual system into a dorsal ventral, actions versus objects, one may need to consider other meaningful subdivisions devoted to social stimuli. Many of the chapters in this book dwell on this, so it is clearly not a new idea (see Atkinson, Heberlein, Adolphs, this volume). Yet, it should be recognized that this outlook represents a major shift in understanding the functions of our visual system. It raises the possibility that eventually the current taxonomy of visual functions will widen significantly so that information about human social interactions and the social environment will be strongly represented.

Whether this will be a success is, of course, unknown but it is important for vision researchers to think more broadly about what events and features of the social world have the potential to be efficiently coded. Following Barlow's (1961) seminal paper, there is of late, much work on the optics and statistics of natural sciences, endeavoring to find those redundant features of natural images so that a more efficient image code can convey scene properties. An important yet daunting task is to do the same kind of analysis with the style and content of human gestures. These are obviously recognized by humans (either consciously or unconsciously), and there must exist mechanisms that are attuned to them. Underlying invariants here could thus act as building blocks for social perception and social cognition. Computer vision algorithms have made some limited progress in this area, identifying a small set of actions from larger subsets. Insights from computer graphics (the entertainment industry) could play a possible role, because the creators of such captivating characters have at least some implicit understanding of human social actions. Troje's (2002) parameterization of human action is also promising, providing a mathematical framework such that the movement patterns corresponding to perceived styles, actions, and actors can be understood.

What we have touched on and what lies ahead in this volume is just a tiny sample of a broad interdisciplinary effort to understand humans as evolved social beings, whose vision, together with other senses, will play a likely role in understanding our strong continuities with other species while also appreciating our uniquely human qualities.

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AQ3: Please provide editor name(s) and publisher details for reference Barlow, H.B. (1961).

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