

Signals, cues and meaning

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This chapter explains signaling theory, which is the basis for much of the analysis and design work in the rest of the book. It describes the basic concepts and discusses how to apply them to analyzing human behavior.

Many of the things we want to know about each other are not directly perceivable. These qualities include emotional states (are you happy?), innate abilities (are you smart?), and the likelihood of acting a particular way in the future (will you be a loyal friend?). Instead, we must rely upon signals, which are perceivable indicators of these not directly observable qualities.

Qualities can be almost anything: strength, honesty, genetic robustness, poisonousness, suitability for bookkeeping employment, etc. We rely on signals when direct evaluation of the quality is too difficult or dangerous. A bird wants to know if the butterfly it is about to eat is poisonous before it takes a bite, and relies on the signal of wing markings to decide whether to eat or move on. An employer wants to determine before making a hiring decision whether a candidate will be successful or not, and relies on signals such as a resume, references, and the candidate's actions and appearance to predict suitability for the job. A smile can be a signal of happiness, a wedding ring a signal of being married, smooth skin a signal of youth, and a big house a signal of wealth. Our language is full of signals, both the words we say and the way we say them. Saying "yes, I would like another helping of your special Tuna-Delight" can signal either hunger or politeness while the accent with which it is said can signal country of origin and social class. Indeed, much of our communication, whether it is with words, gestures, or displays of possessions, consists of signaling information about who we are and what we are thinking.

Signals have varying degrees of reliability. Some are quite highly correlated with the quality they represent: upon seeing such a signal, one can be sure that the quality is present. Seeing someone lift a 200 lb weight is a reliable signal of strength; no matter how much a weaker person wishes to signal strength, without actually possessing that quality he or she will not be able to lift that weight. Other signals are less reliable and those who wish to give the impression of having the quality, without actually possessing it can imitate them. Most people wearing wedding rings are indeed married, but an unmarried woman may choose to wear one, falsely signaling that she is married to forestall unwanted attention.

Signaling theory is concerned with understanding why certain signals are reliable and others are not. It looks at how the signal is related to the quality it represents and what are the elements of the signal or the surrounding community that keep it reliable. It looks at what happens when signals are not entirely reliable – how much unreliability is tolerable before the signal simply becomes meaningless?

Signaling occurs in competitive environments. The interests of the sender and the receiver seldom align exactly, and often they are quite at odds with each other.

Sometimes the competition is fierce and overt. Prey may signal to predators that they are poisonous or that they can run so fast or fight back so strongly that pursuing them is futile. Competitors can signal their strength to each other; if they are an uneven match the weaker may acquiesce and actual battle, which is costly for all, can be avoided. Sometimes the competition is subtle, as when the signaling is between seemingly congenial companions. However, even within cooperative relationships there are elements of competition and conflicts of interest about plans and identity: I wish to present myself in the best possible light while you want to know what I am really thinking and what I really can and will do.

In competitive situations, being deceptive can be quite beneficial. If a bug presents itself as poisonous when it is not, it may avoid being eaten. If I present myself as more experienced than I really am, I may get a better job. Yet if the rate of deception becomes too high, the signal loses its meaning. Thus, for communication to occur, for signals to maintain their significance, something must limit the rate of deception. This is the core question of signaling theory: what keeps signals reliable?

The answer is costs: a signal will be reliable if it is beneficial to produce truthfully, yet prohibitively costly to produce falsely. These costs can be inherent to the signal or they can be imposed by society. Signaling theory provides a framework for understanding the different types of costs, and the balance between the advantages of greater reliability vs. the costs incurred in maintaining honesty. Much of this chapter will look at the economics of signaling: the costs of signal production, deception detection, punishing cheaters, etc.

Signals can be ambiguous. Their meaning is not always clear and universally agreed upon, and the costs that maintain their reliability are not always apparent. The art of signal analysis comes in applying the theoretical framework to real situations and determining what are the actual - and not always obvious - costs and benefits of a signal. We will also look at the interpretation of signaling, at how signals acquire their meaning and how people negotiate the differences among their different subjective understandings of them.

1. Basic concepts

1.1. Cues and signals

The first step in understanding the dynamics of signaling is to define exactly what we mean by words such as “signal”. So far we have said that signals are perceivable indicators of otherwise hidden qualities. Yet not all such indicators are signals. We will use the term “cue” to refer to all the things we perceive that indicate some other hidden state or intention and we will reserve the word “signal” for those cues that are meant to serve as communication, either because they have evolved for that purpose or because they are intentionally communicative.

Cues are “any feature of the world, animate or inanimate, that can be used ... as a guide to future action” (Hasson 2000; Maynard Smith and Harper 2003). Everything that we use to infer a hidden quality is a cue. A cue is a signal only if it is intended to provide that information.

Many of the cues we use to infer hidden qualities are unintentional conveyers of information rather than signals. I will sometimes use the term **evidence** to refer specifically to unintentional cues. The smell of CO₂ that guides a mosquito to you is evidence of your presence – you did not choose to provide the mosquito with this information and indeed would preferred not to have done so. Evidence unintentionally conveys information and it may be harmful to the person or animal producing this cue to have revealed it.

Signals are cues that are meant to indicate some quality. More precisely, a **signal** is a perceivable action or structure that is intended to or has evolved to indicate an otherwise imperceivable quality about the signaler or the signaler's environment. The purpose of a signal is communication and its goal is to alter the receiver's beliefs or behavior.

A poorly performed signal is evidence of the signaler's lack of the relevant quality. All the applicants for a job signal their potential to be a good employee in their resume, but some do so better than others do. A poorly qualified candidate attempts to signal his suitability for the job, but the employer sees evidence of his inability to handle it.

The distinction between signals and evidence is important, because the dynamics of signaling do not hold for non-signal cues. When a signal loses its audience – perhaps because it is too unreliable – eventually it ceases to be produced, since with no audience, it has no benefit. Non-signaling cues – such as the CO₂ one emits – operate outside this system. Even if there are no mosquitoes around, we still give off carbon dioxide.

A feature may function simultaneously as a signal and as an unintentional cue. One might intentionally display a signal for one receiver only to have it be picked up as evidence by another. One may dress in furs as a signal of success and wealth – but a robber may interpret this same clothing as evidence that waylaying the fur-wearer will net a hefty haul of fine jewelry. Or, the intended receiver may interpret a signal in unintended ways. The fur-wearer may intend to the signal wealth, taste and success to someone she hopes to impress, but that person may instead interpret the furs as evidence that she is cruel to animals.

A feature may be evidence in one context and used as a signal in another. Wrinkled hands are usually evidence of old age, their appearance results from the loss of collagen, elastin and subcutaneous fat, not from any communicative purpose. Yet in situations where being old is advantageous, ranging from ticket booths that give senior citizen discounts in our otherwise youth obsessed society to cultures where old age is revered and respected, one might choose to show off gnarled and wrinkled hands, amplifying their appearance to signal advanced years.

All cues, both signals and evidence, provide a means to infer some quality. Signals are meant to communicate the quality; their purpose is to alter the receiver's beliefs or behaviors in ways that benefit the signaler. Unintentional cues, or evidence, exist for other reasons and they may provide information detrimental to the one who reveals them.

1.2. Honesty and reliability

A signal is reliable when most instances of it are honest; it is unreliable when it is sometimes honest, but sometimes not. Wearing a wedding ring is an unreliable signal of marital status, for it is not always honest: a ring on a married person's finger is an honest signal, while the same ring on a single person's hand is a deceptive one.

The intention of an **honest** signal is to indicate a particular quality, one that does indeed exist within the signaler or the environment. A **deceptive** signal is the opposite: its intention is to indicate the existence of a quality that the signaler or environment does not actually have. A signal is a **reliable** indicator of a quality if the signal always means that the quality is there: a reliable signal is always honest. An **unreliable** signal is one that can either be honest but may not be; there is no cost, or insufficient cost, compelling it to be.

Honesty and deception thus refer to specific instances of a signal, while reliability and unreliability refer to the signal in general.

As we will see when we look more closely at the issue of intentionality, a signal can be unreliable without people using it deceptively. A woman may have very short hair to signal that she is lesbian, but other, straight, women may have similar haircuts not to deceptively signal that they are gay, but because they like they style or find it easy to care for. Very short hair is an unreliable signal that as woman is gay: some women displaying this feature are honestly signaling they are gay, others are neither gay nor attempting to deceptively signal that they are.

1.2.1. Reliable signals are stable

When a signal is reliable, both signalers and receivers benefit, and the signaling system is stable.

Signalers benefit when the receivers change their beliefs and behavior in response to the signal. Receivers benefit from honest signals, for decisions made and opinions formed with true information are generally better than those that result from false assumptions. When the interests of the signaler and the receiver align – when both benefit from honest signaling – we have straightforward, cooperative communication.

The dynamics of signaling systems become more complex when the signaler is motivated to be dishonest. Receivers can pay a high cost if they heed a deceptive signal and so if a signal becomes too unreliable, they will come to ignore it. When this happens, signalers no longer benefit from producing that and they eventually cease to do so.

Thus, instances of dishonest signaling are be detrimental not only to the receivers, but to other, honest, signalers. Honest givers of that signal find that their message is ignored, and they lose the benefit of that signal. This is how dishonest signaling undermines a communication system.

Particular signals can tolerate varying amounts of dishonesty. How much depends on the cost to the receivers of believing a dishonest signal and to the honest signalers of being doubted. Polite compliments such as “you look great” are often dishonest signals of the speaker’s opinion of the other’s appearance. However, the cost to the receiver is low and there are other benefits from this action (such as signaling friendliness and social competence) so its unreliability is generally tolerated. On the other hand, if adults claiming to be adolescents infiltrate an online teen chat group, the costs are high, both to the teens who mistakenly trust the deceiving adults and to the honestly signaling members of the community who subsequently cannot establish trust because the high rate of deception makes their existing signals of membership meaningless. Here, even low levels of dishonesty are harmful and so the community must find ways to make it prohibitively costly for non-teens to signal being teenagers.

1.2.2. The pace of signal evolution

Signaling systems are dynamic. Signalers and receivers continuously adjust the signal form and response within an economy of costs and benefits.

In the world of animal signaling, they make these adjustments slowly, in evolutionary time. The bright warning (aposematic) coloring of a poisonous butterfly is a highly visible signal of its distasteful flavor. However, coloring is not an inherently reliable signal and it is possible for deceptive (Batesian) mimics to evolve¹. Batesian mimics have the same coloring as the poisonous ones, but are palatable. While the population of mimics remains small, a bird that bites a butterfly with the bright warning colors is likely to have a bad experience, thus reinforcing the connection between bright colors and bad taste; the signal remains reliable enough to protect both the honest poisonous ones and the dishonest palatable ones. However, as more and more mimics appear, the value of the aposematic colors as warnings diminishes: a bird that bites the bright mimic is likely to get a tasty meal, and is encouraged to eat more that look like it. If too many mimics invade, the meaning of the signal is lost, and the coloration no longer protects any of them. Eventually, the poisonous ones may evolve a new marking

¹ Batesian mimics, first identified by H.W. Bates in 1861, consist of a protected (poisonous) model and an unprotected (palatable) mimic. The mimic is protected by its resemblance to the model. Mullerian mimics consist of a set of two or more protected types that resemble each other. With Batesian mimics, the mimic is detrimental to the model by making its signal of unpalatable identity less reliable. Mullerian mimics are mutually beneficial. The classic example of Batesian mimicry, the Viceroy and Monarch butterfly, has proven to actually be a case of Mullerian mimicry: apparently, Viceroy’s are not very tasty either. (Salvato 2001; Speed 1999)

and the cycle begins again. This evolution of models and mimics is a slow process, taking many generations².

Human signals evolve in a complex polyrhythm, some at the slow pace of evolutionary time, others with the rapidity of information transfer. Signals such as the facial hair that indicate one is an adult male evolve in biological time, while the cultural meaning of mustaches and beards can change over the course of a few years. Some culturally evolving signals change over hundreds of years, such as the shifting pronunciations and usage that create separate regional accents, signals of geographic and social origins. Others vary quite rapidly, such as what fashionable clothing to wear and which new club to go to, in order to signal of one's knowledge of the ever-accelerating cultural scene.

Invention and the increasingly important role of information in our society drive many of these changes. As we look in more detail at the dynamics of signaling – at the costs and benefits that bring or disrupt equilibrium – we will see how signaling influences cultural and biological change.

2. A brief history of signaling theory

We hold efficiency in high esteem. Waste is bad. In the domain of new technologies, we extol new devices for their ability to save us time and energy. The ideal, it seems, is to be direct and streamlined. Yet seemingly wasteful displays are everywhere, from the exuberant colors of a peacock's tail to the shiny chrome and deep hum of an expensive sports car. Are these simply weird anomalies, needless and heedless expenditures of energy or money? Or do these exhibitions of excess serve a useful purpose?

This is the question that Thorstein Veblen was addressing over a hundred years ago when he wrote *The Theory of the Leisure Class* (Veblen 1899). Veblen observed that to gain the esteem of one's fellow man, simply having wealth and power is not sufficient: it is necessary to display them. He noted that such displays must be of actions or goods that went well beyond the practical, for if there was a utilitarian reason for having or doing something that alone could explain its existence. He proposed that seemingly irrationally excessive acts and expenditures functioned as displays of status, wealth and power. The key idea in his theory was that their "wastefulness" was an integral part of the display. In order for the display of goods or leisure to indicate wealth or status reliably, it must be wasteful – there must be some cost associated with it beyond what one would spend for reasons of utility. "Throughout the entire evolution of conspicuous expenditure, whether of goods or of services or human life, runs the obvious implication that in order to effectually mend the consumer's good fame it must be an expenditure of superfluities. In order to be reputable it must be wasteful." This idea, that excess cost ensures reliability, is

² Though, aposematic coloring evolves rapidly compared with the evolution of other traits (Joron 2003).

at the heart of contemporary signaling theory. Although he did not use the terms “signal” or “quality” and his analysis is more anecdotal than that of today’s evolutionary biologists, his ideas echo in much contemporary work.

A century later, biologist Amotz Zahavi was looking at similar questions, only from the viewpoint of a biologist. He noted phenomena such the peacock’s extravagantly large and colorful tail, a display that requires a great deal of energy to keep up and that makes the bird vulnerable to predators, and the gazelle’s strange reaction to seeing a predator, where it jumps up and down in place (stotting) rather than running off as fast as it can. Why would these displays evolve? They put their displayer at risk for predation and they waste hard-earned energy and strength. Common sense would seem to indicate that evolution should favor the efficient. Zahavi argued that these apparently wasteful displays were actually signals whose cost ensured their reliability. He proposed the “Handicap principle” which stated that for signals to be reliable, they must be costly in the domain of the quality being signaled (Zahavi 1975) (Zahavi and Zahavi 1997). He argued that animals with conflicting goals would evolve costly signals of their strength and status, even though – indeed, because – they lower the animal’s chance of survival. By displaying its ability to thrive even with such a handicap, the animal reliably signals its high quality. Reliable signals of quality are useful to competitors: an honest signal of fighting ability reduces the number of actual battles, which are destructive to all participants. And they are useful to potential mates, who wish to have best genetic advantages for their offspring.

Zahavi’s work at first met with considerable resistance. Partly this was because his paper was somewhat vague about how costly signals ensured reliability. But it was also counterintuitive. Many biologists felt that evolution would favor only the development of less costly signals, especially as the costs would be passed on to future generations. (as noted by Mesterton-Gibbons and Adams 1998). Yet the handicap principle, more clearly stated and formalized, became generally accepted. In 1990 Alan Grafen published a pair of papers (Grafen 1990a, 1990b) showing that costly signaling could be framed as a communication game and that within the formal models of game theoretical analysis such signaling was an evolutionarily stable communication strategy. The belief that extra costs in signals are not wasteful, but function to guarantee their reliability soon became very influential (see, e.g. the 1993 special issue on “The evolution and design of animal signaling systems” of the Royal Society’s *Philosophical Transactions: Biological Sciences* (Butlin, Guilford, and Krebs 1993)).

Subsequent work has extended this theory. Guilford and Dawkins incorporated receiver costs into the economics of the signaling system and proposed that these costs contributed to the use of less reliable but easier to evaluate conventional signals (Guilford and Dawkins 1993). Others have developed a fuller taxonomy of signals, including indices, which are not costly but are reliable because of the existence of the quality is required in order to produce the signal (Maynard Smith and Harper 1995) and amplifiers and attenuators, which highlight or hide certain traits (Hasson 1997; Maynard Smith and Harper 2003).

At around the same time that Zahavi was formulating the handicap principle to explain animal behavior, Michael Spence was developing signaling theory within

economics to explain market phenomena. In “Job Market Signaling” (Spence 1973) he outlined a model of how education level could signal job candidate quality, work that would earn him a Nobel Prize in 2001. Spence’s signaling work helped launch the field known as information economics, which looks at how asymmetries in information upset the classical model of market exchange.

Grafen’s and Spence’s formulation of costly signaling are fundamentally equivalent, but the two fields, economics and biology, examine different questions through the same framework. Much of the economic work has focused on consumer marketing (Kirmani and Rao 2000) and modeling market behavior, while the biologists have focused on understanding the evolution of animal communication, looking closely at the design of signals and at relationship between types of signals and the qualities they could reliably indicate. This emphasis on signal design makes the biological school particularly relevant for the questions I am addressing.

In the next section, we will look at the main types of signals and how they maintain reliability.

3. Types of signals and how they relate to qualities

The basic formula of signaling is that a signal will be reliable if it is beneficial to produce truthfully, yet prohibitively costly to produce falsely. How a signal relates to its indicated quality – whether there is an inherent connection or an arbitrary link between them – determines the relative cost of honest vs. dishonest production of the signal. Understanding this relationship is the basis of signaling theory.

Playing a winning game of tennis is a signal of your coordination, affixing a Greenpeace bumper sticker to your car a signal of your political leanings; and treating the whole bar to a round of drinks a signal of your financial success. Each of these signals has differing degrees of reliability: while the generous toaster may be deeply in debt, it is difficult to fake excellence at a sport. Each of these signals connects with the indicated quality in a different way.

A signal may relate to a quality in several ways:

1) *Costly or “handicap” signals* are costly to produce; they are signals of one’s possession of some kind of finite resource which the signal itself “wastes”. One who is poorer in that resource is less able to bear the cost of making the signal. Paying for a round of drinks is *handicap signal*. The signaler has taken on extra cost or handicap in order to produce the signal; its reliability stems from this seeming waste of the signaled resource.

2) *Indices* are signals that require having the quality they signal in order to produce them. Playing tennis skillfully is an *index signal* of good coordination. Having the quality is prerequisite for producing the signal, which is reliable because of this inherent connection.

Both handicap and index signals are *assessment signals*, meaning that the form of the signal inherently relates to the quality it represents – the form of the signal itself provides an assessment of whether the signaler has the indicated quality.

Assessment signals are inherently costly to mimic deceptively, which helps maintain their reliability. However, if being deceptive is sufficiently beneficial, they may also become unreliable, necessitating additional – often socially imposed - costs to maintain their reliability.

3). The third type of signal are called *conventional signals*, for here the connection of the signal to the quality is simply through convention – there is nothing in the form of the signal that ties it to that meaning. The Greenpeace sticker is a conventional signal. Conventional signals rely on societal forces to maintain reliability.

Costly, index and conventional signals exist in both the animal world and in human society. In addition, I propose that *fashion signals*, which may be unique to human communication, are a fourth type of signal.

4). *Fashion signals* are signals where the form of the signal changes frequently while the meaning remains the same. They are signals of one's adeptness in an information-based world, including access to information and willingness to adapt to continual change.

3.1. The assessment signals: handicaps and indices

With assessment signals, something inherent to the signal itself connects it to the quality it indicates. They are reliable because they are prohibitively expensive for a dishonest signaler to produce.

3.1.1. Handicap signals

Handicap or costly signals are signals that are costly to produce in terms of the quality they signal. They are relatively more expensive for one who possesses less of the quality.

The moose wearing an immense rack of antlers is signaling strength. He uses up a considerable amount of energy just to grow and carry these huge appendages. A weaker animal would not be able to waste necessary strength on such a display. The night-clubber who buys \$400 bottles of champagne to show off his wealth is also using such a signal – he is wasting wealth in order signal it.

Costly signals indicate that one has a desirable, finite and consumable resource in such abundance that one can waste some of it to indicate honesty. In the animal world, these resources are often strength and energy. In the human world, wealth and time- Veblen's conspicuous consumption and conspicuous leisure - are also frequently displayed.

People signal wealth by displaying expensive possessions. Driving an extravagantly expensive car and wearing a lot of jewelry are costly signals that indicate the owner

of these goods has so much money he can waste³ a lot of it on these non-essential goods. A poorer person who tried to emulate this display would face the prohibitive cost of either simply not having the money, or being unable to afford basic necessities.

Wasting time, too, can be a signal. Veblen noted that possessing an excess of time as well as money was a signal of status, but that one cannot directly display an abundance of leisure, for not very many people will watch you do nothing, day after day, year after year. He proposed that the time-consuming acquisition of impractical accomplishments was a way of displaying leisure, to signal that one need did not need to toil at some income-producing enterprise, and he listed among such accomplishments the ability to speak a dead language, knowledge of proper spelling, the occult sciences, and the breeding of fancy dogs (Veblen 1899).

Costly signals allow a tradeoff between investing in signaling and expending that resource in some other way. The amount invested in the signal depends on the expected tradeoff, so one might choose to invest in the signal under some circumstances but not others (Taylor, Hasson, and Clark 2000). This is why they are sometimes called strategic signals – signalers can adjust how much they invest according to overall economic strategy.

3.1.2. Index signals

The second way a signal can relate to a quality is that the quality may be required in order to produce the signal. These are **index signals**⁴.

Tigers mark their territory by scratching trees. A big tiger scratches higher and thus the height of the scratch is an index signal of the resident tiger's size: a smaller tiger simply cannot scratch so high (Maynard Smith and Harper 2003). A lawyer's brilliant argument in front of the Supreme Court is an index of her intellect and analysis: she could not do that performance in the absence of those qualities.

Unlike a handicap, an index is not costly – displaying it does not use up the advertised quality. These signals are reliable because the quality is a prerequisite for producing the signal.

³ Although Veblen's reputation is of a scathing social critic, it is important to note that he was quite careful in stating that he did not mean to use the term "wasteful" in its common pejorative sense. Instead, he meant it as a contrast to "practical" or "useable" and that many goods and activities had both a useful and a wasteful function, but that only the costs associated with the latter served to establish one's "reputability" or status. We follow his usage here.

⁴ The notion of indexical signs is drawn from semiotics, where it means a signifier whose meaning is not arbitrary but is directly related, physically or causally, to the thing it signifies (Chandler 2001). Reliability vs. ingenuity

3.2. Conventional signals

The third way that a signal may be associated with a quality is simply by convention (Hurd and Enquist 2005). Much of human communication falls into this category. Signaling that you are Jewish by wearing a Star of David, that you are an intellectual by carrying around books by Hegel and Lacan, or that you like someone's hat by saying "I like your hat" are examples of **conventional signals**. These signals are not inherently reliable, but are kept so (to the extent that they are) by societal forces. Signaling that you are a police officer with a siren in your car may be an effective way of getting quickly through a traffic jam, but most people believe the potential punishment is too high to make the convenience worthwhile. Here, the community provides punishment costs -- in this case in the form of fines or jail time -- that discourage deceptive signaling.

Conventional signals also exist in the animal world. For example, some sparrows have markings that function as badges of status, signaling their place in the local hierarchy and providing a rough indication of their fighting ability. There is no cost associated with these markings: they are not metabolically expensive to produce nor do they increase the risk that predators will see the bird. (Møller 1987; Rohwer 1977) Yet, because conventional signals rely on social sanctions to preserve their meaning, their use in the animal world, with its relatively simple social structures, is limited.

Humans can talk. We can learn about a distant stranger's misdeeds and choose to shun him; we can construct elaborate networks of gossip and surveillance. Our ability to sanction socially disapproved behavior means that we can rely far more heavily on conventional signals.

Many conventional signals are somewhat, but not entirely, reliable. I may, for instance, choose to display that I am a serious bike rider by wearing a full outfit of cycling gear; but buying these clothes, while financially expensive, does not require paying any costs in the domain being signaled, cycling prowess in this case. Such conventional signals are not inherently reliable, and there are novice cyclists and non-athletes who sport elaborate Tour de France-like outfits. For communication to function, a signal needs to be reliable enough that receivers continue to heed it. If the cost to the receivers of mistakenly believing a deceptive signal is low, the signal can tolerate higher levels of deception.

Conventional signals dominate online communication. Words signal what would be immediately perceivable features in the face-to-face world: we know age, gender, height, and hair color only through typed claims and easily falsified photographs. Online, signals evolve rapidly: it is an excellent environment for observing the dynamics of signaling systems (Donath 1998).

If sparrows with status badges were no more likely to be of high status than those without, or cycling gear only occasionally correlated with biking ability, these signals would not convey information about the underlying quality. Since there are no inherent costs keeping convention signals reliable, what prevents the arrival of so many deceptive signalers that the signal becomes meaningless?

Some are reliable because there is little motivation to produce them dishonestly. A bumper sticker indicating one's intention to vote for a particular candidate is a conventional signal of one's political stand. There is no demand for regulating these statements, since very few people are motivated to present themselves deceptively as supporters of candidates they do not like.⁵

Other conventional signals are reliable because of externally imposed costs. If a conventional signal brings some benefit – for example, displays of status can induce others to treat one with deference – some external means must limit deception or else the signal will quickly become meaningless. Often, those whom the deception directly or indirectly harmed impose the extra cost that makes conventional signals reliable. They can include the receiver of the deceptive signal, other honest signalers who are defending the reliability of their message, and the surrounding community.

And sometimes, conventional signals simply are not reliable. In online games many men claim to be female because it brings them extra attention and willing assistance, while many women claim to be male because it helps them avoid unwanted attention. In these environments, gender claims become almost meaningless. In situations where the cost for being deceived is low – such as fantasy games in which the enjoyment of role-playing outweighs the need to know the person behind the avatar's mask – the unreliable signal may continue to be used. Or, if the cost of deception is high, other more reliable but often more costly signals may come to be used.

3.3. Fashion signals

Fashion signals are signal whose form changes while the quality they indicate -- one's position in a mobile, information-based society – remains the same. To display and comprehend such signals requires having access to information about what is the new form of the signal, the knowledge to distinguish good information from bad, and the willingness to adapt to the new form.

⁵ There are repressive regimes in which honestly signaling one's political preferences would be quite costly. Here, only a devoted dissident might signal honestly. Yet, while it is tempting to say that at least this added cost guarantees the honesty of the dissenting signals, there are other complications such as government infiltrators: people who upon making a deceptive signal of dissidence receive a benefit from the government rather than paying a cost.

The point here is that the models of signaling economics become arbitrarily complex in the human world, given our ability to manipulate the beliefs of others (Theory of Mind), an ability that may be rudimentally present in some non-human primates, but not in other non-human animals (Hauser, Chomsky, and Fitch 2002). Human signaling has layers of complexity unheard of in the animal world.

Such signals exist in many realms. There are of course fashions in clothing and music, but also in programming languages and management styles. A software developer seeking a job with an exciting new start-up needs to display his knowledge of new, up and coming languages; if he knows only older, traditional ones, it indicates that he is not at the forefront of technological innovations. Learning a new language is a costly endeavor and even more so is committing to code a big project in it. New programming languages are constantly being developed and while a few will go on to become mainstream, many quietly disappear (Ghosts in the Machine: 12 Coding Languages That Never Took Off). The programmer who re-codes his work in an exciting new language pays a high price if it turns out to be a technological dead-end. The risk, though, can be worth taking for the programmer who repeatedly adopts new techniques that go on to be popular enjoys a reputation for being knowledgeable and gains the utility added by the successful innovation.

As information travels more quickly, the rate of change in fashion signals increases. In the early days of fashion, around the 14th century, as society became less rigid with the rise of the mercantile class, information traveled very slowly: news of what clothes were being worn at the Parisian court might take almost a year to reach a provincial capital such as Warsaw (Braudel 1979). Today, information crosses the globe instantly, and fashions change with corresponding and accelerating speed.

[Fashion has not been previously modeled as a form of signal. We will discuss it in depth in a later chapter]

3.4. Ingenuity and the limits of reliability

Assessment signals are inherently linked to the quality they indicate. They are reliable because it is prohibitively costly to produce them deceptively. Yet in the world of human communication, ingenuity often finds a way around the reliability that these signals should ensure.

When Maynard-Smith and Harper illustrated the concept of indices with the example of the tiger signaling size by scratching high on the tree, they mentioned somewhat facetiously that the signal would cease to be reliable if little tigers figured out how to stand on boxes. While such ingenious circumventions are uncommon in the animal world, they are ubiquitous in the world of humans. We can rent expensive cars and make diamond rings with cubic zirconium. We wear bronzer to appear as if we spent the weekend relaxing on the beach and undergo surgery to look years younger than we actually are. Humans can find a way to fake almost any signal.

Thus in the human world, many signals are hybrid: both societal forces and inherent ties to the signaled quality maintain honesty. The designer of an online site who wishes the participants to be honest about their age may add a quiz about current events and popular culture of different eras to assess whether they are familiar with fads and events that someone of their claimed age is likely to know. If this knowledge-based index proves to be an insufficient guarantee of honesty, then social costs, such as public exposure within the group or expulsion from the site, may have to supplement it.

People are ingenious, and for most signals, someone will somehow find a way to fake a seemingly unfakeable signal. Unlike tigers, we can always find a way to stand on a box to seem taller, to bleach our hair to be blonder, to borrow an impressive car. Humans are inventors -- and inventing cheaper and easier ways to signal a desirable quality, even in the absence of that quality, is a driving force behind much creativity.

4. The costs and benefits of signaling

Thus far, we have talked about the basic structure of signaling, about how cues can be deliberate signals or accidental evidence and about how signals can be handicaps, indices, fashion or conventional signals. This enables us to understand the structure of communication systems and to categorize different phenomena.

To understand fully the dynamics of signaling, however, we need to look more deeply at the full array of costs and benefits that occur in communication. We would like to be able to answer questions such as why do some conventional, low-cost signals remain reliable, even though there seems to be little societal enforcement of their honesty while others need to be fiercely defended? Why do some difficult-to-copy index signals inspire huge industries of mimicry? What cues should people look for when they go online to seek buyers, sellers and potential life companions in a context where all they see are the unreliable signals of words and pictures?

The answers to these questions are complex, and rooted in the particular conditions of each signal. Yet they all conform to the basic equation of signaling theory, which is that a signal will be reliable when for honest signalers the benefits outweigh the costs while for dishonest signalers the costs outweigh the benefits.

Let's look, for example at the cosmetic industry and particularly at cosmetic surgery, much of which is an effort to signal that you are younger than you actually are. The scale of the cosmetic and cosmetic surgery industry indicates that the benefits of signaling youthfulness are extremely very high in our culture: in 2005 Americans spent an estimated \$9.3 billion dollars on cosmetic surgery [ref]. For women in particular, there is considerable stigma in looking older. For a 20 year old appearing youthful is an effortless index signal, but for a 60 year old, a youthful appearance is a very expensive deceptive signal, costly both in money spent and pain endured. The 20 year old has a higher net benefit in signaling youth (since her cost is so low) but what counts is that the net outcome for the deceptive signal is still positive.

The dynamics of this signal are quite interesting, for as the deceptive signal becomes common it changes the cultural meaning of looking older. People who stand to gain a lot by appearing young and who can financially afford the surgery, such as wealthy women in the entertainment industry and other image-conscious subcultures, are most likely to undergo very expensive, yet effective, plastic surgery procedures. In these communities, plastic surgery has become so ubiquitous that looking old - appearing with wrinkles or sagging skin - becomes evidence of not only of age also of lower economic status. Thus, it becomes doubly stigmatized, which in turn makes it even more compelling to signal youthfulness, even at high cost.

Here we see a signal – youthful appearance -- becoming unreliable as the benefits of being deceptive outweigh the costs. Is this unreliability sufficient to make the signal meaningless? Or is the cost of being deceived low enough to tolerate it? What is the cost to the receivers? Are they becoming more adept at evaluating age – that is, are they paying higher assessment costs? How harmful is the deception to the honest signalers, people who are actually young? Do they in turn change how they signal youth to make it harder to fake?

As we'll see in this section, there are a number of costs and benefits that affect the decisions of both signalers and receivers. As we come to understand them better, we can use them to analyze why people behave as they do – and make predictions about how they will act and about the impact introducing new behaviors, beliefs or technologies.

4.1. Costs to the signaler

Producing a signal involves some cost. We can categorize the costs by their source: there are costs due to production, predation and punishment

All signals involve *production costs*, even if minimal. Producing a signal must expend some energy. It also incurs opportunity costs: one could have pursued some other activity in its stead.

Some signals involve *predation or risk costs*. These are the unpleasant effects of the signal being observed by an unintended third party and other risks assumed by making the signal. Predation is a constant danger in the animal world. For instance, signals such as elaborate courtship displays can attract predators as well as potential mates. Predators are also a danger for human signalers. Signaling wealth and status by wearing expensive jewelry can attract thieves as well as admirers; signaling toughness by wearing gang tattoos can attract police as well as intimidate rivals.

Dishonest signaling may involve *punishment costs*. These are the costs imposed by aggrieved receivers or other signalers upon determining that a signal was deceptive. We will define punishment costs as a risk only for dishonest signalers; if the risk of overzealous law-enforcement becomes a significant danger for honest signalers we will classify it as a type of predation. We will discuss the role of punishment in maintaining signal reliability in the chapter on reputation, but for now, it is useful to note that these costs require action by the receivers or other signalers.

It is useful to classify the signaler's costs by their purpose into *strategic costs* and *efficacy costs* (Dawkins 1993; Dawkins and Guilford 1991). Both strategic and efficacy costs affect signal reliability.

Strategic costs are the additional costs that ensure the honesty of the signal, in other words, the handicap costs (Zahavi 1977). Strategic costs are usually in the form of resource expenditure, such as using extra energy to show how fit one is. They can also be in the form of risks: placing oneself at extra danger to signal how brave one is. Strategic costs are the defining feature of handicap signals. Signalers who wish to indicate that they have a quantity of a particular resource can indicate their

abundance of it by wasting some. However, they would still like to waste as little as possible: the ideal strategy is to signal at as low a rate as possible that is still too high for one with less of that resource to maintain. Fierce competition can force the signaler to signal at the maximum rate, which is the rate at which it is just marginally more beneficial to signal than not to. Signals that employ strategic costs are unambiguous signals of that resource.

Efficacy costs are the costs needed to make the signal perceptible. They can provide important information about the signaler's level of need or motivation. An example from the animal world is begging baby chicks: the ones who beg loudest, paying the highest energy costs, are presumably the hungriest: the hungry ones stand to gain the greatest benefit and therefore would be willing to pay a higher cost (Godfray 1995; Hasson 1997; Vehrencamp 2000). Efficacy costs do not relate directly to the quality that is being signaled, but are part of the general cost of producing the signal. They contribute to the honesty of the signal by amplifying it, making it easier for the receivers to perceive.

However, it is important to note that efficacy costs can create ambiguity: if some chicks are more energetic than others are, a less hungry but stronger chick might beg louder than its hungrier but weaker sibling might. We will refer to these efficacy costs as *indicators of need* in cases where they indicate the importance the signaler places on another signal.

Understanding people's motivations is often a matter of understanding what costs they are paying as efficacy costs vs. strategic costs. Let us take the example of a woman who is wearing very stylish and expensive high-heeled shoes. These are an index signal of being in style – of having a certain taste and knowing what is in fashion this season. They are also a costly signal of wealth. And they are tight, pointy and difficult to walk in, so the wearer is paying a cost in terms of comfort. In our culture, it is unlikely that the discomfort is meant as a costly signal of the ability to bear pain; it is more likely to be an indicator of need, showing the value she places being in style⁶. The expense of the shoes is more ambiguous: it can be a costly signal of wealth and/or a further indicator of need. The office worker who spends a hefty percentage of her salary on a pair of stylish shoes may be deceptively indicating wealth – or honestly signaling that she places a very high value at being in style.

⁶ Certainly there are arbitrarily uncomfortable articles of clothing that are indeed meant as signals of willingness to endure pain and hardship, but for high heel shoes, which project an image of pampered luxury, the interpretation of discomfort as an indicator of the value placed on the other signaling functions of the shoe, rather than as a signal of stoicism, seems correct.

4.2. Benefits to the signaler

Signalers accrue both *signaling benefits* and *functional benefits*. Signaling benefits are the benefits the signaler gains by changing the receiver's beliefs or actions. These are the goals of signaling, e.g. increased status in the receiver's opinion, successful courtship, scaring away a predator, getting a job. Functional benefits are the personal enjoyment (hedonic) and utilitarian advantages that are part of the signaling behavior. E.g. signaling wealth by driving an expensive sports car can be fun.

Some actions are purely communicative. A vervet's alarm call or a person's speech is a communicative act with little other motivation. Other actions are mixed, with some signaling component amidst other functional motivations (Lotem, Wagner, and Balshine-Earn 1999). Erving Goffman's classic sociological study of impression management, *The Presentation of Self in Everyday Life*, opens with the story of Preedy, a vacationing Englishman who is at the beach, about to go in the water. The passage details his thoughts about what impression he hopes to make on the other sunbathers by the way he enters the water. How can he appear carefree, confident, and athletic? Certainly, one can walk from towel to ocean with the sole purpose of going for a swim, yet it is also possible that the desire to make an impression on others, to signal one's physical fitness, energy, etc., motivates such a trip. Preedy's walk to the water has signaling benefits – he (presumably) makes a favorable impression on the other beach-goers; it also has functional benefits – he is enjoying a sunny seaside day.

It can be difficult to ascertain the ratio of signaling to functional benefits in any action that involves both communication and utility, for it depends on the internal state of the actor. Two people can perform the same action but with different motivations: Jake may be walking down the street in t-shirt to show off his muscles while Jack is doing the same thing because it is a warm day and he's on his way to the store. People often endeavor to minimize the impression of the signaling benefit they hope to derive from their actions: we claim to wear our clothes because they are comfortable, not because we want other to think we are cool; we say we contribute to a charity because we want to help, not because we want others to think of us as generous. We sense that others will discount the sincerity of the signal if they believe its intention was to influence the opinions of others.

4.3. Benefits to the receiver

For a signaling system to be stable, the receivers as well as the signalers must benefit. Their benefit comes from heeding the signal and subsequently modifying their beliefs and actions based on this new information. The lower status sparrow who is about to eat a seed benefits from recognizing the high-status markings on an approaching bird's breast; he gives up the seed and avoids an unpleasant fight. Receivers who do not believe that heeding a signal will be beneficial (usually because they do not think it is honest) will ignore it. If receivers consistently ignore a signal because it is deemed unreliable, the signalers will stop sending it, since they receive no benefit to offset their costs.

Like the signaler, receivers get both signaling and functional benefits. The signaling benefits derive from the increased knowledge about the signaled quality and the

benefits of subsequent behavior or opinion modification. The functional benefits are the personal enjoyment and utilitarian advantages that come with experiencing the signal: if George takes Mary to a fine restaurant to signal to her his good taste and interest in a relationship, she gets, along with this signaled information, a nice dinner.

As with the benefits to the signaler, where there are mixed signaling and functional benefits for the receiver, the ratio of their value may be ambiguous. Is Mary happy to accompany George because she enjoys his company or the steak? A signal with functional benefits for the receiver may work to the advantage of the signaler, by giving the receiver added incentive to pay attention to the signal (Roberts 1998). However, it also raises the possibility of exploitation: a receiver with little interest in the signaled information seeking a signal to obtain the functional benefits. [We will look in greater detail at disentangling the functional and communicative components of such signals in the chapter on gifts.]

4.4. Costs to the receiver

For all signals, receivers pay some assessment costs, analogous to the production costs borne by the signaler. These are the costs in time and resources required to pay attention to the signal, as well as the risks involved in doing so. Some may be minimal – a brief glance at an outfit or expression – while others take significant time. In the animal world, courtship songs or dances help the receiver to assess a potential mate’s fitness, but the time spent watching and listening is time not spent seeking food and may also increase the risk of predation for all. Humans can spend days deciding if a dating site profile signals an appealing personality; in person, they may spend years assessing whether someone will be a good lifelong mate. Acquiring the knowledge required to interpret and evaluate a signal may also be costly. If I am trying to determine whether an applicant for a highly specialized job is qualified, I must have invested a considerable amount into having the knowledge needed to make that assessment.

Receivers also potentially pay the cost of heeding a dishonest signal, which can range from mild to fatal. If receivers know that believing a particular signal will be very costly if it is dishonest and that encountering a dishonest signaler is likely, they may choose to ignore or disbelieve the signal, rather than risk the costs of being deceived. People are normally willing to accept the ID and uniform of a gas company meter-reader as a sufficiently reliable signal that the person at the door is indeed an employee of that company come to read the meter. But if attacks by fake meter-readers have occurred in the neighborhood, people will be far more cautious about looking for a very reliable signal of identity before letting the presumed gas company employee in to the house. They will be willing to take on higher assessment costs in order to ensure greater reliability in the face of greater risk.

4.5. The costs of dishonest signaling

Dishonest signaling imposes costs on both the receivers, who get bad information, and on the honest signalers, who find that they are no longer considered credible or that they must pay higher costs to satisfy suspicious receivers.

Dishonest signaling occurs when its benefits outweigh the costs. Previously reliable signals can become unreliable if the benefits increase or if new inventions make the cost of producing the deceptive signal lower.

4.5.1. Changing signals to assure reliability

One outcome is that society -- i.e. other, honest signalers and potential receivers -- imposes external costs on dishonest signaling. Twenty years ago, you could board an airplane with just a paper ticket and no identification. Today, your ID is rigorously checked and ever harder to fake biometric identification techniques are being developed. Today, the effort required to board an airplane under a false name is far higher -- and the cost of being an honest traveler is also higher.

Once a signal becomes unreliable, another possible outcome is that the signal loses its meaning, and the honest signalers find some other, more reliable way to convey the quality. Store-bought shoes once signaled membership in an elite, upper class; once changes in manufacturing made them easy for even poor people to obtain they ceased to signal wealth. There were, and are, innumerable signals of wealth, but the fact that your shoes are store bought is no longer one of them.

Unreliability is inherent to fashion signals. When a fashion is new, only those at the forefront of that domain adopt it. But the fashion soon spreads to more conservative and less well-connected people. The item or behavior soon ceases to signal the information prowess it once did. Department store bargain bins are filled with merchandise that once signaled being in style, but which became widely copied and ceased to signal social status or special knowledge. Fashion signals function in a cycle of imitation and diffusion: there is relatively little policing of the signal and instead a rapid and continuous evolution of forms. What distinguishes them from simply a change in signal use is that their purpose is to indicate social knowledge and position -- the signal's ceaseless variation is essential to its function. The abandonment of yesterday's now widely imitated signal is part of the fashion process.

4.5.2. Imposing punishment to assure reliability

Another possibility is for the receivers or the honest signalers to impose additional costs on the dishonest signaler. These *punishment costs* can rebalance the equation so that dishonest signaling ceases to be beneficial and the signal can retain its meaning. This is the primary means for keeping conventional signals honest and is a supplemental cost for indices or handicaps when needed.

There is evidence that punishment for deceptive signaling occurs in the animal world (e.g. (Hauser 1992) though proof of its existence is difficult to make (Maynard Smith and Harper 2003). In a study of house sparrows, lower status birds with small badges were painted with shoe-polish to have the large badges of high status birds. The painted ones were initially treated as if they were indeed high status

birds, but upon being challenged and found to be actually less fit, they were subject to a great deal of aggression by the other birds (Møller 1987; Rohwer 1977) ⁷.

In the human world, there are abundant examples of punishment for deceptive signaling, both informal and institutional. This had made it possible for us to develop a rich, expressive and rapidly adaptable vocabulary of conventional signals. And, for a species with an extraordinary ability to circumvent the costs keep assessment signals reliable, they provide a means to rebalance the costs and benefits, and retain a useful signal's meaning.

However, imposing punishment costs on transgressing signalers is not free for the irate victims. *Policing costs* are the costs incurred by those who take on the task of punishing the dishonest signaler. It takes time and energy. And, the punisher incurs risk of retaliation: a dishonest signaler may attack in return, whether with physical force or counter-accusations.

In the domain of human communication, understanding punishment and policing costs is very important since many signals are not inherently reliable and rely on social forces to maintain honesty. Arguably, the ability to effectively impose punishment was necessary for the evolution of human communication as we know it, with its often efficient, adaptable and expressive but not inherently costly forms.

Yet there is a fundamental motivational question about people's willingness to incur policing costs in order to punish transgressors. Society as a whole benefits when deceptive signalers are punished, but what motivates individuals to do this policing? Often, they are not likely to benefit from it personally or immediately, and they may not have been the actual victim of the deception. Why take on the costs of policing when the personal benefits may be low? This is the puzzle of *altruistic punishment*.

Certainly, such punishment does occur – it is done in all societies, big and small and it occurs at both the personal and the institutional scale, ranging from disapproving gossip to penal codes. Theoretical models of social interaction show that cooperation dwindles away in the absence of altruistic punishment (Fehr and Gächter 2002); especially with larger groups, willingness to altruistically punish transgressor is essential for maintaining society. Yet until recently, it was difficult to explain why individuals would choose to take on this task. How could society be dependent on a behavior that seems to defy our understanding of motivation?

It turns out that punishing social defectors is not in fact an illogical form of self-sacrifice: there are strong emotional benefits to punishing social defectors. Recent neurobiological studies (Quervain et al. 2004) have shown that imposing effective punishment on those who have abused trust activates the dorsal striatum, a part of

the brain that creates the sensation of reward from achieving a goal. Furthermore, people who experienced stronger activation of this region were willing to incur higher costs in order to punish defectors. There is a strong emotional benefit to policing, arguably sufficient to overcome the costs. Evolutionary simulations show that populations that include members who were thus inclined toward “altruistic” punishment could lead to relatively large, stable and cooperative societies (Boyd et al. 2003; Fehr and Gächter 2002).

4.6. Costs and benefits are both extrinsic and intrinsic

The costs and benefits that determine the reliability of our communication come in many forms. Some are externally visible and quantifiable, such as spending time and money. Others are internal and psychological. There are strong social rules about acting deceptively and the act of breaking such rules can be very emotionally unpleasant, enough in itself to deter many people from lying.

All costs and benefits are subjective. A purchase may have an objective monetary price, but the marginal cost for a wealthy person is less than for a poor one. Furthermore, people place different value on their money and time. (Zelizer 1997).

Internal costs and benefits are also significant. While punishing social defectors is costly if we only factor in the externally visible costs, controlled experiments and neurological studies have demonstrated that people do derive satisfaction from doing so. Similarly, cooperating and working with others can be emotionally rewarding in itself. This too is now corroborated by studies showing patterns of neural activation that make cooperative behavior inherently rewarding and that may inhibit the impulse to exploit others by accepting but not reciprocating helpful acts (Rilling et al. 2002). In analyzing the dynamics of signaling, it is important to account for the emotional costs and benefits as well as the visible and material ones.

5. Interpreting signals

Thus far, we have spoken of signals as being honest or not, and of receivers believing them, or not. The implicit assumption has been that everyone understands the signals to have a certain meaning. Yet communication is more complex than that. Misinterpretations are common. Cultural signals can be subtle, context dependent and highly changeable over time. Receivers may ignore or disbelieve a reliable signal because their understanding of the factors guaranteeing its honesty may be imperfect.

In order for a signal to have its intended effect, the receiver must both understand and believe it. We say that a signal has been *understood* when the receiver’s interpretation of the signal is what the signaler intended; if they differ, we say that the signal has been misunderstood. We say that a signal has been *believed* when the receiver assesses it to be true; if it is assessed as false, we say that the signal has been disbelieved.

If I smile to indicate that I am happy, and you think I am signaling happiness, then the signal has been understood. If I smile to indicate ironic detachment, and you interpret it as intending to indicate happiness, then the signal has been misunderstood. In either case, the signal may be believed or not: I may smile to

indicate detachment, while you may (mis)understand it to signal that I am happy and you may not believe that I am happy. Here the signal has been misunderstood and disbelieved (although, as can happen, the receiver's comprehension of the signaler's state may be correct in this case, as the disbelief offsets the misunderstanding, though they mistakenly think the signaler was being deceptive). A receiver's assessment is correct upon understanding and believing an honest signal or not believing a dishonest one.

Both honest and dishonest signals can be understood or not, and believed or not.

For a receiver to learn something new and true – to learn of some quality - from a signal, the following must all occur:

- **The signal must be honest**
- **The receiver must understand it.**
- **The receiver must believe it**

If any one of the above three requirements does not occur, the receiver's assessment of the quality will be wrong: i.e. believing a dishonest or misunderstood signal or not believing an honest signal.

If the receiver misunderstands the signal, then at best nothing is learned and at worst something wrong is learned. While we can imagine anomalous situations in which someone misunderstands a false signal in such a way that they end up believing something true, or misunderstands a true signal and correctly not believes the misinterpretation, in these cases they still have an incorrect assessment of the signaler's veracity

In the domain of biological signals, most research has focused on the honesty of the signal and the receiver's belief in it. There is also a substantial body of work on signal efficacy – on the design of the signal so that it can be perceived (Guilford and Dawkins 1991; Hauser 1996) Relatively little has addressed the process of understanding that is central to communication.

Although animal cognition and communication is a very active research area (Hauser 1996; Hauser and Konishi 1999; Maynard Smith and Harper 2003; Searcy and Nowicki 2005), our understanding of animal communication and consciousness is still quite primitive. If an animal ignores a signal, is it because it was not believed? Not understood? Not even noticed? It is difficult to tease apart the subtleties of why an animal responds in a particular way, and thus models of animal communication

have focused on the overall effect of the signal rather than on the actual process of signal cognition.⁸

Our understanding of human cognition is far from complete. Intense controversy surrounds such topics as what is learned vs. what is innate (e.g. (Pinker 1994, 2004). But it is far deeper that our understanding of animal consciousness and communication; here we can distinguish, at least conceptually if not in every individual examples, among perceiving, understanding, and believing.

6. Signaling among people

Signaling theory was developed by biologists looking at animal communication. Animal signals are commonly assessment signals, either handicaps or indices, and much of the biologist's research focused on these types of signals.

The signaling theory model certainly holds for human communication, for it is about the general economics of signal reliability, not the specific form of the signal. But an analysis of human social interactions needs to take into account the big differences between human and animal social conditions, mental capabilities and personal goals.

Signaling among humans differs significantly from animal signaling. Conventional signals are very common. So is deception, both because of the prevalence of low-cost, unreliable signals, and because of human ingenuity in finding ways to cheat. Humans also signal about different things than animals do (though the basic messages of "I'm really strong. Go away" and "I'm quite attractive. Come here." occur across all species). In the human world, most signals arise in a process of cultural, rather than biological,. We can create new signals deliberately and consciously and we can bring our complex social coalitions and institutions to enforce social norms.

Signaling theory is becoming increasingly influential among anthropologists studying human communication (Cronk 2005). Rebecca Bliege-Bird and her colleagues look at rituals such as extravagant feasts as costly displays of hunting prowess (Bliege Bird, Smith, and Bird 2001; Bliege Bird and Smith 2005). Richard Sosis explores the self-sacrifices involved in religious commitment as costly signals that ensure the trust needed to sustain a cooperative community.(Ruffle and Sosis 2007; Sosis 2003, 2009). The sociologist Diego Gambetta also uses signaling theory to understand trust, but his domain is the criminal underworld – how can people known to be untrustworthy, and for whom law enforcement is predation, not protection, establish enough trust to work together (Gambetta 2009). Their

⁸ See (Hauser 1996) for an excellent model of the process of how communication occurs – what are the necessary conditions in sender, receiver and environment, for information to be transferred. (Maynard Smith and Harper 2003) also discuss the problem of knowing what animals understand and how they come to learn it, as an issue within signaling theory.

accounts shed light on what otherwise seem like irrational and behaviors – hunting difficult and dangerous game when trapping small animals and gathering vegetables provides greater nutrition, spending enormous amounts of time in religious services and wearing esoteric clothing - showing that instead they are important communicative strategies.

The key features that distinguish signaling among humans from animal's are:

- **Many human signals evolve culturally, and thus can change rapidly**
- **Humans have the social institutions to enforce norms, making conventional signaling viable**
- **Humans are ingenious and can find myriad ways to fake seeming reliable signals**
- **Humans signal about different things, including knowledge**
- **Humans can design their own communication systems, deliberating creating new types of signals**

I discuss each of these briefly below.

- **Rapidly changing cultural signals**

Many human signals have evolved culturally rather than genetically. Culturally evolved signals are dynamic – they can arise and be adapted to very quickly. There is cultural learning among animals, but it is far more limited than human learning (Hauser 1996; Oliphant 1999).

Humans have the cognitive ability to learn an immense number of signals and to adapt as they change over the course of our lifetime. We can create arbitrary signals and learn their meaning through deliberate explanation, rather than the slow process of genetic variation.

In the human world, the meaning of a signal is often dynamically changeable. Different cultures have different norms for behavior, and the same action that signals polite deference in one culture may be interpreted as strange subservience in another. Subcultures define themselves with distinct styles, the nuance of which may be undecipherable to outsiders. To a teenage, knowing another teen's choice in music helps to place the latter within a complex grid of cultural claims and beliefs: these choices encode attitudes about sex, drugs, gender, race etc. But to an outsider, the meaning is opaque. Rapidly changing displays of fashionable information can maintain status within groups.

As we look closer at human signal, questions arise about how we come to understand a signal. How does a signal acquire its meaning? How do the recipients and other observers come to comprehend it? Both humans and other animals

signal to indicate membership in a group, but only humans (perhaps) who do so by inventing esoteric signals that only the initiated can understand.

I say “perhaps” because our understanding of animal communication is itself limited. There may be types of communication occurring in many other species that we simply do not recognize. By reframing certain aspects of signaling theory to account for the complexities of human communication, we may also open fresh approaches to thinking about animal communication.

- **Sociability: Reputation makes conventional signaling possible**

Conventional signaling, while often unreliable, is widespread among humans. For it to be useful, we require not only the cognitive ability to create complex symbolic representations, as discussed above, but also the ability to impose social sanctions to keep these signals sufficiently reliably.

Humans can communicate information about reputation and have developed institutions for enforcing social norms. Thus, we can depend on socially imposed costs to maintain signal reliability to a much greater degree than animals can. This – along with our ability to think abstractly - has enabled the widespread use of conventional signals among humans. For instance, the license that says you may drive or perform surgery is a conventional signal; it has no inherent costs keeping it honest. We rely on policing by social institutions to maintain its reliability.

Because we have the ability to carry out “altruistic” cooperation and punishment, communicative signaling among humans is fundamentally different than among animals (Stevens and Hauser 2004). First, we have the cognitive ability for reputation based, institutional and long-term punishment: the punishment for an impermissible act may be removed in time and space from the act and be carried out by third parties or institutions. Second, people experience affective benefits to carrying out such punishment. Because we can establish such extensive social enforcement of norms, we can rely more heavily on non-costly signals, even in competitive situations. Such signals are not always honest, but the mechanisms exist for maintaining a sufficient degree of reliability.

Understanding the conditions that encourage cooperation within groups, and that maintain the reliability of signals has important ramifications for how we design online environments. The cognitive limitations that prevent animals from establishing strong reciprocity can become human limits when interacting in an environment with poor social design. If we cannot recognize individuals from one situation to another we cannot keep track of who is contributing and who is free-loading and we cannot impose community sanctions; similarly, if we cannot communicate with others in group, we cannot form a community.

- **Ingenuity: Humans can “stand on boxes”**

Humans are ingenious. We can often find a way to circumvent the costs involved in a seemingly reliable signal. The costs that guarantee honesty in the animal world often serve to slow down, but not stop, deceptive mimicry among humans. We have invented plastic surgery, luxury car rentals and elevator shoes.

There is little in the human world that can be considered absolutely reliable, especially if the rewards for successful deception are high. Even very costly signals need to be embedded within a social framework, which can add further costs to help ensure their honesty.

Signaling theory can help us disentangle ingenuity from fraud, ambition from deception. The theory itself does not provide an easy answer, but it frames the question in clarifying manner. For example, when is using performance enhancing drugs wrong? Many of us drink coffee, schools may insist that a child with attention-deficit disorder take stimulants, while athletic competitions ban many such drugs. Several drugs purport to enhance mental performance. Is it cheating when a student takes them to write a paper or take a test? Is it irresponsible if a researcher trying to cure cancer does not take them? Signaling theory requires that we articulate what exactly is the signal and what is the otherwise unperceivable quality it indicates; it requires identifying the costs and benefits to signalers, receivers, and other signalers. For athletes and test takers, it highlights that as a society we need to have a better understanding of what, actually, are the qualities we think or want these performances to signal – only then can we consistently and thoughtfully draw the line between well-prepared and unfairly advantaged.

- **Different types of signals: Signals of knowledge, information access**

Humans signal about different things than other animals do. Of course, many things are the same: like other animals, we signal our strength, status, and the features that make us attractive to potential mates. But humans also signal some things that are either unique to humans or are far more prevalent in human signaling. We signal creativity and artistic ability (traits we do share with a few other species, such as bowerbirds and songbirds), we signal complex social affiliations, and we signal our access to knowledge.

Knowledge, for example, is a resource, but unlike energy or other finite resources, use does not diminish it and the receiver may acquire it simply by perceiving it. The economics of such a resource are quite different, and, I will argue, give rise to a different type of costly signal; it is to signal access to knowledge that fashions arise, in such fields as clothing, music and academic citations.

- **Deliberately designed communication media**

Other animals have evolved communication strategies in response to the environment in which they find themselves. For example, bullfrogs have deep, low frequency voices that carry long distances across swamps (Hauser 1996). However, only humans invent and design their own communication environment.

Humans live in a constructed world. Our everyday interactions are a mix of the natural and the synthetic, of the long evolved and the recently invented. That we can speak at all is an innate ability; the language we speak in developed over thousands of years, the phrases we use may be this month's neologisms. Our appearance too is a combination of ancient structures and modern inventions, the genetic code that shapes our hairline and the cultural and technological developments that cause us to dye it hot pink.

Mediated communication is significantly different from face to face communication because the whole environment is constructed. Here, deliberate design decisions affect every aspect of communication: whether you communicate by typing or speaking, whether your comments are ephemeral or archived, whether you are communicating with one known person or a horde of faceless strangers. These design decisions deeply affect the dynamics of signaling; they determine everything from what will be reliable to how inventive the signalers can be.

In the few years since computers were invented and computational media became prevalent, we have seen an explosion of such environments, from email to massively multi-player games, from the real-times visibility of video conferencing to the slow rhythm and careful composition of blogs. Each of these supports a different ecosystem of identities, cues, and signals; each produces a different culture.

While humans have long been able to invent new signals, it is only recently that we have been creating wholly invented contexts for our communication. Understanding how these designs affect signaling is essential for explaining why certain designs result in certain types of interaction, and for designing compelling and successful new spaces.

7. Applying signaling theory – some examples

Applying signaling theory is both art and science. It involves making a hypothesis about what the signaler is attempting to communicate and assessing the veracity of that claim; it involves analyzing the multiple costs and benefits of both signaler and receiver. It is a valuable tool for understanding cultural evolution and social communication, for it requires thinking precisely about the motivations, intentions, and abilities of the participants in the interaction.

This section looks at two social signals – gang tattoos and suntans – and shows how signaling theory can elucidate how and why they are used, and the cultural forces that affect their meaning.

7.1. Gang tattoos

Gang tattoos are signals of membership in a certain gang. By publicly proclaiming this affiliation, they bring the benefit of that community to the wearer: members of the gang will stand up for each other and the wearer of the tattoo can walk the neighborhood with the implicit strength of the gang in support.

The gang tattoo is a reliable signal, with many costs. Tattoos have some production cost, for they are painful to obtain. Yet that cost alone is not what keeps them honest – indeed many mild-mannered office workers today sport more extensive and painfully obtained body art. More importantly, a gang tattoo has a high opportunity cost: it means being at odds with mainstream society. While these tattoos are not necessarily big or showy, they are often placed prominently, on the hands or face, places where it is impossible to cover them up; wearing these marks of gang affiliation make it difficult to get a job or live outside the world of the gang. Earning the right to wear the tattoo may mean having to have committed a crime in order to gain admission to the gang. And being in a gang is a responsibility: members have to participate in the gang's activities, back up other members. The tattoo also

increases its wearer's risk of assault from members of rival gangs. These costs, in terms of willingness to renounce mainstream life and to fight rival gangs, make the gang tattoo a reliable – and permanent - signal of membership. (Goldberg 2001).

Both inherent costs– it is painful and it places its wearer outside of mainstream society – and social enforcement maintain the reliability of the tattoo. Gang members will harshly punish someone they find falsely wearing their insignia.

Extreme circumstances can increase the benefit of the signal to the point where some deceptions occur. In prison, a non-affiliated inmate facing constant hostility and danger may decide that the protection offered by wearing an intimidating gang tattoo is worth the risks it entails. However, the cost of this deception to an honest signaler, that is, to an actual member of the gang, is also high, for they risk having to fight to defend someone who is not in fact entitled to the benefits of affiliation. Thus, the cost of punishment for deceptive signaling is extremely high: in prison, wearers recognized as pretenders have been ostracized or killed. (Hall 1997).

The gang tattoo is a signal of affiliation in a world of clearly demarcated boundaries. As a physical marker it is a conventional signal – anyone tattoo themselves with one of these patterns. But the risks and responsibilities it entails and its effective removal of the wearer from mainstream society makes it a very costly signal, one that few non-members would want, or dare, to wear.

Gang tattoos are reliable signals not only of the member's current affiliation with the gang, but also of their lifelong commitment to the gang. But several recent changes in the legal system, in medical technology, and in cultural mores are changing this signal's dynamics.

Legally, recent changes in some state criminal codes have made gang tattoos much more costly to the signaler by mandating harsher penalties when someone considered a gang member commits a crime. These are effectively “predation risks” for gang members: here, the “predator”, the unintended receiver, is the police, for who the tattoo functions of evidence of the wearer's illegal affiliation. This makes a publicly legible signal of gang membership less appealing; we would predict that gang members - at least in areas with these harsher laws - will develop more ambiguous signals that require subtler interpretation.

Medical advances are making the tattoo a less reliable signal of lifelong commitment. Laser tattoo removal makes it possible for the reformed gang member to eradicate these previously permanent signals of affiliation. This process is painful and expensive, but necessary for those who wish to leave gang life: a tattoo teardrop on one's face or a 187 (the California penal code number for murder) on one's hand make it very difficult to find work or be part of mainstream society.

Culturally, tattoos, which have always been a marker of marginalization, have become very popular and what was once stigma has become mainstream. Simply having a tattoo is no longer indicates the alternative and alienated; those who want to signal those traits must choose increasingly extreme representations. Gang tattoos, with their real repercussions from both gang members and police, remain one of the last forbidden zones, tempting for those who seek to both shock and

attract danger. Paradoxically, this cultural development may help keep actual gang members out of trouble, by providing a plausible scenario for claiming that while they have the tattoos, they were just posing.

[See (Gambetta 2009) for an in-depth examination of signaling in the criminal underworld].

7.2. Suntans

The gang tattoo, though its reliability and desirability are changing, has remained fairly stable in its form and meaning. Sometimes, however, cultural changes transform the meaning of a signal.

In pre-industrial Europe, much lower-status work was outdoor labor, and these laborers had the resulting dark tanned skin. Pale skin signaled wealth and refinement. Ladies wore broad-brimmed hats, carried parasols and took great care not to be colored by the sun. In the 19th century, labor moved into factories and offices and pale skin, a sign of a life spent toiling indoors, became common among the working class. Being tan required time in the sun, time that only the leisured would have. Signaling theory (and Veblen) would predict that fashion in skin coloring would switch, reflecting the changing cost of time spent indoors or out.

Pale skin had been a signal of refinement for centuries and the fashion for tanning lagged several decades behind the move to indoor labor. In the 1920's, when pale skin was still in fashion, Coco Chanel returned from a vacation and cruise in France with a (probably accidental) tan which is believed to have catalyzed the shift in signal form from pale to tan as the costly indicator of a leisurely life. Over the next several decades, tanning became increasingly popular and tan skin became a signal not only of leisure, but of overall health and attractiveness.

By the 1970's, millions of people lay out in the sun clad in only the most minute of outfits, covered their skin in oil in order to tan better, and sometimes used aluminum reflectors to increase the sunlight reaching them. However, by the 1980's it became increasingly clear that a tan was far from healthy: rates of skin cancer increased markedly and the correlation between tanning, disfigurement, and death became clear.

Here we have a fascinating, if disturbing, example of the subjectivity of signaling costs and benefits – and of the very high value people put on signaling. Many doctors thought that once people realized that sunbathing could lead to melanoma, they would avoid tanning. But this did not happen. People continued to flock to the beaches. While this could be attributed to the accompanying functional benefit of enjoying the sand, sun and waves, this does not explain the many people who

continue to go to tanning salons, spending hours lying under ultraviolet lights, a process with none of the beach's hedonistic pleasure.⁹

Public health workers have been campaigning for years to get people to stop tanning by telling them of the dangers of skin cancer, but have had very limited success. Greater knowledge of the dangers of tanning has a mixed effect on modifying people's behavior (Balanda et al. 1999; Branstrom et al. 2001). For some, the knowledge that tans can lead to cancer has led them to stop tanning entirely. Yet many ignore the warnings and continue to tan. Signaling theory can help us understand this seemingly irrational behavior: for some, the dangers of tanning may contribute to its value as a signal.

Tanning correlates with a high level of sensation seeking: people who seek out risky behaviors, it turns out, are more likely to not only to sunbathe, but also to go to tanning parlors. This was discovered in a study that had sought to show the opposite – the researchers sought to prove the hypothesis that thrill seekers would avoid tanning parlors, with their hours of passive lying in a ultraviolet bed, but instead found that they gravitated to them (Armes 2002). This seeming paradox makes sense if we look at it in terms of signaling.

Health, vitality, and youthful appearance are resources. Being tan shows that you are willing to risk those things: that you are so young and beautiful and have so much robust good health that you can afford to waste some of it. We see this in adolescent disdain for covering up in wide brimmed hats and in the perception that high SPF lotion is for those who are afraid. Today, while a tan is no longer a reliable signal of leisure and wealth, it functions as a signal of being carefree and robustly impervious to danger.

Researchers have found repeatedly that although some people modify their behavior upon understanding the risks of sun-tanning, a large percentage do not. The attempt then has usually been to make the warnings stronger, or combine them with other types of warnings, i.e. not only does tanning raise your likelihood of getting cancer, it makes you as wrinkled as a prune, which has also proved ineffective. If the signaling model is correct, for some people, the warnings may be part of the problem. They simply reinforce the appeal of the tan to those who see being pale, covering up, and slathering on protective lotion as a cue that one needs to be fearful for one's health and unwilling to take risks, while bronzed skin signals

⁹ Indeed tanning is one of the few domains where people's behavior clearly indicates their different personal weighings of the different costs and benefits. The person who goes to the beach slathered in 40 SPF sunscreen is seeking the functional benefits of the beach and not signaling benefits (or costs) of tanning; the person who goes to the salon is seeking to produce the signal of a tan and willing to put up with the costs in time and discomfort; the person at the beach with minimal sunscreen is seeking to enjoy both functional and signaling benefits

being so robust, healthy and full of youth that one can afford to squander some youthfulness and health.

If this is the case, it has important implications for how to persuade people not to engage in risky behavior such as tanning – or any of a number of other activities such as smoking, unsafe sex and hazardous driving. If we assume that people behave rationally, that is, they act in their own self-interest, the challenge is to understand what the individual's personal and subjective worldview is that leads to a particular belief or action. This worldview determines one's personal economics, i.e. one's assessment of the costs and benefits of a particular action. If one's personal economics includes a desire to signal imperviousness to risk, then it becomes possible for some behaviors, such as sun-tanning, smoking and wearing certain tattoos, to be glamorous not in spite of the risks but because of them.

This example highlights the importance of understanding the dynamics of signaling in order to understand behavior. As noted by Veblen and Zahavi, seemingly irrational behaviors make sense once we see their costs not as unpleasant and preferably avoidable downsides to some activity but as essential means for assuring the reliability of a communicative signal.

7.3. Signaling theory explains irrational-seeming human behaviors

8. References

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