Signals, cues and meaning

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, wrinkled hands a signal of age, 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 be a signal of hunger or of politeness and 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. Others signals are less reliable and can be imitated by those who wish to give the impression of having the quality, without actually possessing it. Most people wearing wedding rings are indeed married, but an unmarried woman may choose to wear one to signal 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 can be tolerated 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 unevenly matched, 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. But even within cooperative relationships there are conflicts of interest about how plans and identity are perceived: 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. So, 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 how the advantages of greater reliability are balanced against 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. It is not always clear or universally agreed upon what a particular signal represents or what are the costs that might maintain its reliability. 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. Cues and signals

The first step in understanding the dynamics of signaling is to more precisely define 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. Following the usage of (Maynard Smith and Harper 2003) we will use the term “cue” to refer to the more general set of things we perceive that indicate some other hidden state or intention and we will reserve the word “signal” for those cues that are intended to serve as communication.

Cues are "any feature of the world, animate or inanimate, that can be used … as a guide to future action” (Maynard Smith and Harper 2003). Everything that we use to infer a hidden quality is a cue. If the cue is *intended* to provide that information, then it is a signal. More precisely, a **signal** is a perceivable action or structure that is intended to or has evolved to indicate an otherwise not perceivable 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.

Many of the cues we use to infer hidden qualities are not signals. These non-signal cues are unintentional conveyers of information. I will be using the term **evidence** to refer specifically to unintentional cues. Evidence conveys information without this being the aim of the provider and it may be harmful to the person or animal producing this cue to have revealed it. The smell of CO_2 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.

A feature may act simultaneously as a signal and as an unintentional cue. A signal intentionally displayed for one receiver may be picked up as an unintentional cue 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 a person she hopes to impress, but this person may instead interpret the furs as evidence meaning that she is cruel to animals.

A signal that is poorly performed 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. The information the employee gleans from reading the iffy resume is not to the benefit of the signaler, but it is still a signal. What counts is the signaler's intention (or at least hope) that the signal would e advantageous..

Individual signals can be honest or deceptive, and as a type they can be reliable or unreliable. An **honest** signal is one that is intended to indicate a particular quality and that quality does indeed exist within the signaler or the environment. A **deceptive** signal is the opposite: it is intended 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. 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 requirement that a signal be intentional, whether from conscious intent or evolved purpose, means that producing it must be beneficial for the signalers, for if it is not they will cease to produce it. It also means that the receivers of a signal must also benefit from acting upon it, or they will come to ignore it. Heeding an honest signal is usually beneficial to the receiver, for decisions made with greater information are generally better than those made with less. Honest signals thus benefit both the signaler and the intended receiver.

Deceptive signals are usually harmful to the receiver, for decisions made with false information are generally worse. If a signal is not reliable – if it is given sometimes by honest signalers, but sometimes by deceptive ones – the receivers may sometimes pay a high cost for heeding it. If a signal becomes too unreliable, i.e. it is often deceptive, the receivers will come to ignore it. Deceptive signaling thus harm not only to the recipients of the signal, but also the honest givers of that signal because it causes receivers to doubt and ignore that signal. This is how deceptive signals undermine a signaling system.

Exactly how much dishonest signaling a particular signal can tolerate varies, depending on the cost to the receiver of heeding a dishonest signal and to the signaler of not being heeded. What is important to keep in mind is that signals work within an economy of costs and benefits, where adjustments in signal form and receiver behavior are continuously being made.

In the world of animal signaling, these adjustments are made 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 evolve[1]. Batesian mimics

[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

have the same coloring as the poisonous ones, but are palatable. If the population of mimics is small, a bird that bites a butterfly with the bright coloring is more likely to have a bad experience than a good meal and 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 and the cycle begins again. Compared with other traits, aposematic coloring evolves rapidly (Joron 2003), but the evolution of models and mimics still takes multiple generations.

The world of human signaling changes in a complex polyrhythm. Some signals, such as the facial hair that signals an adult male, evolve in biological time (though the cultural meaning of mustaches and beards can change over the course of a few years). Others take hundreds of years, such as the shifting pronunciations and usage that create separate regional accents, signals of geographic and social origins. And some vary quite rapidly, such as the ever accelerating pace of new music hits, signals of one's knowledge of the current 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 begin to understand how signaling influences cultural (as well as 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 sportscar. 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, it is not sufficient simply to have wealth or power; it is necessary to display them. And he noted that such displays must be of actions or goods that went well beyond the practical, for were there a utilitarian reason for having or doing something, that alone could explain its existence. The seemingly irrationally excessive acts and expenditures he observed functioned, he proposed, as displays of status, wealth and power. The key idea in his theory was that their "wastefulness" was an integral part

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butterfly, has proven to actually be a case of Mullerian mimicry: apparently, Viceroys are not very tasty either. (Salvato 2001; Speed 1999)

of the display. In order for the display of goods or leisure to reliably indicate wealth or status, it must be wasteful – there must be some cost associated with it that is 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 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 lion, 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 the reliability of the signal. 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. Such signals 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 byMesterton-Gibbons and Adams 1998). Yet the handicap principle, more clearly stated and formalized, has come to be 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. Today, it is widely accepted that such extra costs in signals are not simply wasteful, but instead function to guarantee their reliability.

Subsequent work has extended this theory. Guilford and Dawkins (Guilford and Dawkins 1993) 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. 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). In the next section we will look the main types of signals and how they maintain reliability.

3. Indices, handicaps and conventional signals

A signal will be reliable if it is beneficial to produce truthfully, yet prohibitively costly to produce falsely. How a signal is related to the quality that it indicates, whether there is an inherent connection between them or if they are arbitrarily linked, determines the

relative cost of honest vs. dishonest production of that signal. Understanding this relationship is the basis of signaling theory.

There are three main ways that a signal may be related to a quality.

3.1. Handicap signals

First, **handicap or costly signals** are signals that are costly to produce in terms of the quality being signaled. They are relatively more expensive for one who possesses less of the quality. The antelope wearing an immense rack of horns 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 often indicate the possession of some desirable resource, which the signaler has in such abundance that some can be wasted to indicate honesty. In the animal world, these resources are often strength and energy; in the human world money and time are also frequently displayed.

Costly signals allow a trade off between investing in signaling and expending that resource in some other way: the amount invested in the signal depends on the expected trade-off, 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 call strategic signals – their use can be adjusted according to overall economic strategy.

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 waste[2] 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.

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

[2] 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 perjorative sense, but instead as a contast 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.

3.2. Index signals

The second way a signal can be related to a quality is that the quality may be required in order to produce the signal. These are called **index signals**[3]. 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. While they are not costly for the honest signaler, they are prohibitively costly for the deceptive one.

3.3. Conventional signals

Third, a signal may be associated with a quality simply by convention. 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 be too high to make the convenience worthwhile. Here, the community provides punishment costs - in this case in the form of fines or jail time - which discourage deceptive signaling.

Conventional signals are found in the animal world. For example, some sparrows have markings that function as badges of status, signaling their place in the local hierarchy. There is no cost associated with these marking: they are not metabolically expense to produce nor do they increase the risk that predators with see the bird.

Conventional signals are very common in human communication. I may, for instance, choose to indicate that I am a serious bike rider by wearing a full outfit of cycling gear; but buying these clothes, while financially a bit pricey, does not require paying any costs in the domain being signaled, in this case of cycling prowess. Such conventional signals are not inherently reliable, and indeed there are novice cyclists and non-athletes who sport elaborate Tour de France outfits.

Conventional signals dominate online communication. Here, we use words to signal what would be immediately perceivable features in the face to face world. Age, gender, height, and hair color are known only through typed claims and fakeable photographs.

Although conventional signals are open to cheating, something must keep them sufficiently reliable to remain meaningful. 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, the signals would not convey information about the underlying

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[3] 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

quality. Since conventional signals have no inherent cost to keep them honest, what prevents there from being so many deceptive signalers that the signal becomes meaningless?

Some conventional signals are generally honest because there is little benefit to be gained from them producing 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 deceptively present themselves as supporters of candidates they do not like.[4]

However, if it is advantageous to produce the conventional signal dishonestly – for instance, displays of status can induce others to treat one with deference -- there will need to be some external force to keep deception in check or the signal will quickly become meaningless. Conventional signals can be reliable, provided there is a penalty imposed on deceptive signalers who are detected. The reliability of conventional signals is externally controlled by the punitive actions of those who are harmed by the deception. These include the receiver of the deceptive signal, other honest signalers who are defending the reliability and validity of their signal, other potential receivers of the signal, and the receiver's community of family, friends and other associates.

3.4. Reliability vs ingenuity

Conventional signals, with no inherent connection between signal and quality, are as easy to produce dishonestly as honestly; thus social sanctions are the only force that keeps them reliable. Index and handicap signals, by contrast, are inherently linked to the quality they signal; they are sometimes called assessment signals, for the form of the signal alone makes it possible to assess the existence of the quality. An index, because it is necessary for producing the signal, and a handicap, if sufficiently costly, are reliable because producing them deceptively is prohibitively costly.

However, in the human world, ingenuity often finds a way around the reliability that is seemingly ensured by index and handicap signals. When Maynard-Smith and Harper used the example of the tiger scratching high on the tree as their illustration of an index signal, they mentioned somewhat facetiously that the signal would cease to be reliable if little tigers figured out to stand on boxes. While such circumventions are uncommon in the animal world, they are ubiquitous in the world of humans. A winter tan is a costly signal of wealth and leisure, indicating that one has bountiful time and money, enough to

[4] Human signaling has layers of complexity unheard of in the animal world. We can imagine a repressive regime in which honestly signaling one's political preferences would be quite costly. Here, only a devoted dissident might signal honestly. And, 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 receive a benefit from the government rather than paying a cost for making a deceptive dissident signal. The point here is that the models of signaling economics become arbitrarily complex in the human world, given our ability to mentally model and 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).

vacation somewhere warm, sunny and far away. It signaled these traits reliably, until tanning parlors were invented and people with less time and money could also sport bronzed skin in winter.

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 creative design.

4. the costs and benefits of signaling

Why do some conventional, low-cost signals remain reliable, even though there seems to be little societal enforcement of their honesty while others, equally low-cost, are fiercely defended? Why do some difficult to copy indexical signals inspire huge industries of mimicry (In 2003 Americans spent an estimated $9.3 billion dollars on cosmetic surgery [ref])? What cues should the millions of people who attempt to analyze the veracity of online buyers, sellers, and potential life companions known only through the signal of their words and pictures be seeking? The answers to these questions are complex, and rooted in the particular conditions of each signal. But we can begin by looking at the basic equation of signaling theory, and then in more detail at the sources of the costs and benefits that make up the equation.

The fundamental equation of signaling theory 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 (Bacharach and Gambetti 2001).

4.1. Costs to the signaler

All signaling 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 very minimal. Some energy must be expended in the production and some other activity could have been pursued in that time.

Some signals involve *predation* or *risk costs.* These are the unpleasant effects of the signal being observed by am 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 policemen 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. Punishment costs are a risk only for dishonest signalers; if the risk of overzealous law-enforcement becomes a significant danger for honest signalers it can be classified as a type of predation. The role of punishment in maintaining signal reliability will be discussed in depth 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 also useful to classify the signaler's costs by their purpose into *efficacy costs* and *strategic costs* (Dawkins 1993; Dawkins and Guilford 1991). Efficacy costs are the costs needed to produce the signal so that it can be perceived. 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. Both strategic and efficacy costs affect signal reliability.

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. If competition is fierce, the signaler might be forced 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 or general costs are not directly related to the quality that is being signaled, but are part of the general cost of producing the signal. However, 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 (Hasson 1997; Vehrencamp 2000). Here, a cost unrelated to the resource being signaled constributes to the honesty of the signal. However, it is important to note that general costs can create ambiguity. If some of those chicks more energetic than others, a less hungry but stronger chick might beg louder than its hungrier but weaker sibling.

4.2. Benefits to the signaler

The benefits a signaler accrues can be divided into *signaling benefits* and *functional benefits.* The 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. The functional benefits are the personal enjoyment (hedonic) and utilitarian advantages that are part of the signaling behavior: 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, athletic? Certainly, one can walk from towel to ocean solely for the purpose of going for a swim, yet it is also possible that such a trip be motivated by the desire to make an impression on others – to signal one's physical fitness, energy, etc.

The ratio of signaling and functional benefits from any action in which there is an audience and thus the possibility of communication is ambiguous; it is a function of the internal state of the actor. People often endeavor to minimize the impression of 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), to contribute to a charity because we want to help (not because we want others to think of us as helpful). We sense that others will discount the action if it is believed to be performed in order 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 modifying their beliefs and actions; if they do not (or at least, if the signaler believes they do not) there will be no motivation for signaling. 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.

Like the signaler, receivers get both signaling and functional benefits. The signaling benefits are those that come to the receiver from the increased knowledge about the quality that was signaled and subsequent behavior or opinion modification. The functional benefits are the personal enjoyment and utilitarian advantages that come with experiencing the signal: if George is signaling to Mary both his good taste and interest in a relationship with her by taking her to a fine restaurant, along with this signaled information, she gets 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 very 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 either 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. This can occur with minimal cost, conventional signals, which have little inherent cost. It can also occur with costly, handicap signals if the benefit becomes great enough; or with index or handicap signals if some circumvention is developed and the cost of dishonest signaling diminishes.

Once a signal becomes unreliable one possible outcome is that the signal loses its meaning, and the honest signalers find some other way to more reliably convey the quality. 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. As will be discussed further in the chapter on fashion, there are a wide variety of signals, which we will term *fashion signals* which function in a cycle of imitation and diffusion: here there is relatively little policing of the signal and instead a rapid and continuous evolution of forms.

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. For conventional signals, this is the primary means by which they are kept honest; for indices or handicaps, this can add to the inherent costs of dishonest signaling when needed.

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, for 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 immediately or personally benefit from it, 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). Yet, while we can see from models of society that it is necessary and from observations of society that it occurs, until recently it was difficult to explain why individuals would choose to take on this task. Could society be so dependent a behavior that seems to defy our understanding of motivation?

The key to this puzzle is 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. In other words, there is an emotional benefit to policing, which can be sufficient to overcome the costs.

There is evidence that punishment for deceptive signaling occurs in the animal world, 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) [5].

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.

4.6. Putting it all together

We have now outlined the basic costs and benefits that form the dynamics of a signaling system. Such systems are stable, so long as the honest signalers and receivers benefit sufficiently and dishonest signalers are sufficiently rare. But the world is dynamic, and signaling systems are often in flux.

It is also important to keep in mind that these costs and benefits can be in many forms. Some are externally and quantifiable, such as the time a task takes or the monetary price of an item. But there is a strong psychological component to all these equations. I have thus far emphasized the neurological basis for imposing punishment because it is so fundamental for understanding human signaling. Yet all aspects of the cost/benefit analysis of signaling have emotional as well as economic components. Cooperating, working with others, can be emotionally rewarding in itself (Rilling et al. 2002): there are patterns of neural activation that make behaving cooperatively inherently rewarding and may inhibit the impulse to exploit others by accepting but not reciprocating helpful acts. There are strong social rules about acting deceptively and the act of breaking such rules can be in itself very emotionally unpleasant for some people, enough in itself to deter them. Even the seemingly objective costs, such as how much money something costs, have a significant subjective and psychological component: not only do people have differing amounts of money, they place a different value on it (Zelizer 1997).

Social signaling is inherently ambiguous. We cannot entirely disentangle the multiple things that a particular signal may indicate.

As we look at how the various costs and benefits of honest and dishonest signaling add up, it is important to remember that these internal affective responses are also a key part of such equations.

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. These issues will be discussed greater depth in the reputation and design chapters.

4.7. Applying signaling theory – some examples

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 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 be admitted into 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 – permanent - signal of membership. (Goldberg 2001).

However, 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 very 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: wearers recognized as pretenders have been ostracized or killed (Hall 1997).

Recent changes in the criminal code have made gang tattoos much more costly by mandating harsher penalties when a crime is committed by someone considered to be a gang member. These are effectively "predation risks" for gang members. The tattoo, which was not intended as a signal to the police, functions as evidence to them of the wearer's illegal affiliation.

A couple of factors, one technological and one cultural, are reducing the reliability of these tattoos. 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. At the same time, tattoos, which have always been a marker of marginalization, have become very popular. Simply having a tattoo is no longer indicates the alternative and alienated; those who want to signal those traits must choose increasingly extreme representations, which includes gang symbols. (Paradoxically, such a choice might keep the wearer out trouble, for their protection from the repercussions of being caught illegitimately sporting gang tattoos by a real gang member is their distance from that world; their protection from the harsh criminal penalties is the believability of their claim to have simply been posing).

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 can be tattooed 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. That there are occasional dishonest signals are indications that one is either in extreme circumstances (e.g. prison) or outside the cultural territory in which the costs of the signal are highest.

Sometimes, large scale cultural changes can change the meaning of signal. In pre-industrial Europe, lower status work was frequently outdoor labor and 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 (date, ref) in became increasingly clear that a tan was far from healthy: rates of skin cancer increased markedly and the correlation between disfigurement or death, and tanning, became known.

And 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 continue to flock to the beaches. And the appeal is not just the sand, sun and waves, for they continue to go to tanning salons, spending hours lying under ultraviolet lights, a process with none of the beach's hedonistic pleasure. Paradoxically, tan skin has become of signal of attractiveness closely associated with good health – although in fact it can lead to wrinkles and cancer.

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. Signaling theory can help us understand this seemingly irrational behavior. 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. Many ignore the warnings and continued to tan. And perhaps for some, the dangers of tanning 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 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, (Armes 2002) but instead found that they gravitated to them. This seeming paradox makes sense if we look at it in terms of signaling.

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 also makes you as wrinkled as a prune, which has still proved ineffective. If the signaling model is correct, the warnings may, for part of the population, be part of the problem. In a world view in which being pale, covering up, and slathering on protective lotion is seen as a cue that one needs to be fearful for one's health, that one is unwilling to take risks, while bronzed skin signals a being so robust, so healthy and full of youth that one can afford to squander some youthfulness and health, such warnings simply reinforce the appeal of the tan.

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 from smoking to 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.

5. Intention and interpretation

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 the signals have been understood by all to have a certain meaning. Yet communication is more complex than that.

The communication of a signal involves both intention and interpretation. A signaler may have intended to indicate a particular quality, but the receiver may misinterpret the signal. Cultural signals can be subtle, context dependent and quite changeable over time. Misinterpretations are common.

We say that a signal has been *understood* when the quality that the receiver interprets the signal to mean that which the receiver 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, and disbelieved when assessed as false.

A signal can be understood without being believed. If I smile to indicate that I am happy, and you interpret my smile as intending to indicate happiness, 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, you may 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.

Neither understanding nor belief necessarily means that the signal was actually honest or not. A dishonest signal can be communicated or believed, and an honest sign misunderstood or disbelieved.

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

The receiver's assessment is correct upon understanding and believing an honest signal or not believing a dishonest one. On the other hand, 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 does not understand 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

Most work on signaling theory has focused on the honesty of the signal and the receiver's belief in its trustworthiness. Relatively little has been said about the process of understanding that is central to communication.

Although animal cognition and communication is a very active research area (Hauser and Konishi 1999; Hauser 1996), our understanding of animal communication and

consciousness is still quite primitive. If a signal is ignored, 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 the more subjective subtleties of signal cognition.[6]

Our understanding of human communication is far deeper, and in discussing human signaling, we can look more closely at the process. Certainly there is still a great deal still to be learned here and there is intense controversy over what is learned vs. what is innate (e.g. (Pinker 1994 [1994], 2004). But we can easily distinguish, at least conceptually, if not always as the participants in a communication, among perceiving, understanding, and believing.

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

For example, cryptic acronyms have become ubiquitous in online communication. While their origin is partly due to technological constraints – typing is an effort, especially on a tiny telephone keyboard - they also function as demarcations of social boundaries. Those within the group understand them, outsiders do not. "LOL" indicates not only its direct referent, meaning "laughing out loud" which is a signal that the writer is amused, but also indicates the writer's claim to membership in a group that marks speech with such acronyms. Not everyone who sees this phrase will understand it: some may not know the expansion of the acronym and others may barely recognize it as a marker of social membership, let alone have an interpretation of its meaning as such. Among those who do interpret it as a social marker, the connotations vary: some may see it as a practical shorthand, some as a signal of cool informality, while others may view it as a cue that the writer is an unsophisticated consumer of jargon-filled chat culture.

The focus in this book is on design, on the culturally determined meaning of signals, and on how people adapt their communication strategies to changing circumstances. Thus, the issue of understanding the signal is central. Many signals of social affiliation, for instance, are opaque to outsiders, some deliberately so. As new signals are developed, it is important for us to understand how their meaning is transmitted.

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[6] 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.

6. Human signaling

The ideas in this chapter draw heavily from work done in theoretical biology, which often, though not exclusively, focuses on signaling among animals. Applying signaling theory to human communication requires some modifications, some different areas of emphasis.

People have the cognitive ability to punish remotely – we have memory and recognition and the ability to communicate. Our ability to carry out socially coordinated punishment makes it possible for us to rely much more heavily on conventional and other not inherently reliable signals. We are able to inventively circumvent the costs that keep assessment signals reliable – thus human signaling frequently take the form of an arms race between the inventive circumventer and the stabilizing punisher. We have "theory of mind" – we can imagine what another's world view of another is like and work to manipulate it. We have an immense capacity for learning, and so new signals and meanings travel as swiftly as their contemporary communication infrastructure will allow them to.

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