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Chapter 25: The Philosophy of Communication and Information

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Introduction

What is the relation between communication and information? At first glance, the answer seems straightforward. Communication occurs when a sender conveys information to a receiver. And information is what is being conveyed by a sender to a receiver. This is how human language, a paradigmatic communication system, appears to work. You ask your friend for the time and are told that it is 4 pm. It is natural to think that this is an instance of communication *because* your friend conveyed to you the information that it is 4 pm. The natural answer carries a long way, but not all the way.

This chapter discusses four issues that are central to our current understanding of communication and its relation to information. The first issue concerns the nature of communication. What is communication? The second issue is communication as a possibly distinguishing feature of humans. What, if anything, is communication in non-human animals? The third topic concerns the dynamics of communication. How can communication systems arise and how can they be maintained? The last issue is the relation between information and communication. How important is information to communication?

What is communication?

Some of the most influential views about the nature of communication originated from thinking about one particular communication system, human language. Philosophers of language are particularly active in attempting to determine the nature and mechanisms of linguistic communication. They commonly distinguish between the code model and the inferential model of communication. Some authors add two further accounts of communication, the signaling model and the extended senses model.

According to the code model, physical signals (lines on paper, sounds, and so on) are associated with distinct thoughts. A group of signals and their associated thoughts constitute a code. The code is shared between speakers and hearers. When a speaker intends to communicate her thought to a hearer, she first determines which physical signal is associated with her thought (encoding) and then sends that signal to the hearer. The hearer perceives only the physical signal. But he can retrieve the speaker's thought by determining which thought the code assigns to the signal he receives (decoding). The gist of the code model can be illustrated with conventional codes.

Suppose the captain of a stranded ship wants to communicate to a rescue aircraft that *it is probably safe to land here*. Luckily she remembers the international ground/air emergency code.

The code has a symbol with precisely that meaning (Δ, fig. 1). So she and her crew dig a Δ-shaped system of ditches in the sand. The aircraft pilot perceives only the shape in the sand. Yet, in virtue of consulting the same code, he retrieves the captain's belief that *it is probably safe to land here*. Communication has occurred.

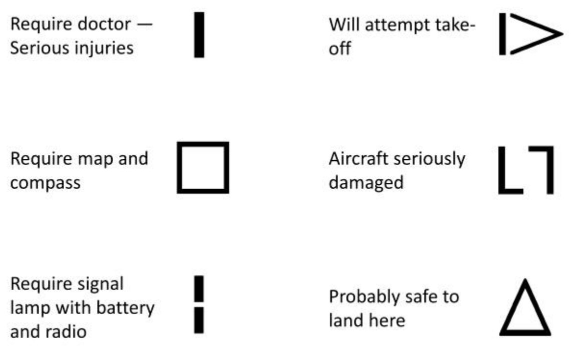

Figure 1: Some signals from the international ground/air emergency code.

The code model has informed much theorizing about human verbal communication. Until well into the 20th century, many scholars regarded spoken and written words as signals that are associated with specific thoughts. Speakers convey their thoughts by putting them into words and hearers apply a shared code to the speakers' utterances in order to retrieve the thoughts. The model is therefore very close to the intuitive view of communication sketched at the beginning. Communication occurs when a sender conveys a piece of information (meaning or thought) to a sender, and information is what is being conveyed. The code model adds to this view a claim about *how* the information is conveyed. Information is conveyed by means of a correspondence rule that assigns discrete meanings to physical signals (the code). Semioticians like Ferdinand Saussure (1916) sought to establish this account as a general theory of communication. The code model also underpinned important strands within modern philosophy of language (compositional theories of meaning) and linguistics (generative semantics).

The code model has a noteworthy consequence. It implies that language comprehension involves no more than recovering the linguistic meaning of a sentence (Bach and Harnish 1979; Sperber and Wilson 1995). This implication, however, is untenable. Consider the sentence

[1] "You will be here tomorrow"

The sentence has a linguistic meaning. It means, roughly, that the hearer will be where the speaker is now, at the time of utterance, the day after the speaker utters the sentence. Nevertheless, the sentence is referentially ambiguous. If Kate utters [1] to John in his office on 4 April, then the sentence conveys the thought that John will be in his office on 5 April. But if John phones Kate from his home on 30 April, then the same sentence conveys the thought that Kate will be at John's home on 1 May. So, in order to comprehend precisely which thought [1] conveys, the hearer must do more than merely determine (decode) its linguistic meaning. What is conveyed in these exchanges is more than what is linguistically encoded.

Moreover, suppose Kate utters [1] as John's line manager, intending to convey that John *ought* to be there. In this context, Kate takes the attitude of requesting or ordering towards [1]; uttering [1] is said to carry "illocutionary force". It is important to both John and Kate that her attitude is conveyed to John. But John will not understand that he has been given an order if all he does is to decode the sentence's linguistic meaning.

Finally, a sentence may not express the intended thought explicitly. When Kate says "Mary is always right" in an ironic tone, then that sentence implies Kate's belief that Mary is not always right (the implied thought is an "implicature"). Again, determining the sentence's linguistic meaning will not be enough for the hearer to grasp what the sentence conveys.

Many philosophers of language agree that these limitations render the simple code model inadequate as an account of human verbal communication. In response, many pragmatists seek to add a separate, pragmatic level of decoding. It remains controversial, however, whether rules of pragmatic interpretation can save the code model (Sperber and Wilson 1995). Let us now turn to the inferential account of communication.

According to the inferential model, the crucial elements in communication are intentions and inferences. The speaker has a thought she wants to convey and intends the hearer to figure it out. In human verbal communication, she provides evidence for her thought by uttering a sentence. The hearer tries to infer the speaker's thought by attending to her utterance, its contexts, and certain rules of conversation. Communication has occurred if he succeeds in inferring the speaker's thought.

Inferential models originated with a seminal paper by Grice (1957). Grice focused on the speaker's intention to convey something by uttering a sentence. He asked: under what conditions does the speaker "mean" something by making an utterance? According to Grice, a speaker S means something by uttering x if and only if S intends

(a) x to produce a certain response in a certain audience A,
(b) A to recognize S's intention (a)
(c) A's recognition of S's intention (a) to function as at least part of A's reason for A's response r.[1]

Suppose Kate wants to convey to John her belief that birds can fly and so she says "birds can fly". Kate intends (a) the sounds of "birds can fly" to produce in John the belief that birds can fly, (b) John to recognize her intention, and (c) John's recognition of her intention to be part of John's reasons for believing that birds can fly. Here the speaker-meaning of the sentence "birds can fly" matches its linguistic meaning. But the two can come apart. If Kate says ironically to John "Mary is always right", then she intends John to believe the opposite of the sentence's linguistic meaning.

For our purposes the main point of Grice's account of speaker-meaning is twofold. First, his account is widely taken as an account of communication. It is concerned with utterances, which are paradigmatic vehicles of human communication. Crucially, the account specifies the conditions under which utterances manage the feat of getting the hearer to entertain the speaker's thought. Second, grasping the speaker's thought relies on the hearer's inferential abilities. It relies in particular on the hearer's ability to infer the speaker's intention to convey a thought by employing her utterance as a piece of evidence.

Shortcomings of Grice's original analysis prompted many revisions (e.g. Bach and Harnish 1979; Avramides 1989). An influential account indebted to, but clearly distinct from, Grice's analysis is relevance theory (Sperber and Wilson 1995; Carston 2002). Relevance theory seeks to address the worry that understanding is often rapid and does not require a self-conscious process of inferential reasoning. Relevance theorists argue that understanding utterances is a sub-personal, computational process, rather than a high-level cognitive activity.

Human linguistic communication is now often construed along broadly Gricean lines. Contemporary pragmatists regard human verbal communication as involving features of both the code and the inferential model. There is, however, a third view of the nature of communication.

The code and inferential models can be seen as focusing too much on the speaker's mental states (Green 2007). On the inferential model, for instance, the route to entertaining Kate's thought that birds can fly goes through John's inferring that Kate *wants* him to believe that birds can fly. On the code model, John determines which *thoughts* are associated with Kate's utterance. Some philosophers emphasize that communication is less about gaining access to the speaker's mental states and more about gaining access to the speaker's perceptions of the world (McDowell 1980; Millikan 2004). If Kate phones John to tell him that an important letter has arrived, John learns something about Kate's intentions or her attitude towards the letter's arrival. But more importantly, he also gains access to a state of the world he presently cannot perceive himself. The primary goal of communication is therefore to "widen each other's perceptual reach" (Green 2007, p. 10). Green characterizes this view as a third model of communication, referring to it as the 'extended senses' model. It is unclear, however, whether this view constitutes a distinct account of communication or whether it merely represents a shift of emphasis (from speaker's mental states to states of the world).

Some philosophers distinguish a fourth account of communication, the signaling model (Bennett 1976; Green 2007). Since the signaling model aims to capture the ostensibly communicative interactions in non-human animals, it will be discussed in the next section.

Before turning to communication in non-human animals, it is worth noting that so far we assumed receivers to acquire the *same* thoughts as the senders. This is indeed a widely held view, although one generally accepted without much argument. Several philosophers endorse a less demanding view (e.g. Sperber and Wilson 1995; Carston 2002). On that view successful communication requires only some degree of similarity between the contents of speakers and hearers: for *A* to understand what *B* said is for *A* to grasp a proposition *similar* to the one expressed by *B*. There are several difficulties with the weaker view, however. For instance, it becomes difficult to make sense of the standard distinction between, on the one hand, saying or understanding exactly what someone said and, on the other hand, saying or understanding something similar but not identical (Cappelen and Lepore 2006).

Communication in non-human animals

This section explores the sense in which communication occurs in non-human animals. After introducing two ways of crediting animals with communicative abilities, the focus will be on the relation between animal communication and human language.

Human language takes pride of place in philosophical work on communication. Yet communication is arguably a much broader phenomenon. Biologists of all stripes agree that non-human animals can communicate. They point to the roaring contests of rival stags, the waggle dance of honey bees, and a panoply of other interactions in a wide range of species. An instance of animal communication that has attracted much attention is the alarm call system of vervet monkeys. Vervets can emit three acoustically distinct types of alarm calls in response to perceiving three classes of predators (snakes, leopards, eagles). Monkeys that have not perceived the threat but hear an alarm call respond as they would to the predator itself, e.g. run up a tree when hearing the leopard-specific alarm call. Vervets thus seem to warn one another about the presence of snakes and other predators. However, animal senders lack *intentions* to inform receivers. Even ardent defenders of the reality of animal communication admit that while senders emit signals that are meaningful and informative to receivers, there is no evidence that senders are in a psychological state of intending to inform others (e.g. Seyfarth and Cheney 2003). The lack of such intentions is problematic because it threatens to undermine the very idea of communication in animals. Recall that communication is often conceived in broadly Gricean terms, as involving a set of complex mental states, e.g. intentions to inform others and intentions for others to recognize one's intention. How can this tension be resolved?

One answer is inspired by an instrumentalist approach towards propositional attitudes. The instrumentalist approach is exemplified by Daniel Dennett's (1983) intentional stance. One takes an intentional stance towards a system if one explains and predicts its behavior by attributing to it mental states. Attributing mental states to a system can be justified simply on the basis of increasing explanatory and predictive power. Importantly, this practice is justifiable even if the system lacks the attributed mental states in any psychologically realistic sense. So, in the present context the crucial question is whether or not attributing complex Gricean intentions yields a significant epistemic pay-off. If it does, then it is reasonable to construe animals as engaging in strong, Gricean communication. Whether or not the intentions are psychological real is irrelevant.

Another answer is to allow that communication comes in different forms and that, furthermore, animals instantiate a comparatively unsophisticated variant. Several philosophers distinguish more or less explicitly between communication in a strong, Gricean sense and communication in a weak sense, as information transfer. Animals are then regarded as engaging in the latter but not the former (Bennett 1976; McDowell 1980).

Information transfer is the core of the fourth account of communication, the signaling model. On the signaling model, animals do not need to entertain communicative intentions, nor do they need to encode thoughts or extend each other's perceptual reach. They only need behaviors that have the evolutionary function to convey information (Bennett 1976). Bennett's version of the signaling model was broadened by Green (2007). For Green signals are structures designed for transferring information, where the design may be due to evolution *or* deliberate planning. Systems communicate with one another as long as they exhibit structures designed to convey information, whether the design is a due to a natural process or human deliberation.

The signaling model of communication resonates well with the sciences. In animal behavior studies, communication is normally understood as information transfer by means of signals (Bradbury and Vehrencamp 2011). Signals are structures or behaviors that evolved in order to convey information. The roaring of stags during the mating season, for example, is taken to have evolved in order to convey information to his rivals about the sender's fighting prowess. Signals are distinguished from cues. Cues convey information without having evolved for this purpose. The amount of time a starling spends foraging on a patch informs other flock mates about how much food is left. Yet foraging time has not evolved in order to convey information about how much food is left; it is simply a function of how readily the starling finds food.

However, the signaling model is much less straightforward than the slogan "information transfer" suggests. We will look in more detail at the role of information in communication below. As we will see, the status of information is unclear and partly contentious. Here I bracket these complexities and, instead, focus on the relation between human *language* and animal communication. This topic is important because even if one accepts that animals can communicate in some sense, there are significant differences between human and animal communication. Indeed, linguistic communication was for a long time seen as the distinctive mark of humans.

Philosophers like John McDowell, Robert Brandom, and Donald Davidson stand in this tradition. They see the differences between human language and animal communication as symptomatic of a fundamental discontinuity. The discontinuity has two aspects (Bar-On 2013a). One aspect is the gulf in communication systems among humans and current animal species ("synchronic discontinuity"); another is the impossibility of a philosophically illuminating account of the emergence of human language from non-linguistic precursors ("diachronic discontinuity"). The three philosophers do not deny that, since humans evolved from animals, our linguistic abilities have precursors in the sense of there being certain stages in language evolution that differ from our present state. Human language is not a miracle, appearing fully-formed out of nowhere. But attempting to trace those precursors is to stay within the descriptive realm of the natural sciences. And such descriptions cannot do justice to our linguistic practices, which are thoroughly normative. Their normativity surfaces in the rules that render the application of words to things correct and incorrect. McDowell (1980) therefore insists that our linguistic practices figure in "the logical space of reason", which is distinct from the logical space of the natural sciences. No list of human language precursors will bridge these two spaces. Human verbal communication is not an elaboration of animal communication.

Davidson (2001) and Brandom (2009) emphasize the (purported) inability of animals to form concepts. Davidson concedes that animals respond differently to the presence and absence of external objects and to the behaviors of others. Animals can also respond to another individual's behavior as they would respond to the object itself, as seen in vervets. There is even a possibility of error. A vervet, say, might run up the tree in response to a leopard-specific alarm call, although the sender has emitted the call by mistake (what looked like a leopard from the distance turned out to be an antelope). Yet these abilities are no more than the manifestations of dispositions and habits. Animals lack concepts of phenomena like truth and belief. They consequently do not treat the sender as a subject with its own point of view about the world, a view that may be true or false. Such an ability already requires possessing a language (Davidson 2001). There is then no intelligible intermediate stage between the non-linguistic, concept-free communication of animals and linguistic communication in humans. Again, the latter is not a more elaborate version of the former. Bar-On (2013a) calls the approach of these authors "continuity skepticism".

Continuity skepticism comes under pressure from two directions. One source of pressure are certain conceptual advances in economics and evolutionary biology. Evolutionary game theory, for instance, raises the prospect of naturalising the origin of communication systems. We will return to this topic in the next section. First we will look at the second source of pressure, i.e. the spectrum of empirical findings from linguistics and psychology.

Scientifically inclined theorists of language evolution tend to advocate a multi-component view of human language. "Human language" here refers to the internal (neural and psychological) faculty that allows humans to learn and employ culturally specific communication systems, such as Chinese or English. On the multi-component view, the human language faculty is composed of several partly independent subsystems. Each subsystem has its own neural implementation and function (e.g. Christiansen and Kirby 2003; Fitch 2010). Now, some components of the human language faculty are found in animal species, whereas others are not. We already encountered one of the missing components: the intentions on the part of senders to inform receivers (e.g. Seyfarth and Cheney 2003). Two other missing features are the possession of a large vocabulary (e.g. Fitch 2010) and, more controversially, "discrete infinity" (Hauser et al. 2002). Discrete infinity is the ability to construct and understand an infinite number of linguistic expressions, where the expressions are composed of a finite set of components. While animals lack these components of the human language faculty, others are present in at least some animal communication systems. One example is the ability to employ signals or expressions in order to refer to states in the environment. This is what the vervets appear to do when emitting a leopard-specific alarm call in response to a leopard (Cheney and Seyfarth 2007). Furthermore, animal receivers engage in inferences on the basis of perceiving a signal and their background knowledge (e.g. Fitch 2010). So, according to the multi-component view, there is not so great a gap between human language and the communication system that existed in the hominid lineage descending from our last common ancestor with chimpanzees. The gap was closed by piecemeal acquisition of the components that now make up the human language faculty.

Contemporary theorists of language evolution focus on the precise order in which our "proto-language" evolved from our ancestors. Some theorists argue that the evolution of sophisticated mental abilities preceded the evolution of linguistic expressions. These theorists maintain that a crucial first step was the evolution of the ability to form communicative intentions and the ability to attribute mental states to others (e.g. Fitch 2010). Recently, some philosophers have revived the hypothesis that language evolved from innate affective expressions, such as screams or sighs. On this account, fully-fledged communicative intentions were not preconditions for language evolution (Bar-On 2013b).

In conclusion, there is a remarkable overlap between animal and human communication, alongside the undeniable differences. Characterising this overlap, and tracing possible precursors of human linguistic communication, can illuminate the nature of human language itself. This undermines radical continuity scepticism. As indicated above, the continuity sceptic comes under pressure also from theoretical advances. The next section sketches some of these advances and explores their significance for our understanding of communication.

The emergence and persistence of communication systems

Suppose you want to establish a communication system. You start performing some actions in order to convey a thought, e.g. blow a whistle to convey “come over here!” You must get the prospective receiver to interpret your action as a signal. This is easy if you can tell him what the signal is supposed to mean, because you can then rely on a pre-existing and shared communication system. But it is hard to see how you could achieve this without telling him, or without employing some alternative means of communication. So, how can a system of signs emerge in the first instance? David Lewis (1969) answered this question by appeal to rational choice theory. More recently, philosophers have turned to evolutionary games theory. Both approaches suggest that communication systems can emerge, and be maintained, without prior and explicit agreement among its users.

Consider, first, the rational choice approach. Two biologists, Nelly and Steve, aim to prove the presence of otters along a river. They first have to find footprints or other evidence at several locations and then document the evidence by taking pictures and producing some casts. Nimble Nelly searches down at the river bank whereas stout Steve remains with the bulky equipment up on the main road, delivering it to Nelly if and when needed. Since Nelly cannot document the evidence without the equipment and Steve does not know when and where to deliver it, they need to coordinate their actions. Coordination is achieved by a system whereby Nelly whistles just in case she finds evidence and Steve brings the equipment just in case Nelly whistles. That is, Nelly follows strategy Ne_1 and Steve implements strategy St_1 (tab. 1).

Table 1: A sender-receiver game. Each of the players can choose between two strategies.

Nelly’s strategy Ne_1	If there is evidence, then whistle If there is no evidence, then remain silent
Nelly’s strategy Ne_2	If there is evidence, then remain silent If there is no evidence, then whistle
Steve’s strategy St_1	If Nelly whistles, bring her the equipment If Nelly remains silent, stay with equipment in truck
Steve’s strategy St_2	If Nelly whistles, stay with equipment in truck If Nelly remains silent, bring her the equipment

The combination of strategies $<Ne_1, St_1>$ benefits both participants equally: If Nelly whistles when finding evidence and Steve fetches the equipment, they can document the evidence; and if she remains silent in the absence of evidence and Steve stays away, then they keep the equipment in good shape for later use. Let us represent the positive outcome as a pay-off with the value “1” (top left cell in table 2). Both suffer, however, if one of them departs from this combination of strategies. For example, if Nelly whistles when finding evidence (Ne_1), but Steve reacts by staying away with the equipment (St_2), then they cannot document the evidence. The pay-off for implementing combination $<Ne_1, St_2>$ is “0” (bottom left cell in table 2). Note that the combination $<Ne_2, St_2>$ is beneficial.

Table 2: A pay-off matrix for the sender-receiver game.

		Nelly’s strategies	
		Ne_1	Ne_2
Steve’s strategies	St_1	1	0
	St_2	0	1

Nelly and Steve implement a system in which each action always matches a state of the world, e.g. a whistle matches the presence of evidence. Moreover, the pay-off is optimal in the sense that neither participant could increase her/his pay-off by deviating from the system. The system is said to be in a so-called Nash equilibrium. Finally, it is natural to describe the whistles as having a meaning, perhaps something like “Bring the equipment over here!” Lewis called an optimal system of interactions of this kind a “signaling system”. Signaling systems belong to a larger class of communicative interactions, which are known as “sender-receiver games” in rational choice theory.

Let us now ask how such a system of interactions can arise in the first place. Lewis assumed that in coordination tasks agents are instrumentally rational and choose whichever action is most beneficial to them. So Nelly and Steve might simply discuss the various combinations, discard those with zero pay-off, and choose $<Ne_1, St_1>$ because it requires whistling only occasionally (unlike $<Ne_2, St_2>$). In this case the task is solved by explicit agreement and prior communication. However, Lewis saw that prior communication is in fact unnecessary. Choosing a particular coordination equilibrium, like $<Ne_1, St_1>$, may also be down to salience, precedent, or chance. Suppose Nelly and Steve quarrel and eventually Nelly storms off while Steve retreats to the equipment. Since resentful Nelly is inclined to whistle only when she finds it necessary in order to draw Steve’s attention, she implements Ne_1 by habit (chance). Steve expects Nelly to let him know when to fetch the equipment and therefore decides to stay with the equipment until he hears from her (St_1). Assuming that his expectation results from previous experience with fieldwork, he implements St_1 mostly due to precedent. Consequently, our team can solve their coordination problem without first agreeing on how to coordinate their actions. Nonetheless, they still need to act in an instrumentally rational way. They must still choose actions that they believe to be in their common interest.

The key lesson to be drawn from Lewis' (1969) rational choice approach is that communication systems can arise spontaneously. Communicators do not need prior agreement about which particular signaling convention to adopt (see chapter 12). Lewis argued, in addition, that explicit agreement is unnecessary for *maintaining* a communication system. While eliminating explicit agreement as a precondition, Lewis' solution still relies on conscious agents and rational decision-making. Some philosophers have gone further, purging rational agents from the explanation of communication. They employ evolutionary games theory to argue that communication systems can arise and be maintained through purely natural, biological processes (e.g. Huttegger 2007; Skyrms 2010). That is, the dynamics of communication systems can be fully "naturalised". The following paragraphs introduce the evolutionary games theory approach (see chapter 13).

Suppose there are two cognitively unsophisticated organisms with innate behavioral dispositions. Senders perceive certain states of affairs and react by behaving in distinct ways. Receivers can perceive the senders' behaviors and respond with some further behavior that has equal consequences for both. In the simplest case there are two states of the world, two organisms, and two types of behavior for each organism (tab. 3).

Table 3: Sender and receiver strategies for responding to food.

Sender strategy S_1	If there is food, then emit substance *F* If there is no food, then emit substance *N*
Sender strategy S_2	If there is food, then emit substance *N* If there is no food, then emit substance *F*
Receiver strategy R_1	If perceiving *F*, move towards sender If perceiving *N*, continue searching for food
Receiver strategy R_2	If perceiving *F*, continue searching for food If perceiving *N*, move towards sender

Suppose some senders follow strategy S_1. That is, they emit chemical substance *F* if they locate food but substance *N* as long as they do not. Other senders simply swap the substances they emit in response to the presence and absence of food (S_2). Receivers also have two choices. Some move towards the sender when perceiving *F* but continue searching for food as long as they perceive *N* (R_1). Others respond in the opposite way to the two substances (R_2). We assume that an individual's genes determine which strategy it follows.

The receiver's behavior will generate pay-offs for both the receiver and the sender (table 4). We also assume that the pay-offs are always the same for both. For instance, both sender and receiver benefit from the combination of strategies S_1 and R_1. The sender emits substance *F* when locating food. The receiver's response, moving towards the sender, allows them to jointly process the food for consumption (pay-off = 1, top left cell in table 4). If the receiver does not approach the sender (R_2), they waste the food.

Table 4: A pay-off matrix for food-searching organisms.

		Sender strategies	
		S_1	S_2
Receiver strategies	R_1	1	0
	R_2	0	1

Strategy combinations < S_1, R_1> and < S_2, R_2> show how a receiver can respond appropriately to world states even if it cannot perceive that state itself and relies, instead, on the sender's behavior. Given that senders and receivers successfully coordinate their behaviors in response to states of the world, it is natural to gloss their coordination as an instance of communication by means of signals (e.g. with compound *F* meaning something like "There is food").

Let us now ask how such a system can emerge and how it can be maintained. In order to address this question we need to shift our focus from individuals to *populations*. Recall that the strategy an individual organism pursues is genetically determined. So they cannot change their strategies within their lifetime. But populations can drop or adopt strategies in the sense of decreasing or increasing the relative numbers of individuals pursuing any given strategy. The change of numbers is a consequence of how many offspring an individual with a given strategy has (we assume that individuals simply pass on their own strategy to their offspring). We assume two populations, one composed of senders and the other of receivers. Senders pursue either strategy S_1 or S_2 and receivers either R_1 or R_2.

The emergence and maintenance of communication strategies at population level are illustrated in figure 2. The vertical axis represents the proportion of senders implementing strategy S_2 ("S_2-senders") as opposed to strategy S_1 ("S_1-senders"). The horizontal axis represents the proportion of receivers implementing strategy R_2 ("R_2-receivers") as opposed to strategy R_1 ("R_1-receivers"). Thus, any point in the square represents a pair of populations with a certain combination of S_1- and S_2-senders as well as R_1- and R_2-receivers. The arrows indicate the directions in which natural selection will change a given combination over evolutionary time. Suppose the population starts from somewhere near the lower right hand corner of the square, which represents a population in which most senders are S_1 and most receivers are R_2. The pay-offs for most senders and receivers are then 0 (bottom left cell in table 4). Natural selection will therefore drive the two populations away from this composition on one of many possible trajectories. For illustration, consider the following two trajectories:

(1) Most senders remain S_1, so that R_1-receivers will produce more offspring than R_2-receivers. In the next generation the process repeats itself. Over a few generations R_1-receivers will therefore become more frequent in the population. This process will move the system along the bottom of the horizontal axis to the left, towards < S_1, R_1>. The combination of strategies < S_1, R_1> is evolutionarily stable. A combination of strategies is evolutionarily stable if natural selection drives the system towards it (starting from other combinations) and if natural selection allows the system to persist in this state.

(2) The proportion of both S_2-senders and R_1-receivers increase more or less simultaneously; this will drive the system diagonally towards the middle of the square, where half the sender population are S_1 and the other half are S_2 (likewise for receivers). Populations with these compositions are evolutionarily unstable, and selection will eventually drive them to either < S_1, R_1> or < S_2, R_2>. Which of the two equilibria will eventually be reached depends on both the starting point and the initial trajectory, and both factors can have random causes.

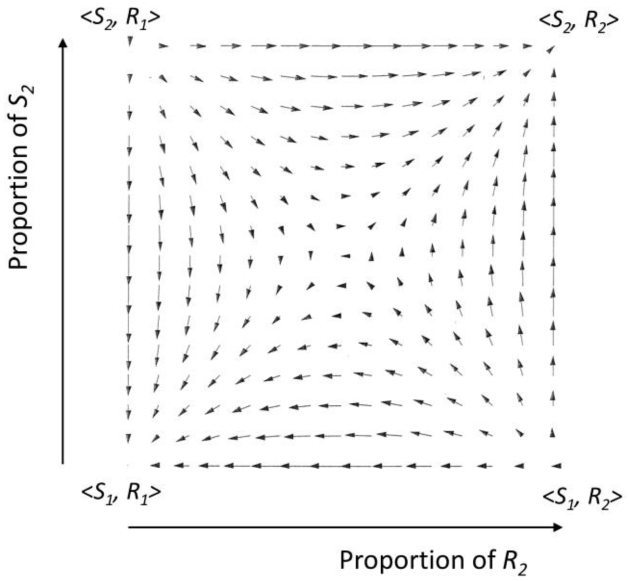

Figure 2: The evolutionary dynamics of two populations, one composed of senders and the other of receivers. Senders pursue either strategy S_1 or S_2, receivers either R_1 or R_2 (see tab. 3) Vertical axis: proportion of S_2-senders; horizontal axis: proportion of R_2-receivers. Adapted from Skyrms 2010 (by permission from Oxford University Press).

The upshot is that communication systems can arise and persist without organisms exercising rational choice or entertaining intentions to communicate. Their signals have a kind of meaning, a meaning that is sufficient to coordinate their behaviors in response to environmental circumstances. An obvious concern is the large gap between the very simple system described here and real-world communication systems, especially human natural languages. Much formal work goes into narrowing this gap by complicating the conditions in various ways, e.g. by introducing more players or allowing for fewer signals than there are world states.

Information and communication

In exploring various aspects of communication, we helped ourselves to the notion of information whenever convenient. It is time to have a more careful look at the relation between these two phenomena. The section starts with a sketch of three notions of information pertinent to communication. The remainder of the section considers information in the signaling model, where it is meant to play a particularly central role.

According to the intuitive view of communication sketched at the beginning of this chapter, "information" denotes whatever is communicated. A large number of things have been proposed as the content of communication. The list includes propositions, thoughts, linguistic meaning, emotions, beliefs, and attitudes among others. On this view the relation between information and communication is very close. Any communication process involves a transfer of information because communication is *about* something or other.

Pragmatists tend to use a stricter notion of information. According to Sperber and Wilson (1995), for instance, information is any thought (conceptual representation) that is presented as factual. Information excludes emotions and attitudes but is not restricted to facts or truths. This notion of information has two important consequences. First, communication does not require, and is not limited to, the transfer of information. Emotions and attitudes can also be communicated (Bach and Harnish 1979). Recall the situation in which Kate is John's line manager and she requests John to be there by uttering "You will be here tomorrow". Kate communicates not only the thought that John will be there but, in addition, the attitude she takes towards her thought. Second, to the extent that information is transferred, both truths and falsities can be communicated (Sperber and Wilson 1995). If John comes to believe that the Earth is flat on the basis of Kate's uttering "The Earth is flat", then Kate has conveyed information to John. It does not matter that the thought is false.

A third, mathematically based notion of information is employed when using evolutionary games theory to investigate the origin and maintenance of communication systems (Skyrms 2010). Suppose a signal's occurrence makes some state more probable than it would be otherwise. For instance, dark clouds in the sky make rain more probable than a cloudless sky. The dark clouds are then informative in the sense that someone who knows about the general relation between clouds and rain can learn something from the current presence of dark clouds. They can infer that rain is more likely now. Skyrms suggests that a signal carries information about some state of the world to the extent it changes (increases or decreases) the state's probability. The more the signal changes the probability, the more information it carries. And if it does not change the probability it carries no information. Skyrms's notion of information is a particular version of probabilistic theories of natural information (Stegmann 2014).

Finally, recall that information plays a dominant role in the signaling model. Communication *consists* in evolved signals transferring information from senders to receivers. The remainder of this section therefore explores more closely the status of information within the signaling model. For this purpose we will focus on animal communication, because it is the model's primary home. In what follows I make two main points. The first is that, on closer inspection, "information transfer" turns out to be an ambiguous notion because there is no generally accepted definition of information in animal communication studies. The second point is that even within animal communication studies it is controversial whether communication amounts to information transfer at all (see chapter 23 for information in other areas of biology).

Within animal communication studies the information concept is employed in at least four different ways (Stegmann 2013). In some contexts, carrying information is simply a matter of correlation. An example is the ‘waggle dance’ of honey bees. Karl von Frisch discovered that certain features of the waggle dance correlate with the location of valuable resources. He also claimed that worker bees use these features in order to find the resources. In the 1970s some ethologists suggested that the recruits use the dancer’s odors instead. This gave rise to a protracted and bitter dispute known as the “bee language controversy”. It was fiercely contested whether or not bee recruits use the dancer’s movements in order to find food. However, all sides accepted that the movements correlate with the location of resources, and all appear to have agreed that the movements carry spatial information (Munz 2005). It is therefore likely that participants of the bee language controversy understood information merely in terms of correlation. That is, a signal carries information about a state *S* if it correlates with *S*. This sense of information may be captured by probabilistic theories of natural information.

In other contexts, carrying information is construed as a receiver-dependent feature. Many authors use “information” interchangeably with what receivers come to know, what they infer, or what they predict when perceiving a signal (e.g. Seyfarth et al. 2010; Bradbury and Vehrencamp 2011). A signal’s information content is thus equated with what receivers predict, infer, or learn from it and is therefore a receiver-dependent property. “Predictions” and “inferences” are here used in a broad sense that does not presuppose significant cognitive abilities. As a corollary, carrying information, too, becomes a receiver-dependent property. A signal carries information relative to, say, members of the same species that can predict something from it. But it does not carry information relative to a different species whose members cannot use it for predictions. In short, a signal carries information about a state *S* just in case a receiver can infer *S* from it.

Furthermore, a signal’s “carrying information” is sometimes construed as being dependent not only on the presence of a receiver, but also on the way in which the receiver processes the signal. Some ethologists distinguish informational from non-informational interactions on the basis of whether or not the signal evokes in the receiver a mental representation or a “mental image” of the referent. Some referential signals, like the vervet monkey’s alarm calls, are said to carry information just in case receivers infer or predict something from them by means of these internal states. Correspondingly, the term “information” is used to denote whatever a receiver’s mental representations encode (e.g. Maynard Smith and Harper 2003; Seyfarth and Cheney 2003). In these contexts, a signal carries information about a state *S* just in case it elicits in the receiver a mental representation of *S*.

Finally, the idea that signals enable receivers to make predictions or acquire knowledge is often put in terms reducing the receiver’s uncertainty about a state of the world (Seyfarth et al. 2010; Wheeler et al. 2011). It is natural to interpret “reduction of uncertainty” psychologically, i.e. as referring to a receiver becoming more confident or certain that a state obtains. But uncertainty is also often understood in terms of the quantities of Shannon’s mathematical theory of communication. Two such quantities are “Shannon entropy” and “mutual information” (see chapter 4). This suggests a fourth way of understanding information: a signal’s information is identical with, or measured by, the value of the signal’s entropy/mutual information.

Correspondingly, a signal carries information about a state *S* just in case it has non-zero Shannon entropy/mutual information with respect to *S* (Halliday 1983).

In conclusion, the term “information” is used in many different ways in animal communication studies and there is no information concept that is both robust and widely accepted. Critics have seized on this fact. They argue that “information” is often ill-defined and appeals to something more abstract and elusive than notions like mechanism and function (e.g. Rendall et al. 2009). It has also been objected that construing communication as information transfer has troublesome methodological consequences. On the informational construal of communication, we are tempted to approach all kinds of communicative processes from the viewpoint of just one particular instance of communication, i.e. human language. Since human language is highly exceptional and sophisticated, it is not a suitable starting point (Owings and Morton 1997).

For these and other reasons some ethologists recommend abandoning the information concept (e.g. Dawkins and Krebs 1978; Owings and Morton 1997; Rendall et al. 2009). Signals do not convey information; they rather persuade or manipulate receivers to respond in certain ways. Information-free communication revolves around the idea that a signal can elicit a receiver response by a variety of non-informational mechanisms. For example, some primate squeaks and screams have acoustic properties that “directly” evoke attention and arousal (Rendall et al. 2009). Similarly, the territorial songs of birds can impact on the receiver’s hormone levels and make aggressive responses more likely. Such effects do not appear to involve cognitive processes. Critics therefore find it inappropriate to describe these signals as carrying information (Owings and Morton 1997). The discussion between informational and manipulationist accounts of animal communication continues (e.g. Seyfarth et al. 2010).[2]

Notes

[1] Here I follow Strawson’s (1964) exposition.

[2] I am greatly indebted to Dorit Bar-On, Casper Hansen, Simon Hutegger, Balint Kekedi, and Stephan Torre for their excellent comments. Any remaining flaws are mine.

References

Avramides, A. (1989) *Meaning and Mind: An Examination of a Gricean Account of Language,* Cambridge, MA: Bradford Books.

Bach, K. & Harnish, R. M. (1979) *Linguistic Communication and Speech Acts*, Cambridge, MA: MIT Press.

Bar-On, D. (2013a) "Expressive Communication and Continuity Skepticism," *Journal of Philosophy* 110: 293-330.

Bar-On, D. (2013b) "Origins of Meaning: Must We 'Go Gricean'?" *Mind and Language* 28: 342-75.

Bennett, J. (1976) *Linguistic Behaviour,* Cambridge: Cambridge University Press.

Bradbury, J. W. & Vehrencamp, S. L. (2011) *Principles of animal communication,* Sunderland, MA: Sinauer Associates.

Brandom, R. (2009) *Reason in Philosophy: Animating Ideas,* Cambridge, MA: Harvard University Press.

Cappelen, H. & Lepore, E. (2006) "Shared content," in E. Lepore & B. Smith (eds.), *Oxford Handbook of Philosophy of Language*, Oxford: Oxford University Press,

Carston, R. (2002) *Thoughts and Utterances: The Pragmatics of Explicit Communication*, Oxford: Blackwell.

Cheney, D. L. & Seyfarth, R. M. (2007) *Baboon Metaphysics*, Chicago: University of Chicago Press.

Christiansen, M. & Kirby, S. (2003) *Language evolution,* Oxford: Oxford University Press.

Davidson, D. (2001) *Subjective, Intersubjective, Objective,* New York: Oxford University Press.

Dawkins, R. & Krebs, J. R. (1978) "Animal signals: Information or manipulation," in J. R. Krebs & N. B. Davies (eds.), *Behavioural Ecology: An Evolutionary Approach,* Oxford: Blackwell, pp. 282-309.

Dennett, D. C. (1983) "Intentional systems in cognitive ethology: the 'Panglossian Paradigm' defended," *The Behavioral and Brain Sciences* 6: 343-90.

Fitch, W. T. (2010) *The Evolution of Language*, Cambridge: Cambridge University Press.

Green, M. (2007) *Self-expression,* Oxford: Oxford University Press.

Grice, P. (1957) “Meaning,” *The Philosophical Review* 66: 377-88.

Halliday, T. (1983) “Information and communication,” in T. Halliday & P. J. B. Slater (eds.), *Animal Behaviour, Vol. 2: Communication,* Oxford: Blackwell Scientific, pp. 43-81.

Hauser, M. D., Chomsky, N. & Fitch, W. T. (2002) “The faculty of language: What is it, who has it, and how did it evolve?” *Science* 298: 1569-79.

Huttegger, S. H. (2007) “Evolution and the explanation of meaning,” *Philosophy of Science* 74: 1-27.

Lewis, D. (1969) *Convention: A Philosophical Study,* Cambridge, MA: Harvard University Press.

Maynard Smith, J. & Harper, D. (2003) *Animal Signals,* Oxford: Oxford University Press.

McDowell, J. (1980) “Meaning, communication, and knowledge,” in Z. van Straaten (ed.), *Philosophical Subjects: Essays Presented to P. F. Strawson,* New York: Oxford University Press, pp. 117-39.

Millikan, R. G. (2004) *The Varieties of Meaning,* Cambridge, MA: MIT Press.

Munz, T. (2005) “The bee battles: Karl von Frisch, Adrian Wenner and the honey bee dance language controversy,” *Journal of the History of Biology* 38: 535-70.

Owings, D. H. & Morton, E. S. (1997) “The role of information and communication: An Assessment/Management approach,” in D. H. Owings, M. D. Beecher & N. S. Thompson (eds.), *Communication. Perspectives in Ecology, Vol. 12,* New York: Plenum Press, pp. 359-90.

Rendall, D., Owren, M. J. & Ryan, M. J. (2009) “What do animal signals mean?” *Animal Behaviour* 78: 233-40.

Saussure, F. de (1916 [1983]) *Course in General Linguistics*, Eds. Charles Bally and Albert Sechehaye, London: Duckworth.

Seyfarth, R. M. & Cheney, D. L. (2003) “Signalers and receivers in animal communication,” *Annual Review of Psychology* 54: 145-73.

Seyfarth, R. M., Cheney, D. L., Bergman, T., Fischer, J., Zuberbühler, K. & Hammerschmidt, K. (2010) "The central importance of information in studies of animal communication," *Animal Behaviour* 80: 3-8.

Skyrms, B. (2010) *Signals: Evolution, Learning, and Information*, Oxford: Oxford University Press.

Sperber, D. & Wilson, D. (1995) *Relevance: Communication and Cognition*, Oxford: Blackwell.

Stegmann, U. E. (2013) "A primer on information and influence in animal communication," in U. E. Stegmann (ed.), *Animal Communication Theory: Information and Influence*, Cambridge: Cambridge University Press, pp. 1-39.

Stegmann, U. E. (2014) "Prospects for probabilistic theories of natural information," *Erkenntnis*, doi: 10.1007/s10670-014-9679-9.

Strawson, P. F. (1964) "Intention and convention in speech acts," *Philosophical Review* 73: 439-60.

Wheeler, B. C., Searcy, W. A., Christiansen, M. H., Corballis, M. C., Fischer, J., Gruter, C. et al (2011) "Communication," in R. Menzel & J. Fischer (eds.), *Animal Thinking: Contemporary Issues in Comparative Cognition*, Cambridge, MA: MIT Press, pp. 187-205.