Signals: Evolution, Learning, and Information

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CHAPTER

6 6 Deception

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Abstract

This chapter shows that in all kinds of signaling systems in nature there is information transmission which is sufficient to maintain signaling, but there is also misinformation and even deception. Misinformation is straightforward. If receipt of a signal moves probabilities of states it contains information about the state. If it moves the probability of a state in the wrong direction — either by diminishing the probability of the state in which it is sent, or raising the probability of a state other than the one in which it is sent — then it is misleading information, or *misinformation*. If misinformation is sent systematically and benefits the sender at the expense of the receiver, then it is *deception*.

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> "I can by no means will that lying should be a universal law. For with such a law there would be no promises at all, since it would be in vain to allege my intention in regard to my future actions to those who would not believe this allegation..."
>
> Immanuel Kant, *Fundamental Principles of the Metaphysics of Morals* [1]

> "the truth, the whole truth and nothing but the truth."
>
> Traditional in English Common Law

Is deception possible?

It seems like a silly question. Any theory that says that deception is impossible is a non-starter. Deception is widespread enough in human affairs, but it is not confined to our own species. Consider the case of a low-ranking male vervet monkey, Kitui, reported by Cheney and Seyfarth.[2] In intergroup encounters, Kitui gave false leopard alarm calls when a new male attempted to transfer to his group. But both groups became excited, ran up trees, and the ↳ transfer never took place. You might wonder whether Kitui was just nervous, terribly
p. 74 afraid of leopards and prone to mistakes. If Kitui were just making mistakes, then his alarm calls were *misinformation*, but not deception. They were misinformation because the state was no leopard, and the probability of a leopard being present goes up given a leopard alarm call. Recalling Chapter 3, there is a positive quantity of information in the signal because it moves the probabilities of the state, but this use of the signal is *misinformation* because it decreases the probability of the true state and increases the probability of the false state. We suspect, however, that these are not simply mistakes because Kitui does this repeatedly and the results are to his own interest and against the interests of the receivers. If so, we appear to have a case of *deception*.

Nevertheless, biologists may worry about the stability of signaling systems in the presence of deception and philosophers sometimes wonder whether deception even makes sense in the context of a naturalistic theory of meaning. The philosophers, as usual, are more skeptical. According to their argument, a signal simply "means" *conditions are such as to cause this signal to be sent*. A signal cannot be false. Deception is impossible.

Systematic deception

One might be tempted to treat Kitui as an anomaly, an individual with non-standard payoffs who happens to wander into a well-established signaling system. If so, not much more needs to be said. But the use of systematic deceptive alarm calls has been documented in many species, both to drive others away from a newly discovered food source and—like Kitui—to deter sexual rivals.[3] These include birds and squirrels, who
p. 75 pose less of a temptation to anthropomorphism than monkeys. For two species of birds, great ↳ tits and shrike tanagers, frequency of false alarm signals seems to be greater than that of true ones.

Or, if the temptation to imagine a mental life is still there with birds and squirrels, consider a somewhat different case of deception. Fireflies use their light for sexual signaling. In the western hemisphere, males fly over meadows, flashing a signal. If a female on the ground gives the proper sort of answering flashes, the male descends and they mate. The flashing "code" is species-specific. Females and males in general use and respond to the pattern of flashes only of their own species.

There is, however, an exception. A female firefly of the genus Photuris, when she observes a male of the genus Photinus, may mimic the female signals of the male's species, lure him in, and eat him. She gets not only a nice meal, but also some useful protective chemicals that she cannot get in any other way. One species, *Photuris versicolor*, is a remarkably accomplished mimic—capable of sending the appropriate flash patterns of 11 Photinus species. I would say that this qualifies as deception, wouldn't you?

Let us think about this, not in terms of some propositional content imputed to the signal, but in terms of its informational content. We consider the probabilities of the states, and the probabilities of the states conditional on the signal being sent.[4] In the case of the false alarm call, the probability of there being a predator present conditional on the alarm call being sent is higher than the unconditional probability. It is not equal to one, and may not even be close to one, due to what we have called systematic deception. But the signal still raises this probability.

If the signal is sent in a situation where the sender observes no predator, it is *misinformation*. If, in addition, it is systematically sent to the benefit of the sender and the detriment of the receiver, it is *deception*.[5]

p. 76 Likewise, the sexual predator Photuris sends a signal that raises the probability of the state of a sexually receptive female being present when that is not the true state. This is just a question of actual frequencies. There is a frequency of receptive females being present and there is a frequency of receptive females in situations where the mating signal is given. The second frequency is higher than the first. As a consequence, the receiving males are led to actions that they would not take if they could directly observe the state.

The signal carries misinformation.

Signals carrying misinformation might sometimes result from mistakes. For instance, we might suppose that occasionally a sexually receptive female of another species gets her flash pattern mixed up and sends the appropriate signal for Photinus. But Photuris is not making a mistake; she is getting dinner. This is a systematic use of misinformation to manipulate the behavior of the receiver for the advantage of the sender.

This is deception.

Half-truth

But the firefly mating signal also increases the probability of the presence of a predator. Its informational
p. 77 content is mixed. Let us look at the matter a little more closely. When a cruising Photinus ↳ looks for an opportunity to mate, nature chooses among three states: sexually receptive Photinus present, hungry Photuris present, nothing happening. Photinus can receive one of two signals, the mating signal or the null signal (that is, no real signal).

This is a little different from the models we have considered, but the same way of thinking of information about states can be applied. There is a baseline frequency for each of the states. There are frequencies when the signal is sent. We can assume for simplicity that in the first two states the mating signal is always sent and the third always leads to the null signal. Then the mating signal being sent raises the probability of both kinds of partner, but leaves the ratio unchanged. If you want to think of it as saying "I am the kind who sends this signal," you can think of it as telling the truth. But it is only a half-truth.

When sent by the predator it contains misinformation in that it raises the probability that a sexually receptive partner is available. When sent by the potential mate, it also contains misinformation, because it raises the probability of a predator. But only the first case counts as *deception* because only in this case does the sender profit at the expense of the receiver. A half-truth can be a form of deception.

Where deception is impossible

Let's just change the payoff structure from common interest to diametrically opposed interest in our simplest signaling game. Nature chooses between two states with equal probability; the sender chooses between two signals; the receiver chooses between two acts. But now the receiver gets paid when the act matches the state, and the sender gets paid when it doesn't.

The only equilibria in this game are *pooling equilibria*. If the signals gave the receiver information about the state, the receiver could exploit the sender. If the receiver altered her behavior in response to the signal she
p. 78 could be manipulated by the sender. ↳ Deception is impossible because the signals carry no information at all. The probability of each state (and of each act) being given a signal is equal to its unconditional probability. The

informational content vectors are all full of zeros; the quantity of information about states (and about acts) in each signal is zero; the information flow is nonexistent.

That is only in equilibrium. A lot of life is lived out of equilibrium. If receivers tend to do act one for signal one and act two for signal two, then senders can profit by deceiving receivers. If senders tend to send signal two in state 1 and conversely, then receivers can improve their lot by learning to read the information in senders' signals—that is, by adjusting their strategies to turn misinformation into useful information. Deception is one of the forces that drive the system to equilibrium.

That is, if the system goes to equilibrium. It may not. Consider our game with strategies restricted to signaling strategies. The sender sends a different signal in each state, and the receiver does a different act for each signal. There are now only two sender's strategies and two receiver's strategies. Payoffs are:

	Receiver 1	**Receiver 2**
Sender 2	1, 0	0, 1
Sender 1	0, 1	1, 0

With two populations, the population proportions live on a square, with the x axis being the proportion of receivers playing their strategy two, and the y axis being the proportion of senders playing their strategy 2. With the replicator dynamics we see cycles, rather than convergence to equilibrium, as shown in figure 6.1.

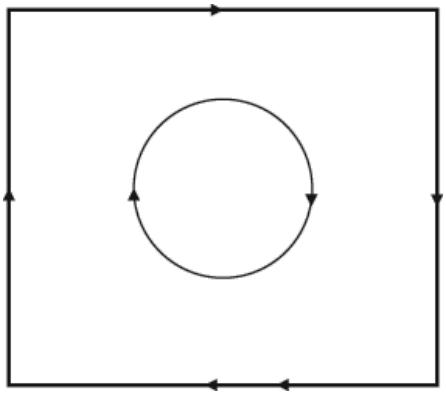

Figure 6.1: Cycles with opposed interests.

In the top half of the square the sender strategy 1 conveys misinformation. In each state, its signals move the probability of the state off 1/2 in the wrong direction because of the prevalence in sender strategy 2. Likewise,
p. 79 in the bottom half of the ↳ square, strategy 2 conveys misinformation. Sender strategy 1 profits at the expense of receivers, on average, in the right half of the square and sender strategy 2 is systematically profitable in the left half. So, according to our definition, deception predominates in the upper right and lower left quadrants. Sender's deception and receiver's adaptations drive the cycle round and round. (The same phenomenon can be realized in a single population, where the payoffs have a rock-scissors-paper structure.)

Prevalence of deception

Consider standard sender-receiver signaling games with all sorts of payoffs. Cases of pure common interest and of pure conflict are the extremes. As the number of states, signals and acts grows, and as dyadic interactions give way to networks, the pure extreme cases become less and less likely. What is typical is a case of mixed interests, in some combination of partial alignment and partial divergence. From purely abstract
p. 80 considerations, what we should ↳ expect to predominate is some combination of information and misinformation.[6]

That is what we find. In all kinds of signaling systems in nature there is information transmission which is sufficient to maintain signaling, but we also find misinformation and even deception. After an extensive review of models of animal signals and of the relevant empirical evidence bearing on these models, Searcy and Nowicki conclude "Evidence supporting the occurrence of deception has been found in all the major categories of signaling systems that we have discussed, including begging, alarming, mating signals and aggressive signals."[7]

How is deception possible?

We have been able to characterize misinformation and deception in behavioral terms. Despite some misgivings in the philosophical literature,[8] misinformation is straightforward. If receipt of a signal moves probabilities of states it contains information about the state. If it moves the probability of a state in the wrong direction—either by diminishing the probability of the state in which it is sent, or raising the probability of a state other than the one in which it is sent—then it is misleading information, or *misinformation*. If misinformation is sent systematically and benefits the sender at the expense of the receiver, we will not shrink from following the biological literature in calling it *deception*.

In certain cases of diametrically opposed interests it is impossible, as Kant says, for everyone to practice deception, at least in equilibrium. That is because, in equilibrium, there is no information at all in the signals. In a game with partially aligned interests it may be in the interest of a sender to restrict information to
p. 81 manipulate a ↳ receiver and it may nevertheless be in the interest of a receiver to act on the information that she gets. Consider the following payoffs (for equiprobable states):

	Act 1	Act 2	Act 3
State 1	2, 10	0, 0	10, 8
State 2	0, 0	2, 10	10, 8
State 3	0, 0	10, 10	0, 0

If everyone uses the strategy, *If sender send signal* 1 *in states* 1 *and* 2 *and signal* 2 *in state* 3; *if receiver do act* 3 *on receipt of signal* 1 *and act* 2 *on receipt of signal*, 2 the situation is an equilibrium. In this equilibrium, the occupant of the sender′s role always manipulates the occupant of the receiver′s role. In state one, the sender′s signal is a half-truth in that it raises the probability of state 2. In state 2 the sender′s signal is a half-truth in that it raises the probability of state 1. These half-truths induce the receiver to choose act 3 in states 1 and 2, whereas accurate knowledge of the state would lead her to choose either act 1 or act 2. The manipulation leads to a

greater payoff for the sender and a smaller one for the receiver. In this sense, universal deception in equilibrium is indeed possible.

It might be objected that this is not *universal* deception because if nature chooses state 3, the signal sent is not deceptive. We have universal strategies that incorporate deception, but not universal deception. The objection can be met by simply expanding the game so there is an equilibrium in which state 3 is pooled with a new state 4:

	Act 1	**Act 2**	**Act 3**	**Act 4**
State 1	2, 10	0, 0	**10, 8**	0, 0
State 2	0, 0	2, 10	**10, 8**	0, 0
State 3	2, 10	0, 0	0, 0	**10, 8**
State 4	0, 0	2, 10	0, 0	**10, 8**

p. 82 Now it would be in the receiver's best advantage to do act 1 in states 1 and 3 and act 2 in states 2 and 4. But there is an equilibrium in which the sender sends one signal in both states 1 and 2 and another in both states 3 and 4, and the receiver does act 3 upon receiving the first signal and act 4 on receiving the second. Given the information supplied, the receiver behaves optimally, preferring a sure payoff of 8 to a 50% chance of 10. The sender has manipulated the receiver to assure herself a payoff of 10. Every signal sent in this equilibrium is deceptive.

Universal deception in this strong sense is not only *logically* consistent in the sense of involving no contradiction, but also *evolutionarily* consistent in the sense of being an equilibrium. I would remind those who would insist that deception is a matter of intentions, that the equilibrium is also *consistent with rational choice*. Sender and receiver may be perfectly aware of what is going on and be perfectly rational and still intend to do what they are doing.

Kant was wrong, wasn't he? (At least if half-truths count as deceptions.) Well, you might say, he was wrong to think that there was an actual inconsistency involved but right that you cannot will deception to be a universal law. For wouldn't our players prefer a system in which the signals carry perfect information about the states? They would not.

If it were a universal law that the senders' signals identify the states and that the receivers choose the act that is best response to that information, the outcomes are those italicized in the payoff table. Compare these with the deceptive equilibrium, whose outcomes are shown in boldface. If one is in the role of sender half the time and that of receiver half the time, the average payoff with honest signaling is 6 and that for deception is 9. Deception is good for you. You would choose the deceptive equilibrium as universal law.

Well, perhaps Kant is not talking about this game, but about all games. You cannot (rationally) will deception to be universal law in all games. Fair enough. But our example shows that one can not rationally will honest signaling to be a universal law either. That is my point. If we concentrate on a few extreme cases, we miss a lot of what is important in communication.

Notes

1 Here is the full quotation, in the translation of Thomas Kingsmill Abbott: “I can by no means will that lying should be a universal law. For with such a law there would be no promises at all, since it would be in vain to allege my intention in regard to my future actions to those who would not believe this allegation, or if they over hastily did so, would pay me back in my own coin. Hence my maxim, as soon as it should be made a universal law, would necessarily destroy itself” (Kant 1785).

2 Cheney and Seyfarth 1990.

3 See Searcy and Nowicki 2005: ch. 6 for review and references.

4 As in Chapter 3.

5 One could argue over whether the clause about the detriment of the receiver should be included. Searcy and Nowicki 2005: 5 leave it out:

> we will define deception as occurring when:
>
> 1. A receiver registers something Y from a signaler;
> 2. The receiver responds in such a way that
>   a. Benefits the signaler and
>   b. Is appropriate if Y means X; and
> 3. It is not true that X is the case.”

Maynard Smith and Harper 2003: 86 put it in.

I do not think that much hangs on the choice; we could talk about strong and weak deception. What is important is that our definition is information-based, rather than depending on imputed propositional content that is false. Imputation of propositional content to animal signals is always problematic. It might make a limited amount of sense in a favorable equilibrium. The information-based concept, however, always makes sense—both in and out of equilibrium.

6 See Crawford and Sobel 1982.

7 Searcy and Nowicki 2005: 223.

8 For a review of the philosophical literature on this subject and commentary see Godfrey-Smith 1989.