Signs and Symbolic Behavior

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1. Introduction

Many people have hoped to develop a general theory of signs (or symbols, or
representations) that could be applied to many systems at different scales. Perhaps the
most ambitious enterprise of this kind was structuralist semiotics (Saussure 1974, Levi-
Strauss 1964).

> By studying rites, customs, etc. as signs, I believe that we shall throw new light
> on the facts and point up the need for including them in a science of semiology
> and explaining them by its laws. (Saussure 1974, p. 17)

The program was expressed in a strong form by Edmund Leach:

> I shall assume that *all* the various non-verbal dimensions of culture, such as
> style in clothing, village lay-out, architecture, furniture, food, cooking, music,
> physical gestures, postural attitudes and so on are organized in patterned sets so
> as to incorporate coded information in a manner analogous to the sounds and
> words and sentences of a natural language. I assume therefore it is just as
> meaningful to talk about the grammatical rules which govern the wearing of
> clothes as it is to talk about the grammatical rules which govern speech
> utterances. (1976, p. 10)

Most would agree this project did not succeed. The quotes above are taken from Dan
Sperber and Deirdre Wilson's classic in theoretical linguistics, *Relevance* (1986). They
gave a harsh summary: "The recent history of semiotics has been one of simultaneous

institutional success and intellectual bankruptcy" (p. 9). Real progress, as Sperber and Wilson see it, has come from a more case-specific approach:

> As the structure of language became better understood, its *sui generis* nature became more and more striking. The assumption that all systems of signs should have similar structural properties became more and more untenable. Without this assumption, however, the semiotic programme makes little sense. (p. 9)

A general theory of signs, for Sperber and Wilson, is not a reasonable goal. Language has rather little in common with animal signaling, and less with cooking and "the wearing of clothes."

Given the history, this attitude is reasonable. But the situation has changed again. Work in several fields has converged in a way that gives grounds to hope for a general theory that has real use. I will describe this approach and show how it might be put to work in one area: investigation of the rise of "symbolic behavior" in human prehistory. A transition to symbolic behavior is seen as an important part of a transition to "behavioral modernity" in our species. Symbolic behavior in this sense includes complex speech, but covers other behaviors too. In particular, it seems to involve a new role for artifacts such as body adornments, tools, and pictures. All the dates are controversial, and some views posit relatively sudden change while other views are more gradualist, but some of the key events appear to have taken place between about 100,000 and 40,000 years ago.[1] By the end of this period, it is thought, central elements of modern forms of human culture were in place, including a ubiquitous role for symbols.

> [A]ll modern cultures share an underlying similarity of nature, in that cultural behavior is largely symbolic, and that individual cultures are identified and transmitted through the learning of those symbols. (Chase and Dibble 1987, p. 264)

What is symbolic behavior, and what is it for an object to be a symbol? There is no consensus. A framework favored by quite a few researchers derives from C.S. Peirce, working in the late 19th and early 20th centuries. In this paper I'll look at how the debates about symbolic behavior appear from the perspective of the newer theory of signs that is emerging.

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[1] For reviews, see McBrearty and Brooks (2000) and Henshilwood and Marean (2003).

2. The Sender-Receiver Framework

My starting point is a model by the philosopher David Lewis (1969). Lewis wanted to understand "conventional signaling." Suppose there are two agents: a *sender* (Lewis said "communicator") who can see the state of the world but cannot act except to produce signals, and a *receiver* (Lewis said "audience") who can only see the signals, but can act in a way that has consequences for both agents. Lewis's main example was Paul Revere and the Sexton of Boston's Old North Church in the American revolution. The Sexton could see the movements of the British army, and displayed a coded message for Revere, who coordinated the revolutionary defenses ("one lantern if by land, two if by sea").

More formally, such a situation includes a set of possible states of the world, a set of available signs, and a set of available receiver actions. The sender applies a *sender's rule*, f_S, which maps states to signs. The mapping need not be one-to-one: the sender might distinguish many states, or few; they might do the same thing whenever they see a particular state, or not. The receiver also follows a rule, f_R, which maps signs to acts. Composed, these two rules yield a mapping from states to acts. The model is about the shaping of these rules or mappings. Why is the sender is making or sending signs in the way they are? Why the receiver is responding to signs in the way they are? What features do the signs in the middle have, as a result? The essentials can be pictured as in Figure 1.
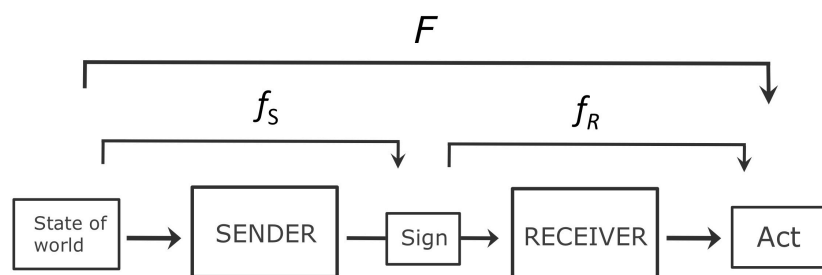
f_S : sender's rule, maps states of the world to signs.
f_R : receiver's rule, maps signs to acts.
F : the resulting mapping from states to acts.

Figure 1: Sender-receiver system

Lewis assumed *common interest* and *common knowledge*. The sender and receiver agree on what acts they want performed in each state of the world, and each knows that the other knows this (and knows that each knows that they know, and so on). Lewis then showed, unsurprisingly, that there can be various *equilibria* under rational choice where the sender sends distinctive signs in each state, the receiver acts on them, and both sides get the best payoff possible in the situation, so no one has any reason to change what they are doing.

Brian Skyrms, in 1996 and 2010, naturalized and evolutionized the Lewis model. He removed the assumptions of rational choice and common knowledge, and showed the model's great generality. Choice was first replaced by evolution by natural selection; signaling can evolve as well as be chosen. Skyrms then extended the model to individual reinforcement learning (trial and error), and to cultural processes of selection through the imitation of successful individuals. Skyrms also moved beyond the simple schema in Figure 1 to consider other structures – multiple senders for one receiver, chains, relays, and networks.

Recent years have seen integration of this work with models developed in biology and economics. The Lewis model can also be integrated with *information theory*.[2] Claude Shannon developed information theory within a version of a sender-receiver set-up, but the main concepts coming out of his work have even broader application. One of these concepts will be important below. Shannon's concept of *mutual information* measures the degree of association between any two variables. To what extent does the state of one variable predict the state of another? Mutual information is all over the place – clouds predict rain, and vice versa – but the evolution of sender's rules and receiver's rules is one way that associations between variables can be shaped. In particular, a sender by their policies can make a sign into a good predictor of a state of the world, or a poor one.

This shaping of the sender's rule depends on the relationship between the goals, roughly speaking, of the sender and receiver. Lewis assumed common interest. More exactly, there is *complete common interest* when for every state of the world, the sender and receiver have the same preference ordering over acts the receiver might perform. In

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[2] For links to biology and economics, see Skyrms (2010), Zollman et al., (2012), Wagner (2012); for information theory, Shannon (1948), Cover and Thomas (2006).

many cases this does not hold. Suppose there is complete *conflict* of interest: for every state, the sender and receiver have reversed preference orderings over acts the receiver might perform. Then, it would seem, if the sender sends signs that are associated with (carry information about) the state of the world, the receiver can exploit them to pair acts with states in a way the sender does not want to occur. Conversely, if the receiver is sensitive to signs, the sender can re-assign states of the world to those signs in order to get the receiver to do things he does not want to do.

		States		
		S1	S2	S3
	A1	3,3	0,0	0,0
Acts	A2	2,2	3,3	2,2
	A3	0,0	2,2	3,3

a. Complete common interest

		States		
		S1	S2	S3
	A1	3,0	0,3	0,3
Acts	A2	2,2	3,0	2,2
	A3	0,3	2,2	3,0

b. Complete conflict of interest

		States		
		S1	S2	S3
	A1	0,0	2,3	2,3
Acts	A2	2,3	0,0	3,2
	A3	3,2	3,2	0,0

c. Partial common interest – agreement on the worst

Table 1, a-c: The entries in each cell specify sender payoff and receiver payoff, respectively, for each combination of receiver's act and state of the world.

The usual outcome with complete conflict of interest is that the sender will not send informative signals when the system is at equilibrium. The sender might send the same sign all the time – in effect saying nothing – or the sender and receiver might never settle on stable rules. Surprisingly, there are some cases of complete conflict of interest, in the sense outlined above, where equilibria exist in which informative signals are sent and used. These cases are rare. Between complete common interest and complete conflict of interest there are many kinds of *partial* common interest. An example is given in Table 1c – sender and receiver disagree entirely on what is best but agree on the actions they most want avoided. Cases of partial common interest have different consequences according to their specific features, but partial common interest often allows some signaling to occur, while weakening the informational properties of signs when the system is at an equilibrium.[3]

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[3] For partial common interest, see Crawford and Sobel (1982) and Godfrey-Smith (2013). For cases with signaling despite complete conflict of interest, see Godfrey-Smith and Martinez

In case (a) in Table 1, there is complete common interest and the system has several equilibria in which states are mapped to signs one-to-one and both sides always get maximum payoff. These combinations of rules are *strict Nash equilibria* – any unilateral deviation leads to the deviator being worse off. In case (b), there are no equilibria in which signals contain any information about the states. In case (c), partially informative signaling is an equilibrium (though not a strict Nash equilibrium); if the sender refuses to distinguish states 1 and 3, but does distinguish these from state 2, the two sides can reach a *modus loquandi*.

These facts about equilibria depend on the details of idealized models, and real life is more complicated. But some general messages can be exported from the models. One such message is that it "takes two to tango." If the receiver gains nothing from attending to signs, they will stop attending to them, and the sender will have no reason to keep producing them. As common interest fades, so does stable communication, though each side may continue trying to exploit the other.

The Lewis model has at least three dimensions of generality. It applies both within and between organisms. It applies to communication over space and over time – when time is bridged, signaling yields *memory*, in both its usual psychological sense and extended senses. Third, the sender and receiver rules can be shaped by selection processes of different kinds operating at different scales. In the cases relevant to this paper, some kinds of change are due to biological evolution and other kinds are due to learning, imitation, or rational choice. What is essential is the idea that the two rules, the rule of sign production and the rule of sign interpretation, coevolve. So there must be some sort of feedback process by which the consequences of the receiver's actions can affect later acts by the sender.

How foundational is the model? How much does it cover? The versions devised by Lewis and Skyrms make idealizations in order to get definite outcomes, as I said, but setting those aside, does the model capture the core of communicative behavior?

(forthcoming). Another sense of complete conflict of interest is the sense seen in a "zero-sum game." Relationships between this sense and the preference-reversal sense are discussed in the Godfrey-Smith and Martinez paper. The cases where information use exists despite complete conflict of interest are not also zero-sum.

For a model in which sender and receiver conflicts prevent them from settling into a stable pattern, see Wagner (2012).

Consider a scenario that contrasts with Lewis's Paul Revere case. Imagine, with David Hume (1739), two men rowing a boat, one on each side, who fall into a cooperative pattern despite not communicating any rule. That can work, but much can often be achieved with a calling of the stroke, either by a rower or by a "cox" who does not row. Does this kind of sign use fit the Lewis model? The initial answer seems to be no. The sender has no private information about state of the world, and the aim is not to achieve coordination of acts with states; the aim is to coordinate one act with another act.

Formally, this scenario can be cast within the Lewis model in at least some cases. If the boat has no cox and one rower decides when to row and calls the stroke, this can be modeled with a matrix of the same kind as above, where the "state" is the sender's act and the "act" is the receiver's act. Many rowboat interactions have complete common interest: for every time at which one person might row, the two sides agree on what they want the other to be doing. There might also be partial common interest (in game theory, the "battle of the sexes" is like this). A general argument about common interest applies as it did above (though the argument may have exceptions here as well): the sender will only make their call informative about their upcoming action when there is at least partial common interest. If not, the receiver will exploit this information and the sender should stop sending it.

The analysis in the previous paragraph shows some continuity between the rowboat case and Paul Revere. In both cases, signs are used to guide acts, and acts have *success-conditions* – conditions in which the acts produced by the sign pay off, from the point of view of the sender, the receiver, or both. In other ways, the rowboat case is different from the Revere case, as the point of signaling is to coordinate acts with acts, not acts with states determined externally. This dissimilarity is clearer in the case where there is a cox calling the stroke. Then signs have no "reference" to something beyond them; they act purely to generate coordination.

I am spending some time on these distinctions because familiar views and habits tell us that a sign always "stands for" something else. This assumption has been part of a number of discussions of symbolic behavior in archeology. A sign has an object; a sign stands for something. Peirce's theory has this feature, and it is not unusual.

Within a sender-receiver model of the kind developed here, it is essential that signs have a kind of *involvement* with external things, with something beyond themselves. But this involvement comes in various forms. In cases like Revere's, the idea of "standing for" applies clearly: the number of lanterns stands for the state of the British army. In the rowboat case with no cox, perhaps the call "stands for" the intention of the calling rower to row at that moment. In the rowboat case with a cox, the call does not stand for anything. A sign can organize behaviors without saying anything about how things are.

In cases where the point of signaling is act-to-act coordination, a sign can be seen as having *imperative* content. It says "row now!" This is true for many of the Lewisian cases, too: "Coordinate our defenses for a land attack by the British!" In simple cases where the aim of signaling is to coordinate acts with states, a sign can be seen both as telling the receiver how things are and as telling them what to do. Lewis discussed how certain kinds of further complexity lead to a sign saying only how things are, rather than what to do, or saying only what to do, as opposed to how things are.

Here are the points in this area that matter to what will come later. First, a kind of involvement with something beyond itself is essential to being a sign. This differentiates the particular kind of stabilization of behaviors in a sender-receiver system from other situations in which two agents interact. Suppose I hand you a glass of water. If the point of this act is to make available to you the water itself, with its various useful intrinsic properties, then this is not symbolic behavior, even though it is a cooperative interaction between a kind of "sender" and "receiver." If, on the other hand, the water is handed to you not because of its intrinsic properties, but because it will prompt behavior whose success depends on its relations to facts or acts elsewhere, and then we are at least entering the general arena of symbolic behavior. *Standing for* an object, or for a state of affairs, is a special case of this phenomenon, though, and not always applicable. So it is not a good idea to organize all discussion of signs around the idea that signs stand for objects. In the rest of this paper I use the term "sender-receiver system" to refer both to cases where the point of sign use is to coordinate acts with states, and cases where the point is to coordinate acts with acts. Different sender-receiver relations give rise to different kinds of involvement between signs and other aspects of the world. (In some

models both agents signal, and then act in a way guided by what they hear, and so on.) [4]
In archeology, the limitations of a simple referential model of signs have sometimes
motivated moves towards more radical views influenced by poststructuralism (Robb
1998). Empirical diversity in sender-receiver relations does not motivate a move of that
kind.

The next topic to look at is a range of *partial* cases of a sender-receiver system.
One family of these cases is those where a receiver or interpreter makes use of a naturally
occurring sign or indicator, a sign not produced for their use. In biology these are called
cues, as opposed to *signals*. In philosophy they have been called *natural signs*. Clouds
are natural signs of rain. A case like this is a fragment of the set-up pictured in Figure 1.
There is a link between states and cues, but no sender who determines that link. Or
perhaps there is a sender, but one that is not responsive to the receiver's actions and their
consequences. Either way, there is no coevolution of the sender's rule and the receiver's
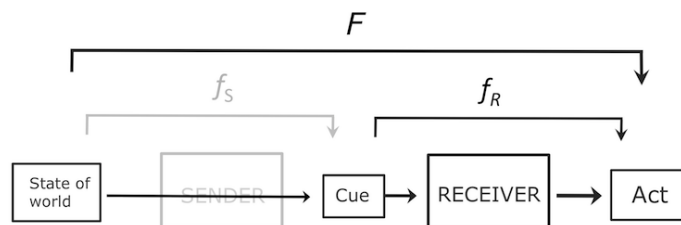rule.

Figure 2: A situation where the receiver's actions have no
consequences for the production of signs.

A smart receiver or interpreter will use cues to guide their actions, as well as signs
coming from coevolving senders. The crucial difference is that in the case in Figure 2, the
way the receiver uses cues to guide action does not have consequences for the
stabilization or re-shaping of the left hand side, the mechanism by which the cues are
produced. In the "full" case in Figure 1, where there is a sender whose actions are
affected by the consequences of a receiver's choices of action, the *use* of signs comes to
affect what gets *produced*. Each sign is the way it is because of the operation of the
sender's rule at that time, but the sender's rule changes as a consequence of the receiver's

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[4] For some other models see Robson (1990), Farrell and Rabin (1996).

patterns of use. I described these two as sharply different cases, but the difference is often one of degree. The sender might change in response to the way the signs are used, but more slowly or less adaptively than the way the receiver changes. The opposite is also possible. Either side might be more adaptable than the other, and to any degree.

A "constraint" on senders that has a quite different role is signal cost. In recent biology, signal cost has been much discussed as an enforcer of honesty (Maynard Smith and Harper 1998). What is required for this enforcement role is that dishonest senders must pay more, or benefit less, than honest ones. "Paying more" in this sense includes paying the same amount but being less able to afford it. Within my version of the sender-receiver framework, signal cost is a constraint placed on senders by the evolution of a particular receiver's rule. If a receiver wants an accurate indicator of a sender's status or quality, they can choose to ignore signals other than those that are hard for low-quality senders to produce. If receivers will only attend to costly signals, senders have to find a way to pay the cost, or opt out of the interaction. Cost in this sense may well be empirically important, but informative signaling can often be maintained by partial common interest without a role for cost.

There are other kinds of partial or marginal cases of a sender-receiver system. In clear cases, definite objects fill each of the three roles – sender, sign, receiver. Sometimes the separation between these entities is not so clear. And even when entities of the right kind are present, it may be that relations covered in the sender-receiver model are mixed in with others, so the resulting behaviors are only partly due to factors the model covers. The way to handle the model is not to force all cases into the slots seen in Figure 1, but to recognize both clear and marginal cases as natural products.

That concludes my outline of the model. This framework overlaps with earlier work of many kinds, but I think it is a better one than has existed before. The starting point is the Lewis model, which is integrated with information theory, with an evolutionary framework, and with concepts from the social sciences. The emphasis is on the coevolution of interlocking behaviors on either side of a sign. Why send (produce, inscribe), and why do it in a particular way? Why receive (read, use, attend)? Rather than focusing, as in the structuralist tradition, on signs themselves and the relations between

them, or on a single set of behaviors (either expression or interpretation), the focus is on the two-sided phenomenon of sign production and use.

Before moving to prehistory I'll compare this framework with an older one. C. S. Peirce's theory of signs has been used by a number of people in archeology and anthropology (Deacon 1998, Chase 1991, Hovers et al. 2003, Rossano 2010). Peirce described sign use with a triad: *sign, object, interpretant.* An interpretant might be seen as a receiver or reader, but more exactly, the interpretant is the process of interpreting or understanding a sign (Peirce 1998, Atkin 2010). This is, in effect, a theory focusing on the receiver side of the structure in Figure 1. It does treats those receiver's responses in relation to an "object," but it is not a theory of the relations between sign production and sign use.

For Peirce, reference to an "object" is a feature of all signs, though this reference can take various routes. Peirce distinguished three main kinds of signs: *icons*, *indices*, and *symbols*. Icons refer by means of a pictorial relationship or resemblance to their object; indices refer by means of a physical association (smoke and fire); symbols refer by means of an imposed convention or rule.

Recent writers making use of Peirce's view accept the idea that symbols are more sophisticated signs, built on icons and perhaps indices. Here is Hovers et al. (2003, p. 492) writing about body adornment with ochre:

> The following discussion revolves around symbols, the most complex of these referential associations, but it is important to recognize that they invariably rest on a foundation of icons and indices. Iconic reference is the default, basic, and irreducible referential form.

Rossano (2010, p. 96) says that icons seem most basic in a general sense, but some simple cases seem to be indexical:

> The least contentious interpretation is that iconic artifacts (in the form of pigment use) and indexical ones (handaxes with imposed form, composite tools, beads) are roughly contemporaneous (within a time frame around 500,000–100,000 ybp). Clearly, the move to symbolic thinking arrives later.

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Setting aside the examples for a moment, how do Peirce's distinctions relate to the sender-receiver model? Is a Peircian sequence from simpler icons and indices to symbols motivated in principle? In general I think it is not. Many of the simplest sender-receiver systems in animals (and bacteria) would count as symbolic if fitted into Peirce's model. Firefly flashes are used to indicate sex and species in mating interactions. These flash patterns are not indexical or iconic. Any "symbolic" sign can *become* indexical, in a sense. By the evolution of a sender's rule it can come to have a physical association with a state of the world. But that association is a consequence of its symbolic use, rather than a pre-existing relationship that explains how it refers. All sorts of intermediaries between senders and receivers can acquire a semiotic role, even in simple systems, if evolution produces the right relation between the behaviors on either side of them.

A pre-existing pictorial relationship or physical association can often make something into a convenient raw material for sending and receiving. A naturally produced waste chemical might be useable as a cue of the presence of a particular organism, and that may lead to the organism making that chemical purely for signaling purposes, even when it is not being produced as waste. Then a pre-existing indexical relationship becomes integrated into a sender-receiver system. The idea that indexical or iconic relationships can furnish raw materials for symbolic behavior is a good one, but the stronger view that symbols always "rest on a foundation" of icons and indices is mistaken.

It is useful also to compare my sender-receiver model and the Peircian view to one part of the literature on animal signaling (seen especially in Krebs and Dawkins 1982 and Owren, Rendall and Ryan 2010). On this view, animal signals are often attempts to manipulate other animals, often successfully. What about my argument that it takes two to tango, and a receiver must benefit from attending to signs or it will ignore them? Owren, Rendall, and Ryan think that often the sender has the upper hand; it would cost too much for the receiver to change their sensory systems in a way enabling them to ignore unwanted signals. This approach treats the receiver side as less flexible, as more constrained, and puts the emphasis on sender strategies. Peirce's view focuses on the receiver or interpretation side.

The main features of the framework I advocate are as follows:

(i) Understanding how signs work is understanding the coevolution of behaviors of sign production and interpretation.

(ii) There is continuity between sign use in human social life and many cases in non-humans and within organisms. A variety of selection processes can shape and stabilize the behaviors on either side of a sign. Some sort of feedback from the actions guided by sign use is essential, as that is the means by which the use of signs by receivers can have consequences for their ongoing production.

(iii) The extent and form of common interest between sender and receiver is important in enabling sign use to stabilize.

(iv) Sometimes the role of sign use is to coordinate acts with states of the world, sometimes to coordinate acts with other acts. There may be further categories, and many empirical cases will be mixtures. Sign use is distinguished from other kinds of interaction by a distinctive role for relations of involvement between signs and other things, these relations being mediated by the actions that result from sign interpretation. These relations need not always be a matter of reference or standing-for, however.

(v) Sender-receiver systems are seen in partial and marginal cases as well as clearer ones. Partial cases include cases with asymmetries between the adaptive capacities of sender and receiver, cases where the entities treated as distinct by the model are entangled, and cases where the relations treated by the model have secondary importance in comparison to other factors bearing on the system.

3. Symbolic Behavior in Prehistory

Sometime before about 50,000 years ago, rapidly or gradually, our species made a transition to a form of living in which symbols came to play a central role. As noted earlier, debates over the origins of symbolic behavior are partly concerned with language and thought, but also concerned with shifts in the role of physical artifacts. The sender-receiver model is a good tool for thinking about these phenomena, as the model is abstract enough to cover many kinds of behavior and, especially in the form developed above, designed to work with partial cases and shades of grey. In this section I'll discuss

debates about symbolic behavior in archeology. I'll avoid speculation of my own about prehistory, except for illustrative purposes. The aim is to connect the sender-receiver framework to data, case studies, and hypotheses developed by specialists in this area.

Steven Kuhn (this issue) gives an outline of our present understanding of the history of communicative behaviors using artifacts. The earliest traces of behavior of this kind are mineral pigments, especially ochre, and these go back over 250,000 years. Much later, 80-90,000 years ago, ornaments such as beads begin to appear (see also Stiner's paper in this issue). A more controversial case of an artifact with a possible symbolic role around this time is tools such as hand-axes, which come to show apparent stylistic differences. About 45,000 years ago, body ornaments and tools diversify, and wall drawings, elaborate graves, and musical instruments also appear – this is the period some researchers associate with a sudden change, perhaps due to one or more genetic mutations of large effect (Klein 2003).

Let's begin with the use of pigments, and assume for purposes of discussion that these were used to adorn the bodies of the living. This case certainly lends itself to a treatment in sender-receiver terms, though as we'll see, not all possible uses of pigments fit the model well. I'll start by assuming that one person is marking their body (or having another mark it) in a way designed to be observed another people. The reason to make the marks is to induce behaviors in observers that would not occur, or would be less likely to occur, otherwise.

There is no point in making the marks if their behavioral consequences in observers will not be helpful to the sender, the person marked. But a sender cannot dictate how a receiver will interpret the marks; the receiver will react to the marks with habits or rules that have been selected to serve the receiver's interests. If the marking of the body is stable in some context, this is probably because the behavioral consequences of observing the marks are beneficial, on balance, for both sides.

A possible exception is marks and displays intended to strike fear in one's enemies. How do they fit the model? They may involve a phenomenon discussed at the end of the previous section. If marks strike fear into an observer, this is due to evolved or learned mechanisms that implement a receiver's rule. That rule might be in place because the fear is beneficial to the fearful, or if it is not beneficial, it might be in place because

the process of adaptation on the receiver side is constrained and the sender can take advantage of this constraint. Owren, Rendall, and Ryan (2010) hold that this is common in animal signaling, as noted above.

Let's assume that the marks are present because of common interest between sender and receiver. What are the marks' likely roles? Some roles involve something like *reference*. If you can infer a person's origin or affiliation from the marks on their body, then the marks refer to, or stand for, the bearer's origin or affiliation. This referential role may be mixed in with others. Suppose members of a group mark their bodies in similar ways to foster a sense of unity. The point of marking is not to carry information, but to induce behavioral coordination of some kind. You could still insist that the marks "refer" to something, perhaps to social practices, but such a description is rather forced; the signs have a different role from transmitting factual information, and there is no need to find a referent.

Thinking about this second role, it becomes clear also that a role of body adornment that fits the sender-receiver model may be mixed in with others that do not. I said that the function of the marks on one person's body involves their observation by other people, but some roles for the marks need not have that character. It might be that part of the social function of the marks is achieved by the communal practice of *making* them, and knowing from the making that one has marks in common with others. Then if the marking is first-person, we could say that the sender is also in the role of receiver, but it is probably more accurate to say that this role for a coordinative symbol does not fit the sender-receiver model very well. Suppose that marks have a dual function: one function is to convey information about the bearer to observers and another is to foster unity, where this second role works partly through effects on observers and partly by other means. Then body adornment is a behavior with a mixed role, part of which fits the sender-receiver model and part of which does not, and within the part that fits the sender-receiver model, some of it involves carrying information and some involves pure coordination of actions.

I'll now discuss the controversial case of stone tools, such as hand-axes. One family of hypotheses holds that these artifacts initially had a purely utilitarian role, but came to have a symbolic role as well. The *style* of an artifact may have a social function,

perhaps indicating the origin and affiliation of a user, perhaps cementing shared activity within a group, and perhaps as a marker of individual-level properties.

Philip Chase (1991) notes that some kinds of style in artifacts can arise for reasons unrelated to symbolic behavior. What looks like a stylistic tradition in tool-making might be established by opportunistic copying and by local constraints on materials. "Passive" style does not indicate a symbolic role, whereas "active" style may do so (Sackett 1982). How do we distinguish the two? Chase's conception of symbolic behavior comes from Peirce. Any symbol has a relation to a referent, and that relation is arbitrary.

> The problem is that active style is extremely difficult to recognize. A symbol of any kind exists because of the link *in the mind of its maker or beholder* between sign and referent. (1991, p. 199)

Chase then notes that it is hard to find objective marks of these psychological states.

Here is how a case like this looks from the point of view of the sender-receiver model. "Links in the mind" are relevant, but only as they bear on the way the artifact is produced and acts taken in response to it. Suppose first that tools are produced by individuals working on their own, with only a minimal role for social learning, and with the sole aim of making useful tools. There is no copying, but local similarities arise due to the raw materials. Style arises "passively." This makes it possible for people to make inferences about affiliation and origin from observation of artifacts: because he has that tool, he is from clan X (or he has some other relevant property). So "passive" style has a social role, because it makes artifacts into *cues* of relevant facts. So far, the production side is not sensitive to this fact; people just try to make good tools. The situation is like the one drawn in Figure 2 – the production side on the left is unaffected by practices of interpretation on the right. Inferring the affiliation of a person from a tool is like inferring that they have been on holiday from their sunburn.

A transition is obviously then possible, though, one in which tool production comes to be affected by this practice of interpretation. As a result of a selection process – perhaps deliberate choice, perhaps something else – tools are made in a particular way *because* they are going to be interpreted as markers of origin and affiliation.

Idiosyncrasies that function as indicators of origin (or markers of other facts) are introduced for that reason. What is needed is that there be some mechanism affecting production that is sensitive to the advantages of producing tools with an indicator role of this kind, given the habits of interpretation in place downstream. In this sequence, what was once a tool with a purely utilitarian role has undergone two changes; it becomes first a cue (Figure 2) and then a sign in the richer sense that fits the sender-receiver model (Figure 1). In one sense of the term, a transition to symbolic behavior has occurred.

The role of matters of degree is evident. Production behaviors may be affected by many things; perhaps there is only a small role, a 1% and occasional role, for affiliation-marking. Perhaps it is rare that observations of another's artifacts have genuine consequences, or perhaps they do have consequences, but this fact has little or no effect on the production side, at least for a time. Slight effects of downstream interpretation on the production side can later become stronger effects; the 1% can become 80%. I mentioned sunburns above. A sunburn, or certainly a tan, can have a symbolic role in this way, indicating a luxurious lifestyle, and here, too, a person might be just a little less likely to use sufficient sunscreen because of the interpretation waiting downstream. Once an artifact acquires a role that is substantially, or primarily, symbolic, it will be natural to modify its form so it better serves the new role. Ceremonial weapons look different from non-ceremonial ones. The use of an object as a cue cannot be inferred from the properties of the object itself, but when the production of a sign has been influenced by practices of interpretation, this will often show in the sign's material form.

Sign-use is distinguished from other kinds of interaction by the involvement signs have with external things. How is this likely to work in the case of artifact style? It might be that the style carries information (in Shannon's sense) about tribal identity. Stylistic conventions in more complex artifacts might also have a role in coordinating actions, rather than carrying information about a state of the world. Once again, reference to an "object" may or may not be relevant.

Tools can have a further social role that is discussed in connection with symbolic behavior. Artifacts can be repositories of information and technical know-how, as well as

being useful objects in themselves.[5] One person can make a useful object by copying another. In my discussion above, I assumed to keep things simple that handaxes were not being copied and that social learning had only a minimal role in the persistence of the practice, but this was a very unrealistic assumption. As Hiscock (this issue) emphasizes, the practical difficulties and dangers of making stone tools put a premium on learning from experts. Apprentice-based learning and highly scaffolded learning environments (in the sense of Sterelny 2012) were probably important from early stages. So let's again consider a sequence of events. One person makes an artifact and another copies them. A difference from the cases above is that the "interpretation" step is now a further act of production. Initially, we can assume that the production of any handaxe is not affected by the fact that it will later be copied in turn; each person is just trying to make a new handaxe. Stylistic lineages may arise in this process, but again they are "passive" in Chase's sense.

Each artifact then acts as a kind of memory store, but one that is fortuitously re-created at each step. This is memory in a minimal sense, though a sense that may be empirically quite important. When copying is high-fidelity, it can lead to the refinement of designs and cumulative improvement (Tomasello 1999), even though no one is trying to achieve this. Each person is just trying to make a useable tool; each might as well be the last member of the lineage. But tendencies to copy give the culture an inadvertent memory. Peter Hiscock (this issue) argues that given the quantity and the durability of stone tools, and of the debris from their manufacture, the effects tool-making practices had on the environment of early humans may have been substantial. "Landscapes filled with lithic artifacts become effectively a library of designs and production procedures."

A transition might then occur to a coevolutionary relationship, in a way analogous to that seen above. It comes to be that habits of later interpretation have some bearing on the production side. Each person is trying to make not only a tool, but a means for the transmission of the technology. Then the practice of copying generates memory in a stronger sense.

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[5] "Examples of recognizable external symbolic storage include art work, personal ornamentation, lithic style, and the social use of space" (Henshilwood and Marean 2003, p. 635).

Kuhn and Stiner (both in this issue) also discuss beads and pendants, especially those made from shells, as symbolic artifacts. These first appear about 80-90,000 years ago in Africa and the Eastern Mediterranean and become very widespread from about 40,000 years ago in both Africa and Eurasia. Here an information-carrying role was probably important – they conveyed messages about an individual's identity, affiliation, and social standing. Stiner gives a cooperative interpretation of the elaboration of these artifacts, one in which human groups used these markers in the formation and navigation of expanding social networks, which provided some degree of "insurance" and mutualistic support. Kuhn, taking the story further in time, suggests that after 30,000 years ago or so, increasingly elaborate bead ornaments began to function as signals that indicate status by means of their high cost. I discussed signal cost as an enforcer of honesty in the previous section. Signal cost is a constraint placed on senders by the development of a particular receiver's rule. If a receiver wants an accurate indicator of a sender's status or quality, they can choose to ignore signals other than those that are hard for low-quality senders to produce. Kuhn suggests that the extravagant disposal of valuable goods in burials, which appears after 30,000 years, functioned as a conspicuous and hard-to-fake indicator of status of this kind.

Around 40,000 years ago, the most aesthetically striking prehistoric symbolic artifacts also appear: cave paintings. These are natural cases to approach using a sender-receiver model of some form, but much uncertainty surrounds their intended use, and some hypotheses would take cave art to the edges of, or outside, the model (Clottes and Lewis-Williams 1998). If, as has been argued for at least some cases, the aim of painting a bison was to conjure up bisons which could be hunted, and this bringing-into-being of the animals was not seen as going through the reception of the painting by a supernatural agency, but was more direct, then despite its pictorial features the bison-painting was not made *to be viewed* by anyone or anything. The roles of cave art may be diverse, with some cases fitting a sender-receiver model well and others fitting it poorly.

4. Collectives

I'll briefly discuss one other aspect of the application of the sender-receiver model to empirical systems that is important in this context: the relation between individual-level and group-level agents as sender and receiver.

The basic application of the model is to signaling between individuals. This is a social phenomenon, and there might be a situation where the social facts in a society are brought about entirely by person-to-person signaling. But it is also possible to consider groups, collective entities, as occupants of the sender or receiver roles. Familiar questions about individualism and the social, seen both in biology and the social sciences, then arise. To what extent is symbolic behavior best seen as an individual-level interaction with group-level consequences, as opposed to a social activity in a richer sense? In the model that is relevant here, we would be looking for processes of sending and receiving, and processes of the shaping and stabilization of those rules, that involve groups as units.

Many familiar phenomena have a "collective sender" – the collaborative construction of a library or monument, the singing of a choir. Objects like this are not so clearly intended for collective *receivers*. Each person accesses the library (interprets the monument, hears the choir) in their own way. Might genuine collective action be more common on the sender than the receiver side of sender-receiver systems?

There may also be empirically important phenomena that involve collective sending in a thinner sense, a sense that does not involve coordination. Cheney and Seyfarth (2007) present a very interesting view of baboon communication. Baboons, when they vocalize, have simple and inflexible sender's rules – a given experience or interaction fairly reliably induces the same call each time. But as baboons can recognize individuals by their calls, a sequence of calls produced by different individuals can carry a great deal of information. Baboons as receivers can process this complexity, even though they cannot individually produce anything very complex. For example, if a baboon hears a threat call from a low-ranking individual followed by a submission call from a higher-ranking one, they are surprised. The socially produced sequence of calls has a kind of inadvertent syntax, which the baboons can process, even though none of them can produce a sign with this sort of syntactic complexity. Cheney and Seyfarth think that complex interpretation came first, in this case – and can still be seen – while

complex production has not arisen. Perhaps, they think, that pattern also applies elsewhere.

Here there is no collective sender in the rich sense I had in mind above – a collective sender with a rule shaped by a selection process. The baboons are no choir. The individual baboons each have an evolved sender's rule, and the baboon collective (here a pair or another small group) is an object that only gives rise to cues. A richer kind of symbolic behavior arises when sending is genuinely collective, and genuinely collective interpretation is another matter again. How do these distinctions relate to human prehistory?

5. Conclusion

The new family of sender-receiver models of communication is well suited to the investigation of the rise of symbolic behavior in prehistory. Some foundational theories in this area, notably structuralism, have been insufficiently focused on sign *use*. Others, which are concerned with use, focus on one side or the other side – expressive or interpretive – of an essentially two-sided phenomenon. The model used in this paper unifies semiotic phenomena by focusing on the relations between sending and receiving, production and interpretation, marking and reading.

Behavior with the distinctive features seen in a sender-receiver system fade off into other kinds of social behavior, especially other kinds of coordinated and cooperative behavior. The framework discussed here embraces the shades of grey inherent to sign making and sign interpretation. Through prehistory and then history, sign use becomes more clearly demarcated; it emerges from a submerged state in which behaviors have many roles at once, are only marginally sign-using, to produce, in time, a world in which we are surrounded by artifacts like alphabets and keyboards that have been refined over generations for their roles in symbolic behavior.

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