Chapter 14
Costly Signaling Theory in Archaeology

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Introduction

Our ability to signal contributes significantly to what it means to be human. As social primates, humans have evolved to live in groups. Among our many biocultural adaptations to living in groups, we have developed a tremendous capacity for complex verbal and nonverbal communication. These different forms of communication have allowed us to share information with others, including people with whom we have had no previous interactions. More than any other species, we use material culture to convey and gather information—*signal*—to both compete and better facilitate cooperation with others.

The evolution of the capacity for nonverbal signaling is an important part of our evolutionary heritage. The earliest known evidence for humans using material culture to signal can be traced back to the use of ochre and other pigments as far back as 300,000 years ago (Kuhn 2014). By 75,000 years ago, there is evidence of objects being intentionally manufactured, such as the perforated shell beads and ochre from Blombos Cave, with the primary purpose of sending messages (d'Errico et al. 2005; Henshilwood et al. 2009, 2011). It is likely, however, that the underlying capacity for these material signals evolved much earlier. The use of signs to index information can be directly linked to the origins of language (Knight and Lewis 2017), which would necessarily predate the investment in material signals. Recent discoveries of personal adornment items and art associated with Neanderthals suggest that the underlying capacity for signaling may have predated the emergence of anatomically modern humans (see Finlayson et al. 2012; Radovčić et al. 2015; Rodríguez-Vidal et al. 2014).

In order to better understand how we evolved our incredible ability to signal, as well as the roles signaling has had in shaping our societies, archaeologists have increasingly turned to signaling theory (Bliege Bird and Smith 2005). One subset of signaling theoretical applications that has received increased attention in the past decade is costly signaling theory. Originally developed in biology, costly signaling theory (CST) provides an evolutionary explanation for why people engage in seemingly wasteful behaviors and invest in extravagant material displays. Due to the unique opportunities and limitations in the archaeological record, archaeologists employing CST have transformed the initial theory into a new approach. Archaeologists have broadened CST's focus on individual reproductive fitness to community-scale phenomena, such as the creation, maintenance, and subversion of social hierarchy. However, some applications have been critiqued as just-so-stories (see Codding and

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Jones 2007), with a lack of scientific rigor, ambiguity over potential archaeological correlates, and a lack of awareness of the limitations of the theoretical approach. While CST has great potential within a broader evolutionary framework to the human past, archaeologists must continue to refine both the theoretical framework and the analytical methods used to study costly signaling in the archaeological record.

In this chapter, I present an overview of the current state of costly signaling theory research in archaeology. First, I trace its theoretical origins and history of adoption into anthropological archaeology. Second, I highlight key issues that archaeologists have been wrestling with in order to make CST applicable to the past. Third, I discuss the breadth of uses of CST in the recent archaeological literature. Fourth and finally, I present an analytical framework that can make CST more rigorous, and hopefully impactful, in the future. By situating archaeological applications of CST within a broader evolutionary framework focused on human interaction, information exchange, and material culture, signaling will likely continue to grow in importance within investigations of the human past.

What is Costly Signaling Theory?

CST is a theoretical approach designed to explain seemingly wasteful behavior. CST is premised on the following basic elements (drawing on Bliege Bird and Smith 2005; Boone 1998; Johnstone 1997; Smith 2010; Wright 2017, p. 548):

1. There is variation between individuals in a particular trait (e.g., genes, wealth) (Kantner and Vaughn 2012).
2. Individuals signal information to others (personal qualities) and interpret signals from others to help gauge their potential as ally, foe, or mate.
3. The underlying information being signaled is not immediately obvious to others (Glatz and Plourde 2011; Smith 2010).
4. Signals impose a cost on the signaler above and beyond the energetic costs of staying alive and reproducing. Resources that are dedicated to the signal must be able to be put toward other ends, such as survival and reproduction.
5. Signals must have an audience and must provoke a response from the recipients. Recipients of signals use signaled information about personal qualities to determine who to interact with and how they should interact. Both successful signalers and recipients can benefit from the decisions and actions taken by the recipient (Galle 2010).
6. The cost of signaling information should be substantial enough to either ensure honesty (that the signaler really has the quality being signaled) or to pose a significant debt on those attempting to fake the signal (partially honest signaling—see Kane and Zollman 2015). Cheating with costly signals is not a sustainable long-term strategy, as a cheated audience will no longer associate the signal with the underlying information (Neiman 1997; Quinn 2015).
7. Because both the signaler and recipient benefit from the exchange of information, there is long-term evolutionary stability selecting for the capacity for signaling. Honest costly signals ultimately save time and energy for all involved by reducing the need to find out the underlying qualities directly (e.g., ability to provide as a mate) (Gintis et al. 2001; Safi 2015). However, honesty is not a requirement of costly signals in biology or human behavior (see Higham 2014; Wandsnider 2015).
8. The signal that is used to communicate underlying information may change without changing the nature information being exchanged. Runaway signaling, where costs are exponentially increased with minimal increase in benefit, is not an evolutionary stable strategy (Gintis et al. 2001). As such, there is an upper limit on the scale of any one signal. When signals lose effectiveness, individuals may create new, different signals.

While all signals convey information, certain types of signaling provide additional benefits. Hawkes and Bliege Bird (2002) distinguish altruistic signaling from more wasteful signals. Altruistic signals, such as hunters sharing meat or throwing feasts, benefit signal recipients in more than one way. In addition to information, the audience receives other gains (e.g., additional calories) that wasteful signals (e.g., peacock tails, conspicuous leisure) do not convey (Hawkes and Bliege Bird 2002, p. 64–65).

Rather than wasting resources, costly signalers receive a social benefit as a return. While the social benefit may not match the resources put in, in some cases the return may exceed what was originally signaled (e.g., using a costly signal to secure an ally that may provide assistance in times of life and death). As such, signals—even costly ones—should not necessarily be seen as wasteful. CST provides a selective mechanism, rooted in human biology, for the capacity to send and receive signals. Archaeological applications of CST, however, have gone further. Archaeologists have used CST to explore what is signaled, how it is signaled, and why it is signaled in past cultural contexts. Before exploring some of these applications, it is necessary to trace the adoption of CST into anthropological archaeology to better understand its present uses and future potential.

Origins

There are three primary bodies of theory that form the pillars of modern applications of costly signaling theory in archaeology: (1) costly signaling in biology, (2) human behavioral ecology, and (3) non-evolutionary approaches to conspicuous consumption and the use of material culture to communicate information. Separately, each of these theoretical frameworks has advantages and disadvantages for identifying and interpreting signaling behavior in the archaeological record. When combined, they provide an opportunity for a theoretical synthesis that can explain the evolution of human capacity for signaling while taking into account diversity and contradictions within human signaling strategies across time and space.

Costly Signaling and Biology

The most direct theoretical lineage of costly signaling theory in anthropological archaeology can be traced back to biological approaches to animal signaling. In animal studies, costly signaling has been defined as something that increases the fitness of an individual by altering the behavior of recipients of the signal (Dawkins and Krebs 1978; Hasson 1994; Krebs and Dawkins 1984; Maynard Smith and Harper 1995). Fitness, in this context, is an individual's ability to have their genes represented in subsequent generations through both direct fitness (e.g., their offspring that survive to reproduce) and indirect fitness (e.g., genetic material shared with kin) (Bettinger 1991; Hamilton 1964).

Biological approaches to costly signaling are rooted in the concept of the handicap principle (Cronk 2005; Grafen 1990; Higham 2014; Wandsnider 2015; Zahavi 1975; Zahavi and Zahavi 1997). The handicap principle, originally formulated by Zahavi (1975), seeks to explain why animals engage in costly physical displays and invest in seemingly inefficient biological structures. Grafen (1990) expanded on the work by Zahavi to propose a series of models, including costly signaling, that sought to define that the benefits of these handicaps actually outweighed their costs for those who were able to shoulder them. The classic example of costly signaling in animals is a peacock's tail. Peacocks' large, colorful, and highly visible tails require a significant investment of calories to create and maintain while making them more susceptible to predation. Costly signaling approaches suggest that there are benefits to both peacocks via competition for mates and peahens to select mates that are able to shoulder significant parasite loads and the caloric demands to grow full tails. That peacocks' tails evolved and are maintained through natural and sexual selection suggests that the benefits outweigh the costs of these seemingly wasteful physical traits.

Biological applications of costly signaling have contributed to archaeological studies in several ways. First, they established that costly signaling can be an evolutionary stable strategy. While on the surface an action or characteristic might seem like a waste of resources, individuals actually receive benefits. Individuals that have the resources to invest in costly signals reap benefits in the form of increased reproductive fitness. If there is a genetic component to the signal, such as a physical characteristic like a peacock's tail or the cognitive capacity for symbolic behavior, then over time the strategy of individuals that signal will spread throughout the population.

Second, biological applications of costly signaling have emphasized that the honesty of a signal is of critical importance. In biological cases, the underlying quality that is being signaled (e.g., quality as a mate) is hidden and not immediately obvious to others. The cost of signaling is supposed to be high enough that individuals that do not have the underlying quality cannot produce the signal. Signals do not need to be truly honest, where if it is present it is guaranteed the individual has the underlying quality and where it is absent the individual lacks that quality (see Higham 2014; Wandsnider 2015). Instead, signals can be honest even when they index a scalar quality, where signals with a high cost will soon expose the dishonest signaler. Biological signals can also be honest and not costly (Grose 2011; Maynard Smith and Harper 2003; Searcy and Nowicki 2005). This has led some biologists to note that a cost "handicap" is not necessary for honest signaling that confers benefits on both the signaler and the recipient (Grose 2011; Számadó 2011, 2012).

Third, biological applications of costly signaling have demonstrated that signaling is a social process. Each signaling episode involves both a signaler and one or more recipients. While the costs are incurred by the signaler, benefits extend to both the signalers and the recipients. Signalers are able to attract other individuals to interact with them, while the recipients of signals are able to make more informed decisions about which individuals to interact with if they can accurately interpret them. Highly visible signals expand the potential audience and increase the benefit returned to the signaler.

Translating theoretical approaches from biology to anthropology and anthropological archaeology has historically been difficult (see Prentiss 2011). Costly signaling is no different. Biologists have critiqued the translation between the handicap principle and costly signaling in anthropology and other social sciences (see Grose 2011; Számadó 2012). These critiques note in the decades since Zahavi and Grafen, biologists have tested, revised, and added more nuance to animal signaling. Social scientists have relied on the original formulations even though the approaches in more recent animal signaling literature are often more in line with observations from social contexts (e.g., that a signal is costly is insufficient for demonstrating its role as a costly signal). As will be discussed below, archaeologists have made changes to adapt costly signaling to address anthropological questions with the particulars of the archaeological record. The end result is that costly signaling in archaeology is distinct from biological and economic approaches, though problems of empirical testing remain.

Costly Signaling and Anthropological Archaeology

Costly signaling theory became adopted into anthropology through human behavioral ecology. Human behavioral ecology is the study of evolutionary ecology of human behavior, focusing on the recursive relationship between human behavior and our species' evolutionary history (Cronk 1991; Herzog and Goodale, this volume; Prentiss, this volume Chaps. 1 and 11). Human behavior ecology approaches, compared with other similar approaches such as evolutionary psychology and dual-inheritance models, focus on subsistence and reproductive strategies (Nagaoka, this volume; Smith 2000; Winterhalder and Smith 2000). This approach often uses simple models, such as optimal foraging theory, to identify both when people optimize their resource and, more importantly, when people do not. Deviations from expected behaviors as predicted through these simple models are often a window into cultural values and taboos as well as individual agency (Gremillion, this volume). Additional explanatory models are needed to help explain when people do not optimize subsistence efficiency and resilience. This is where CST has fit into human behavioral ecology: CST provides an explanation for seemingly wasteful behaviors that must have an impact on reproductive fitness in order to be evolutionarily stable and persistent in human societies.

Early applications of costly signaling in anthropology were discussed under the handicap principle or show-off hypothesis. Hawkes (1990, 1991, 1993) examined how hunting behavior, especially for men, is influenced by the desire to show off skills and attract potential allies and mates. Examining torch fishing on Ifaluk atoll, Sosis (2000) found mixed support for the hypothesis that torch fishing is a costly signal of a man's work ethic, which followed work by Hawkes as well as Smith and Bliege Bird (2000) on Meriam turtle hunters. Boone (1998) modified the work by Zahavi and Grafen to explore how costly signaling in the form of altruism, what Boone calls magnanimity, evolved. From the start, these early adopters of costly signaling principles in anthropology distinguished between different types of signaling (e.g., altruistic vs. non-altruistic; mate selection vs. prestige).

CST received expanded attention in anthropology following the 2005 publication of a case for its potential explanatory value by Bliege Bird and Smith in *Current Anthropology*. Bliege Bird and Smith (2005) successfully situated signaling behavior as part of a wider suite of social activities and strategic interactions, making the case that behavioral ecological approaches and social theoretical approaches to conspicuous consumption, status, and communication can be integrated into a single approach they call signaling theory. This work drew heavily upon their previous research on Meriam turtle hunting (Bliege Bird et al. 2002; Smith and Bliege Bird 2000), as well as a wide range of case studies such as yam growing in Papua New Guinea and costly religious rituals (Boone 1998, 2000; Henrich 2007, 2009; Sosis 2003; Sosis and Alcorta 2003; Sosis and Bressler 2003).

The first application of CST in archaeology, and a key example in Bliege Bird and Smith (2005), was Neiman's (1997) examination of monumentality in Mesoamerica. Neiman developed a Darwinian theory of wasteful advertising, built on the work by Zahavi and Grafen, which sought to explain the spatial and temporal pattern of the Maya collapse. During the Maya collapse, an ecological disaster impacted the persistence of monumental architecture by spurring migration and increasing population density and audience sizes for signals. Neiman's work both introduced concepts of CST into anthropological archaeology and highlighted the need for quantitative approaches to identifying signaling in archaeological contexts.

Over the past two decades, archaeological applications have expanded beyond monumentality (e.g., Čučković 2017; O'Driscoll 2017; Wright 2017) to include major debates about big game hunting (e.g., Codding and Jones 2007; Fisher 2015; Hildebrandt and McGuire 2002; McGuire and Hildebrandt 2005; McGuire et al. 2007), religious behavior (e.g., Kantner and Vaughn 2012; Munson et al. 2014), trade and exchange (e.g., Quinn 2006a), collective action (e.g., Carballo 2013), art (e.g., Gittins and Pettitt 2017; Hodgson 2017), and material culture signaling (e.g., Neff 2014; Pierce 2017; Plourde 2008; Quinn 2015).

Non-evolutionary Approaches to Signaling

Costly signaling theory is not the only approach for exploring how actions and material culture convey social information (Cronk 2005). Since the 1970s, the communication of social information through material culture, often discussed under the concept of *style*, has been a central part of anthropological archaeological systematics (Sackett 1982, 1985; Wiessner 1983, 1985; Wobst 1977). As anthropologists, archaeologists consider the roles that artifacts and behaviors in the past may have played in promoting social cohesion and/or competition (Binford 1962; Goodale et al. 2011, p. 432). Researchers from diverse theoretical backgrounds continue to explore how actions and material culture convey social information and affect human decision-making (e.g., Appadurai 1986; DeMarrais and Earle 2017; Hodder 2012; Ingold 2013; Keane 2003).

Prior to the introduction of CST into anthropological archaeology, archaeologists used concepts such as conspicuous consumption (Veblen 1994), gift giving (Mauss 1924), and feasting (e.g., Hayden 2014) to explain seemingly wasteful behavior in the past. For each of these concepts, their importance is social: individuals use conspicuous consumption, gift giving, and feasting to create social capital or debt that could be transformed into political authority or power. These theoretical approaches, which were developed outside of a strictly Darwinian framework (but in some cases were operationalized in social evolutionary frameworks of processual archaeology), have been more widely applied than those from behavioral ecology. CST provides a complementary perspective that provides an evolutionary mechanism for how social information exchange and debt creation through seemingly wasteful behavior could first emerge and be maintained in humans.

The broader familiarity with concepts of conspicuous consumption, gift giving, feasting, and social information exchange have helped prime the field for the introduction and adoption of CST. Consequently, there is an opportunity for a broader synthesis that combines the theoretical insights of evolutionary approaches with social theoretical approaches to human behavior and group living to emerge. Galle (2010, p. 20) laments that biases against evolutionary approaches, which are often characterized as deterministic, reductionist, and devoid of individual agency, have made such a synthesis difficult. However, by recognizing the complementary nature of CST and agency theoretical approaches to material culture, decision-making, and the creation of identities, Galle (2010) provides an example of how such a broader synthesis would work in practice.

Yet many members of the anthropological archaeology community remain skeptical that CST, a concept rooted in evolutionary biology, can adequately explain social behavior (see Blanton 2016). While there continue to be valid concerns about several aspects of the theoretical approach and its utility to explain behavior in the archaeological record, the rapid expansion of CST in archaeology over the past two decades speaks to its broader appeal. In order for interpretations rooted in CST to become more broadly accepted within the field of anthropological archaeology, researchers must address several lingering issues.

Key Issues with CST and Archaeology

There are several issues in archaeological applications of CST that are the topic of ongoing debate, theory-building, and modeling. The strongest criticism of CST in archaeology has been that it is too often proposed as a "just-so-story"—an underdeveloped theoretical approach with an underdeveloped suite of predictive and testable models to be able to identify when costly signaling is and is not occurring (Codding and Jones 2007; Quinn 2015). I highlight five key issues that illustrate the dynamic nature of this theoretical approach and the need for CST proponents to continue to develop testable models of costly signaling in the past.

Challenging the Biological Dimensions of CST

Adapting theories from biology to explain the social lives and history of humans has been an issue that anthropologists have wrestled with for over a century. From the earliest proponents of Darwinian concepts to social evolution, the relationship between biological and social theory has been complicated. Recently, archaeologists employing evolutionary theory have more critically examined how models from biology are adopted into the discipline (e.g., Goodale and Andrefsky Jr. 2015; Prentiss 2011, this volume, Chap. 1; Prentiss et al. 2011). There are two aspects of how CST was first developed that must be modified for anthropological archaeology: individual selection and reproductive fitness.

In biology, CST individual organisms are the signalers and recipients of signals. Humans live in multi-scalar social systems, where collections of individuals (e.g., households, villages, polities) have the ability to make decisions (have agency) that may or may not reflect the choices of individuals within those collective social units. In several cases of signaling, such as large monuments (e.g., Neiman 1997), the signaler is not always a single individual. Roscoe (2009) has argued that signaling co-occurs at the individual and group levels. Using an example from contact-era New Guinea, he argues that while individuals seek authority through within-group signaling, the same signaling events, such as feasting, performances, and large-scale architecture, are used by villages to communicate with other villages (Wandsnider 2015, p. 72–73). Glatz and Plourde (2011) also hint at polities being capable of contesting territory through costly monumental architecture. Going forward, archaeologists will have to confront how group-level signaling might work, especially as it relates to broader concepts of who is incurring the costs and reaping the benefits of signaling.

Signaling in biology is also firmly rooted in the idea that the individuals that are capable of incurring the cost of signaling receive a return in increased quantity and quality of mates (Hasson 1994; Maynard Smith and Harper 1995). In biological and ethnographic contexts, it may be possible to monitor if the most active signalers actually have a higher reproductive fitness (see Smith 2004). In archaeological contexts, it is difficult, if not impossible, to measure individual reproductive fitness to see if it was increased by signaling. Madsen et al. (1999), building on Dunnell's (1989) discussion of the role of waste in cultural elaboration, suggest that fitness can be conceptualized as a statistical summary of real-world interactions of individual fitness (Madsen et al. 1999, p. 258).

Human signaling can provide returns in social prestige, an alternative to reproductive or inclusive fitness (see Hamilton 1964). While the ultimate benefit of added social capital is to be able to differentially survive and reproduce (e.g., social networks to buffer against subsistence failures), the proximate benefit of signaling may not result in that ultimate benefit. This added layer of benefit between signal and reproductive fitness means that signaling cannot simply be explained by counting the number of offspring that reach reproductive age. As a result, we must ask (1) can we measure reproductive fitness in the archaeological record, (2) can we link signaling behavior to specific reproductive fitness outcomes, and (3) does it really matter? Kantner (2010), p. 234–235) argues that while, according to human behavioral ecology, humans optimize utility, culture impacts what we actually seek to optimize. Rather than focusing on a single index of fitness, archaeologists have the opportunity to explore what attributes, resources, and relationships are the most important in a particular cultural context (see Madsen et al. 1999). As an evolutionary stable strategy, the capacity signaling—on average—has become widespread through its impact on individual reproductive fitness. The more socially dynamic aspects of signaling, such as how signals mediate social relationships, are more accessible through the archaeological record and more interesting to most anthropological archaeologists than reproductive fitness measures.

Costly and Non-costly Signals

One of the most important aspects in identifying costly signals in the archaeological record is to be able to distinguish costly and non-costly signals. To this end, many applications of CST situate costly signaling more broadly as part of "signaling theory" (e.g., Bliege Bird and Smith 2005). Previously, I have distinguished costly signals and non-costly signals based on how they relate to reproductive

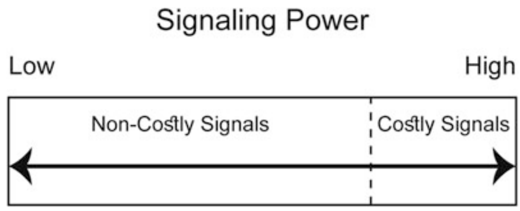

Fig. 14.1 Representation of the continuum of signaling power and the relationship between costly and non-costly signals (after Quinn 2015: Fig. 11.1)

fitness (Quinn 2015). Costly signals are more directly related to reproductive fitness than others, and some signals do not impact reproductive fitness at all. The power of a signal varies along a continuum based on how significant they are in broadcasting and enhancing reproductive fitness (Fig. 14.1). Non-costly signals convey social information, such as age, gender, and group membership, but this information does not directly factor in reproductive fitness. This may be because (1) there is no cost incurred by signaling, (2) there is minimal variation between individuals in the information being signaled, or (3) the signaled information is not received by an audience.

There is a point along the signaling power continuum where people treat signals differently. Below a particular threshold, non-costly signals are broadcast and received that convey information but do not raise or lower the social standing or opportunities for increased reproductive fitness for the signaler significantly. Above that threshold, costly signals are restricted to a smaller portion of society and actively impact the social standing and/or the biological fitness of both the signaler and recipients of the signal.

Whether a signal is costly and provides a social or biological benefit is dependent on its context. Each geographic, temporal, environmental, cultural, and sociopolitical context will have different information that is important to signal. A costly signal that enhances reproductive fitness in one context may neither be costly nor provide a positive return in another context. For example, the ability to hunt is an important skill to signal to others in most hunting and gathering societies. The ability to hunt, however, is not something that is actively signaled today in the streets of New York City. Instead, expensive cars, designer clothes, and the newest technologies signal key fitness attributes in the modern United States: wealth and access to resources. In state-level societies, where there is more segmentation within society (counter culture groups, subcultures, etc.), we should expect signals to vary widely depending on the identities of the signaler and desired audience. As a result, there are many communities within the modern United States where costly signaling through expensive cars, designer clothes, and the newest technologies may be considered gauche and repulsive. In these communities, costly signaling often takes other forms, such as investing time and money in community service or gaining eclectic knowledge.

Socio-ecological variation impacts the cost, information, and necessity of signals. The ecological differences among environments affect the predictability of access to resources, ability to restrict access to resources, and the ability to amass surplus resources. Archaeologists have long recognized that environmental predictability and uncertain access to key economic resources significantly impact cooperation and competition among communities (e.g., Halstead and O'Shea 1989; Winterhalder et al. 1999). As with other socioeconomic strategies, such as food sharing, warfare, and feasting, we should expect the nature of costly signaling to vary across different ecological and environmental contexts. In a case study comparing Rapa Nui and Rapa Iti, DiNapoli et al. (2017) argue that costly signaling may explain the divergent histories of communal investment in large-scale construction projects. People living on Rapa Nui invested in the construction of stone statues (*moai*) and large ritual monuments (*abu*), while people on Rapa Iti constructed fortifications amidst evidence of intergroup conflict (DiNapoli et al. 2017, p. 208). DiNapoli et al. predict that signaling should increase in contexts where key resources are more evenly distributed, as it is only through costly signals that groups can stand out from each other. Where there is heterogeneity in resources, the information about differences in competitive ability should be readily apparent in the access to uneven resources. They also predict that the investment into monumental signals should covary with the quality and availability of key resources. DiNapoli et al. suggest that communities on Rapa Nua invested in monumental ritual architecture and statuary as a way of signaling competitive ability in part because agricultural land was not easily controllable, unlike on Rapa Iti. This example highlights how environmental variability can impact socioeconomic strategies such as costly signaling.

The materials or behaviors available to signal an underlying characteristic will also vary across time and space. The signaling power of any object, monument, or behavior is socially mediated. Consequently, there are no universal criteria for distinguishing costly from non-costly signals. Instead, archaeologists must examine the broader social contexts in which signaling behaviors or materials were deployed and allow for the same signals to gain or lose their social power as costly signals (Quinn 2015).

The consequences for archaeologists are clear. There are no types of objects, raw materials, or behaviors that are inherently costly signals. Archaeologists must demonstrate, and not assume, that something is a costly signal based on characteristics of the object; its context of manufacture, use, and deposition; as well as the broader social context. Archaeologists employing CST must allow for signals to gain or lose signaling power and for signals to be either costly or non-costly. This requires an analytical approach that considers the characteristics of the signal, the signaler, the audience, and the broader social context in which signaling occurred. An example of such a framework is described below.

Costly Material and Behavioral Signals

There are two significant differences between costly behaviors and costly material signals that archaeologists must consider: honesty and archaeological visibility. Archaeologists must take into account these differences when developing models of costly signaling in the past.

Behavioral signals are more honest and more difficult to fake than material signals. In biology, costly signals such as peacocks' tails are honest signals that the individual has the caloric resources and can withstand a high parasite load to grow a large tail. In ethnographic contexts, such as torch fishing and turtle hunting, other individuals witness the behaviors, ensuring that the individual must have had the skill to complete the task. Material culture represents an additional layer between signal and the underlying attribute being signaled that decreases a material culture's signaling power. For example, a bear tooth pendant may indicate that the wearer killed a bear. However, they may have also taken it off a dead carcass, been given it as a gift, or stolen it. The uncertainty on whether the individual who possesses an object incurred the full costs of its production or acquisition diminishes the benefits observers assign to the signaler.

Behaviors are also more difficult to observe in the archaeological record. The material record encourages archaeologists to focus on objects. The physical characteristics, their production, use wear, and deposition are much more accessible to archaeologists than the full suite of behaviors in the past, some of which may not produce material traces that can be identified in the archaeological record. For example, Smith and Bliege Bird (2000) have identified turtle hunting as a form of costly signaling among the Meriam Islanders. Hunters dive for turtles as they swim, requiring strength, ability to control their breath, and knowledge of turtle behavior. Hunting turtles at their nesting sites would be much less costly. Indeed, 90% of turtles eaten during the year are taken when they are vulnerable on land (Codding and Jones 2007, p. 354). In an archaeological trash deposit full of turtle bones, it would be impossible to determine if, and in what proportion, hunters took the easy or hard way. Additionally, a collection of turtle shells would make a great material signal of an individual's hunting prowess. The Meriam, however, toss the turtle shells after they are processed. The lack of a curated material signal of the costly behavior does not diminish the hunt's signaling power for those who witness it. We cannot assume that every costly signaling behavior will be materialized in the archaeological record. The challenges of identifying costly signaling behaviors in the past are expanded in the next section.

Finding Costly Signals in the Archaeological Record

The most important debate to date about the visibility of costly signaling in the archaeological record occurred in *American Antiquity* in the 2000s. McGuire and Hildebrandt (Hildebrandt and McGuire 2002, 2003; McGuire and Hildebrandt 2005) published a series of studies about hunting practices in the Great Basin and California, arguing that communities were hunting bigger game for prestige. The prestige hunting hypothesis cast as CST by McGuire and Hildebrandt (McGuire and Hildebrandt 2005; McGuire et al. 2007) predicts that an increase in group size or frequency of social aggregations will spur individuals to target larger game to receive a social benefit for showing off their hunting skill (Codding et al. 2010, p. 56). The hypothesized archaeological signature of this process is that the relative abundance of large taxa in faunal assemblages will increase, leading to an increase in acquisition costs as hunters have to travel increasingly longer distances to find big game.

In response, Codding and Jones (2007; Jones and Codding 2010) challenged how McGuire and Hildebrandt applied costly signaling theory. Rather than expecting the relative portion of large taxa to increase when costly signaling in hunting was occurring, Codding and Jones suggest that prestige hunting may actually lead to an overall decrease in the archaeological abundance of large prey as only those able to incur the costs of procurement could take large game. Codding and Jones suggest that costly signaling hunting behavior would be difficult, if not impossible, to identify in the archaeological record. Codding and Jones draw attention to ethnographic examples of costly hunting behaviors (e.g., Bliege Bird and Smith 2005; Bliege Bird et al. 2001; Smith and Bliege Bird 2000; Smith et al. 2003; Sosis 2000). Ethnographic studies show that while costly signaling does occur, these events are rare and do not contribute significantly to the diets of communities. Only a few individuals engage in these high-risk hunting strategies and, even then, only rarely (Codding and Jones 2007, p. 350). As a result, costly hunting behaviors contribute very little to faunal assemblages in ethnographic contexts. Codding and Jones argue that any material traces of costly signaling hunting behaviors in the past would be overwhelmed by non-prestige-based provisioning activity (Codding and Jones 2007, p. 354). Instead of prestige hunting, environmental shifts that benefited large game populations may have led to a higher encounter rate (Byers and Broughton 2004; Codding et al. 2010). Based on the difficulty of identifying costly signaling in archaeological assemblages, Codding and Jones suggested restraint in extolling CST's value in archaeology until more work to model CST in archaeological contexts was completed, lest it become a "just-so-story" with no predictive or explanatory power.

In the subsequent years, several archaeologists have developed models for how to identify the material signatures of costly signaling in the archaeological record. Returning to prestige hunting in California and the Great Basin, Codding et al. (2010, p. 56) suggest that looking at butchery and transport patterns could be used to demonstrate whether (1) the increase in large taxa in faunal assemblages is due to an increased encounter rate or (2) that hunters continued to target large game despite an increase in acquisition costs. The incorporation of this additional line of evidence provides a more robust assessment of the costs associated with hunting that are needed before assessing whether hunters gained prestige from hunting large game.

Galle (2010, p. 27–30) provides a template for the archaeological expectations of costly signaling in a study on material culture in eighteenth-century Chesapeake-enslaved communities. Plantations diversified and towns and cities grew throughout the eighteenth century, and Galle predicts that the use of costly imported goods—such as metal buttons and refined ceramics—should have increased as the opportunities for slaves to interact with nonkin and strangers on a regular basis grew. Galle then proposes an abundance index that can be used to compare the distribution of imported goods across houses and between plantations. In her discussion of the origins of prestige goods, Plourde (2008) uses distance from source as a proxy for raw material acquisitions cost. Other archaeologists have also suggested that peculiar distributions and frequencies of artifacts in assemblages that cannot be explained by the function of objects may indicate costly signaling (e.g., Goodale et al. 2011). By combining testable hypotheses with quantitative measures designed to evaluate signaling strategies, Galle demonstrates how archaeologists can identify costly signaling in the archaeological record.

How Costly Signals Change Over Time

The diachronic dynamics of costly signals remain undertheorized. Most work has examined how costly signaling would first emerge (e.g., Plourde 2008). Much less work has focused on how signals change. In one example, Wright (2017) suggests that once Eurasian Steppe pastoral communities began using monuments as costly signals, new forms of monumentality replaced the early stone burial mounds to also serve as signals. For Wright, change in the medium of signaling is not symptomatic of a collapse of socioeconomic networks; instead they were replacements within an already established social strategy that monumental sites are effective signals (Wright 2017, p. 561). Elsewhere, I have argued that the signaling power of material culture items will necessarily drop over time as they become more easily available to individuals who did not incur the cost of their acquisition or production (Quinn 2015). In such a situation, it is not that medium of costly signaling *can* change over time; it is that it *must* change if they are to continue to be honest signals.

Any changes in socio-environmental contexts will impact the costs and benefits of signaling. As DiNapoli et al. (2017) have highlighted, there is a strong link between signaling strategies and the environment. In the uncertain and risky environment of Rapa Nui, signaling took the form of communal monument construction that emphasized cooperation (DiNapoli et al. 2017). As a consequence, less risky and unpredictable environments should diminish the payoff of communal signaling. As environments change, the types of signaling, as well as their costs and benefits, will likewise change. For hunting strategies, environmental changes often impact encounter rates of different types of game and therefore change the cost of acquiring big game. Changes in population density, inter-community conflict and alliances, marriage patterns, and technological systems—to name only a few factors—will also change the payoffs of different signaling strategies. Costly signals must therefore be studied as part of broader socio-environmental evolutionary trajectories. More work is needed to develop predictable models for how costly signaling should change over time.

The challenges and potential solutions to these key issues in archaeological applications of CST are best seen in the diversity of case studies in which it has been employed.

Current Applications of Costly Signaling Theory in Archaeology

The applications of CST in anthropological archaeology can be broadly divided into those that focus on costly signaling behaviors and those that focus on costly signaling materials. Costly signaling behaviors represent an intersection of cooperative and competitive actions. Signaling promotes increased, and more informed, interaction between the signaler and the signal recipients. At the same time, signaling is meant to allow certain individuals to increase their reproductive fitness often at the expense of competitors for mates. The tension between cooperation and competition in signaling strategies is a central aspect of most archaeological investigations of costly signaling behaviors.

One of the first applications of costly signaling in anthropological archaeology is in prey choice and big game hunting. Thanks to optimal foraging theory and prey choice models, archaeologists have had a long history of successfully evaluating hunting strategies. Foraging models make it possible for archaeologists to use deviation from predictions to be able to more systematically assess the social, cultural, and ecological contexts in which subsistence decisions are made (Bird and O'Connell 2012; Bird et al. 2013). Hunting strategies that target prey with either low returns or very high risks may be the product of hunting for prestige. As described above, McGuire and Hildebrandt have been at the forefront on these applications in anthropological archaeology (see Hildebrandt and McGuire 2002; McGuire and Hildebrandt 2005; McGuire et al. 2007), though their work has not gone without critique (see Broughton and Bayham 2003; Broughton et al. 2011; Byers and Broughton 2004; Codding and Jones 2007; Grimstead 2010; Hockett 2005; Fisher 2015; Morgan 2015; Simms et al. 2014). Speth (2010) uses CST to explain why human ancestors spent so much time and effort pursuing big and potentially dangerous prey when they could easily and more reliably acquire the requisite calories and protein by pursing a less risky hunting and gathering strategy. O'Connell et al. (2002) argue that the scavenging of big game during the Plio-Pleistocene is less consistent with provisioning and more consistent with a hypothesis of competitive male displays. Bird et al. (2009) have argued that the costs of big game hunting, in particular frequent failed searches and pursuits, are often underestimated within optimal foraging models. Lupo and Schmitt (2016) emphasize that the social rewards associated with big game hunting are usually limited to only a few select individuals. These works continue to highlight the roles of hunting beyond meeting basic subsistence needs.

A second collection of works on costly signaling behavior has focused on religion, ritual practice, and religious pilgrimage. The potential for religious behavior to be costly signals was first explored in depth by Sosis (2000); Sosis and Bressler 2003). In particular, the costs of practicing religion are often undertaken in highly visible contexts to promote intragroup cooperation (Munson et al. 2014). In one archaeological example, Kantner and Vaughn (2012) developed a model of religious adherence as a costly signal. Kantner and Vaughn postulate that (1) the strength of adherence to a religious system is an underlying attribute that is not easily visible; (2) devotees benefit from reliable information about who is, and who is not, committed to the religion; and (3) devotees benefit from broadcasting their adherence but that these signals would be ideal if they were not able to be faked by non-devotees (Kantner and Vaughn 2012, p. 69). Using case studies from Chaco Canyon and Nasca, Kantner and Vaughn argue that devotees can signal their commitment by undertaking costly pilgrimages to religious centers. Picking up and bringing back material culture objects, such as ceramics, can provide pilgrims a way to signal their devotion and for the audience back home to make better informed decisions about them. These costly signaling activities display a commitment to prosocial beliefs that would foster greater cooperation within the group and could confer prestige on those who coordinated them (Blanton 2016; Blanton and Fargher 2013; Carballo 2013; DeMarrais and Earle 2017).

Feasting is a third type of behavior that researchers suggest could be an example of costly signaling (see Ames 2010; Boone 1998, 2000; Nolan and Howard 2010). For several decades archaeologists have considered feasting as a possible mechanism to promote intergroup cooperation as well as status-driven competition between individuals, lineages, and polities (see Bray 2003; Hayden 1995, 2014; Hayden and Villeneuve 2011). Individuals throwing a feast take on the costs of providing food to others, and in return they receive a benefit of increased reputation and prestige. Only individuals with the ability to procure enough resources for a feast, such as through food production prowess or wealth, can signal—which ensures its honesty as a costly signal. Nolan and Howard (2010) suggest that a model of ceremonial subsistence in the Hopewell based on concepts of costly signaling may explain the rise and fall of Woodland period cultural elaboration in the Ohio River Valley. Ames (2010) suggests that costly signaling feasting behaviors, such as Northwest Coast potlatches, may have contributed to the creation of inequality.

Monumentality and mortuary practices, which combine material and behavioral aspects of CST, continue to be an important topic for employing costly signaling in archaeology (see Neiman 1997; Church 2012). Wandsnider (2013, 2015) has explored the roles of monumental civic architecture and signaling within and between Hellenistic Greek and Greco-Roman cities. O'Driscoll (2017) has argued that highly fortified defensive hillforts in Ireland were constructed as costly signals to convey the power and strength of a community to others. Looking at monuments constructed away from population centers, Glatz and Plourde (2011) argue that landscape monuments of Late Bronze Age Anatolia were used as costly signals to contest territorial boundaries. Wright's (2017) recent work on late prehistoric burial mounds in the Eurasian Steppe has explored signaling in pastoral communities. Silvestri et al. (2017) suggest that plant remains in Middle Bronze Age funerary contexts in Central Italy are evidence of costly signaling through the consumption of valuable food resources. Watson and Phelps (2016) use mortuary practices in early irrigation communities in the US Southwest to identify atypical burials. Watson and Phelps interpret atypical burials as representing acts of violence on the body at, or after, the death of the individual and argue that these practices—what they call "perimortem signaling"—are a form of costly signaling stemming from socialized violence. In one of the more classic examples of monumental architecture that has proven difficult to explain, several authors have explored the significance of *moai* from the Easter Islands (Rapa Nui and Rapa Iti) as costly signals of island communities' competitive ability to cooperate and defend its limited resources (DiNapoli et al. 2017; Graves and Ladefoged 1995; Hunt and Lipo 2011).

Material culture signaling has been explored in a wide range of artifact categories. Adornment items, such as beads, pendants, and buttons, are one of the more obvious artifact classes that signals information (see Galle 2010; Kuhn 2014; Quinn 2006b). Ceramics, which often vary in quality of production and decoration, are effective signals of identity, status, and interregional connections (see Galle 2010; Neff 2014). Groundstone artifacts made of rare stone such as turquoise have high acquisition and production costs (see Kantner 2010). Pipes, the most elaborate of which are often used in important social events, can communicate the status of their users (see Blanton 2016; Bollwerk 2016). More broadly, artifacts classified as "prestige goods," due to their scarcity or difficulty to produce, acquire, and maintain, have also been discussed as potential costly signals (see Ames 2010; Kantner 2010; Plourde 2008; Quinn 2006a). Even chipped stone tools, which are normally studied for their insight into prehistoric technological and economic organization, communicate information in a variety of contexts, from hafting styles, to blade caches, to ritual bloodletting (see Pierce 2017; Quinn 2015; Waguespack et al. 2009).

The diversity of applications of CST in the past decade indicates that the theoretical approach is growing in appeal across the globe. However, the challenges described above remain. While many archaeologists are beginning to use CST to develop testable predictions for costly signaling that can be evaluated in the archaeological record, some continue to use it as a post hoc explanation of a material record that contains perceived, rather than demonstrated, wasteful behavior. Additional modeling is necessary to harness the explanatory power of costly signaling in the archaeological record. In the next section, I provide a generalized framework for assessing material culture signaling power in its cultural context.

A General Framework for Assessing Material Culture Signaling

The signaling power of objects varies across time and space. This general framework serves as an analytical tool for archaeologists to assess the signaling power of material culture. This framework has previously been tailored to the study of lithics (see Quinn 2015, p. 207–212), though this more general version can be adjusted to assess the signaling power of any material culture category. This framework is based on the following premises:

1. The underlying attributes that impact reproductive fitness vary based on the social and environmental setting (e.g., hunting prowess in foraging communities vs. amassing wealth in state-level societies).

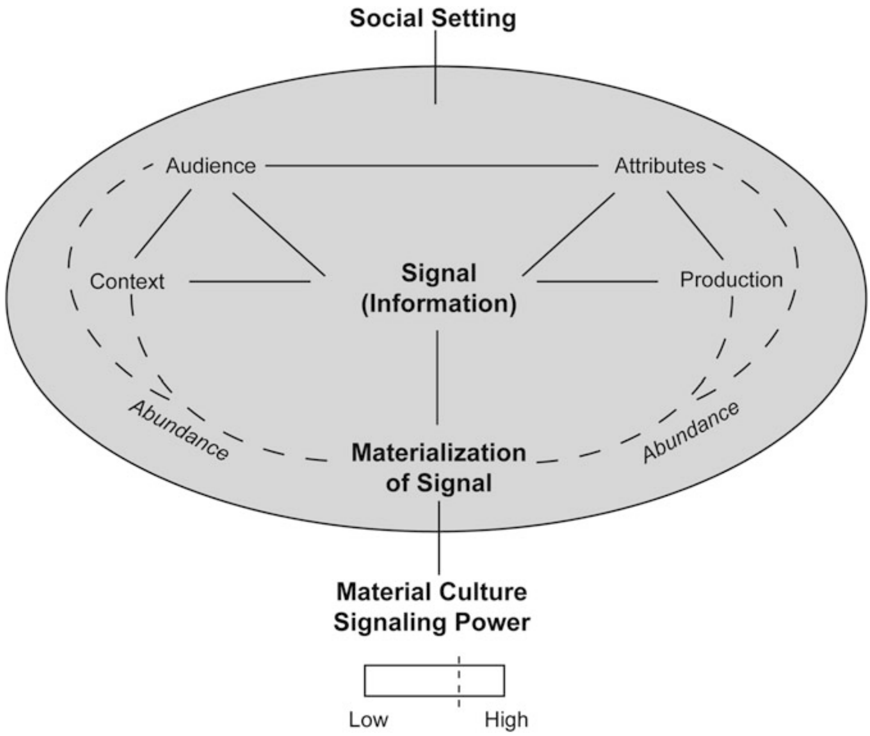

Fig. 14.2 A general framework for studying costly signaling behavior with material culture (after Quinn 2015: Fig. 11.2)

2. The costs of signals are the product of the physical attributes of the object and the social, economic, and technological systems that influence its procurement, production, distribution, and use.
3. The visibility of the signal is a product of its physical characteristics and the audiences that can see it in the situations where it is displayed.
4. The signaling power of an object is dynamic and subject to constant negotiation.
5. Signals will decrease in power the longer they stay in circulation, especially if they are able to be transferred easily between people.

With this framework, archaeologists can begin to quantify the relevant variables to provide a more empirical perspective on costly and non-costly signaling in the archaeological record.

There are several first-order variables that impact the signaling power of material culture: (1) the audience of the signal, (2) the contexts of use and discard of the signal, (3) the physical attributes of the signal, and (4) how the signal is procured, produced, and distributed (Fig. 14.2). These first-order variables are interrelated. As an example, consider the raw material of an object, which can be considered a second-order variable. The raw material an object is made of is a physical attribute of the signal, but it also impacts how the signal is acquired—such as being locally available or only available through long-distance exchange—and its visibility. There are several second-order variables that can serve as potentially quantifiable lines of evidence of the costs and benefits of the signals (Table 14.1). The costliest signals will be difficult to produce or acquire, made of exotic or very rare raw materials, highly visible, and used in social contexts with large audiences.

Costly material signals should rarely enter the archaeological record through loss, as their immense social value would lead people to search and recover them (see Schiffer 1987). The intentional

Table 14.1 Variables which archaeologists can study within the generalized framework in order to identify and explain material culture based costly signaling behavior in the past (after Quinn 2015: Table 11.1)

First-order variables	Second-order variables
Artifact attributes	Size
	Color
	Sheen
	Raw material (distance to source; distribution/access)
Production	Skill level required
	Time to manufacture
	Producer/consumer relationship
	Cost of maintenance
Audience	Relationship between signaler and recipient
	Population size/density
	Visibility of material culture
Context	Use context (daily life; ritual/event)
	Deposition context (caches, graves, votive offerings; loss; discard)

deposition of costly signals—such as in graves, ritual caches, and other votive deposits—would provide additional benefits to the signaler by demonstrating to audiences that they are able to withstand the loss of a valuable signal.

The abundance of material signals in circulation will significantly impact the overall signaling power of material culture. As objects become more common, it is more likely that individuals who do not have the underlying attribute being signaled could come to possess the signal. As audiences encountered these non-honest signalers, the link between the material signal and the underlying attribute would be weakened. The signaling power of all objects, even those possessed by honest signalers, would be lowered. At a certain point, the increasingly abundant objects would no longer be effective costly signals. We would expect the individuals who have the underlying attribute would find a new form of material signal (e.g., conspicuous destruction of the objects or a new type of object) to replace the original costly signal that is no longer honest. The feedback between the abundance of materialized signals and the variables that contribute to the signaling power of an object produces a tension that can lead to rapid changes in signaling strategies.

The approach outlined here begins with archaeologists assessing the information and attributes that most directly impact reproductive fitness in the particular socio-ecological setting. Next, archaeologists use second-order lines of evidence to reconstruct the first-order variables of audience, context of use and discard, physical attributes of the material, and procurement, production, and distribution system. This assessment allows archaeologists to reconstruct (1) how costly a signal is, (2) how visible a signal is, and (3) how well the signal indexes the underlying information being conveyed. Following this initial assessment, archaeologists must look to see how abundant an object is in the archaeological record to assess how well the object would work as an honest costly signal.

This general framework can help archaeologists produce testable hypotheses about signaling strategies in the archaeological record. For example, costly material signals should be rare enough that not everyone can adequately signal. People will seek out costly signals, and even fake costly signals, which over time will lead to an increase in the signal. Finally, signals should be abandoned when audiences determine they no longer accurately display the underlying information being signaled. Future work modeling the spatial-temporal dynamics of costly signaling will provide additional ways to measure signaling power, assess change in signaling over time, and distinguish costly and non-costly signals in the archaeological record.

Conclusion

CST represents a dynamic frontier in evolutionary approaches to the archaeological record. While archaeologists from many theoretical backgrounds have recognized that humans use material culture to convey information, CST provides a unique way of understanding (1) how this capacity first evolved, (2) how signaling fosters both cooperation and competition, and (3) how signals change over time. The global appeal of CST, perhaps best represented in a recent special issue of *World Archaeology* edited by James Conolly (2017), continues to grow. However, there remain significant issues that require additional theoretical models and analytical methods to resolve before CST can reach its potential as an archaeological theoretical framework. In order to explain human behavior through its material consequences, archaeologists must develop theoretical models to frame research questions and identify the data necessary to answer them (Codding and Bird 2015, p. 9). The continued development of CST will require additional conceptual models as well as new case studies. By considering how costly behavioral and material signals mediate social relationships, archaeologists can better understand how individuals influenced the organization and evolution of social, economic, and political systems in the past.

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