Journal of Anthropological Archaeology 35 (2014) 23–31

Contents lists available at ScienceDirect

Journal of Anthropological Archaeology

journal homepage: www.elsevier.com/locate/jaa

A tale of two technologies: Prehistoric diffusion of pottery innovations among hunter-gatherers

Jelmer W. Eerkens [a,*], Carl P. Lipo [b]

[a] University of California, Davis, United States
[b] California State University, Long Beach, United States

ARTICLE INFO

Article history:
Received 30 November 2012
Revision received 11 April 2014
Available online 13 May 2014

Keywords:
Diffusion of innovation
Pottery
California
Brownware
Hunter-gatherers
Luminescence dating

ABSTRACT

We examine the diffusion of a successful and an unsuccessful innovation among hunter-gatherers in the western Great Basin, using a diffusion of innovation model. Modern and historical studies on the diffusion of innovations suggest that diffusion processes follow S-shaped curves, with small numbers of early adopters, followed by more rapid uptick in the rate of diffusion as the majority adopt a technology, concluding again with small numbers of late-adopting laggards. Distributions of luminescence dates on surface-collected pottery sherds show that the technology had a long period of experimentation. Beginning about AD 1000, direct-rimmed pots were introduced in Southern Owens Valley and were used in small numbers over hundreds of years. Likewise, around AD 1350 pots with recurved rims were introduced in Death Valley and were also used in small numbers. Around AD 1550 the direct-rimmed technology diffused to the east, to China Lake and Death Valley, where it was rapidly adopted. By contrast, recurved-rim technologies were abandoned, a failed innovation. Our data suggest that prehistoric pottery diffusions follow a similar S-shaped curve, but that diffusion among hunter-gatherers happens at a much slower rate, over centuries instead of decades.

Introduction

One of the key components of human technology is information, and the means by which such information spreads among potential users. Anthropologists, especially archaeologists, have long made variation in technology a major focus of research. The archaeological record documents a remarkable and diverse range of technologies over time and across space. It is clear that technology, much more so than human biology, has been the major force in the spread of humans across the globe, promoting occupation of even the harshest of arctic, desert, and high altitude environments.

One long-standing pursuit of archaeologists is the identification of the oldest instance of a particular technology (e.g., Kuttruff et al., 1998; Pinhasi et al., 2010) since it is assumed that these events mark important inventions in human evolution (e.g., oldest fire, oldest tools) and their recognition contributes to national pride (e.g., oldest noodle). However, documenting the oldest often erroneously treats technological innovation as a single instance of human ingenuity (i.e., the ''solitary genius''), rather than placing technology in a broader evolutionary context. A similar argument can be made regarding the youngest, or last, instance of a technology (i.e., its extinction). As Basalla (1988) has argued, changes in technology are contingent since technological innovation continually borrows ideas and materials from other domains. The evolution of technologies, then, focuses on issues such as the technological environment and context of innovation, recombination and inheritance, the production and winnowing of technological variation, and rates of technological change (Henrich, 2001).

Such an approach is common among scholars of contemporary technology and it is not unusual to find ideas from the diffusion of innovation integrated into research (e.g., Hargadon, 2003; Henrich, 2001, 2009; Kameda and Nakanishi, 2002; Mesoudi and Whiten, 2008; Moore, 1991; Rogers, 2003; Wejnert, 2002). Archaeology, in contrast, has labored in isolation with its own limited and indiosyncratic language (e.g., Sackett, 1986; Schiiffer, 2002, 2005a, 2005b, 2008). Due to its general common-sense based treatment of technology, the diffusion of this body of scholarship into archaeological research has been slow, despite the suitability of archaeological data for contributing to hypothesis testing and theory building.

Diffusion of innovations

Research on the diffusion of technologies in contemporary and historical settings suggests that technologies are adopted within

* Corresponding author.
E-mail address: jweerkens@ucdavis.edu (J.W. Eerkens).

http://dx.doi.org/10.1016/j.jaa.2014.04.006
0278-4165/

communities in a predictable manner (Rogers, 2003). A community, here, refers to a set of individuals who regularly interact with one another. It is assumed that the members of a community acquire traits with a distribution of probabilities. Individuals who are never exposed to a technology have zero chance of adopting it (unless they independently invent it, see below), while increasing exposure increases the probability of adoption. The absolute probability for any individual is related to a host of factors discussed further below. As a result, individuals of a community rarely adopt new technologies in a simultaneous fashion (Moore, 1991; Rogers, 2003). Instead, technological change occurs over a period of time by individuals with different goals and needs.

Although individuals within a community may be aware of and exposed to a new technology at the same time, some are more apt to try it out. A fraction of those may then decide to adopt the technology, either adding it to the suite of items they already use or replacing an existing technology with the new one. Such individuals are often termed "early adopters" or "innovators" (Rogers, 2003). Ethnographic studies characterize early adopters as venturous (i.e., not risk averse) and readily able to integrate novel and/or complex technical knowledge (Moore, 1991). These early adopters and innovators also play an important role in the subsequent spread of a technology within a community.

Others within the community, the "majority," only acquire traits from adopters in a secondary fashion. Although these individuals delay potential benefits of adopting a new technology, they also minimize risk by viewing the success and failure of early adopters. Observing early adopters using a new technology provides additional information regarding social and economic impacts of new technology, thus reducing the costs of trial-and-error use. Finally, some individuals within a community, "laggards," will only reluctantly, or never, adopt a new technology, preferring long-standing solutions to meet their technological needs. These individuals are often suspicious of innovation and change agents and have a strong connection to traditional means. Typically, they are unable to buffer against the possible risks of failure if they were to adopt a new technology (e.g., Martinez et al., 1998; Uhl et al., 1970; though see Goldenberg and Oreg, 2007 for a different interpretation of laggards).

Any single community is composed of a mixed population of attitudes towards innovation adoption at any point in time. The combination of innovators, early adopters, majority, and laggards within a community helps explain the way a technology changes and diffuses, but this structure is a dependent value and does not "cause" an adoption pattern *per se*. Thus, with time arrayed on the x-axis and the cumulative number of adopters on the y-axis, we can generate an "adoption curve" for a given technology in a community, generating a characteristic logistic or S-shaped distribution of values over time. The slope of the curve varies as a function of cost and performance of the technology relative to the structure of the local environment and communities. The steeper the leading edge of the slope, the more rapidly that diffusion took place. While the speed at which a technology is adopted has been shown to vary (e.g., Fischer et al., 1996; Mansfield, 1961) the basic shape of the adoption curve has been replicated in study after study (Brown and Cox, 1971; see also examples in Rogers, 2003). Indeed, the regularity of this finding in modern and historical studies has led some to suggest that this basic process explains configuration of *all* diffusions of innovation (Mahajan and Peterson, 1985:8).

Determinants for the speed of diffusion can be divided into three broad dimensions. The first dimension is composed of the properties of the technology relative to alternatives. These properties include its relative performance advantage, cost, indirect benefits (economic, or convenience), compatibility (especially with values of a community and other existing technologies), complexity (highly complex technologies are less likely to be adopted), trialability, rate of beneficial returns (the faster the perceived return, the more likely a technology will be adopted), and observability (technologies that are easier to observe are more quickly adopted). The second dimension relates to the social and technological environment in which the technology interacts. This dimension includes how well an existing, competing technology is embedded within and/or interdependent with other parts of culture (the greater the number of interdependencies the lower the probability of adoption of a new technology) and the structure of the community, that is, whether individuals are alike (homophilous) or different (heterophilous) in their language and morals (more alike increases the probability). The third dimension concerns transmission of information within a community. This includes how individuals learn about a new technology (mode of communication; e.g., mass media vs. interpersonal, the former accelerating the rate of adoption) and how isolated a community and individuals within a community are from potential outside sources of innovation (communities on islands are often slower to adopt).

Together these dimensions explain why communities see rapid adoption of some technologies (e.g., mobile phone), while others have been slow to diffuse (e.g., electric vehicles), require state-level mandates (e.g., seat belts), or are not adopted at all (e.g., DVORAK keyboards) despite being generally perceived as "good" or "advantageous." Indeed, even "bad" or "useless" technologies, such as pet rocks, cigarette smoking, and the Windows operating system can be adopted by a majority of individuals within a community when costs are either negligible or difficult to assess over the lifetime of any individual, or are dependent on part of a contingent technological ecosystem.

Archaeological applications of diffusion of innovations research

Archaeological data are unlike historic and modern studies on the diffusion of innovations in two main ways. First, while archaeologists try to date artifacts as best as they can, the temporal resolution of most dating techniques, including luminescence dating of pot sherds used below, is at an altogether different scale than modern studies. For example, luminescence dates are associated with the measurement of events with a precision of roughly 10% of the absolute value in years. Thus, even in late prehistory, archaeological events have a degree of uncertainty measured in decades (for example, our average below is ±25.9 years, ranging between 8 and 160 years, for 167 luminescence dates). By contrast, modern ethnographic studies regarding the diffusion of modern innovations have error terms on the scale of months or weeks.

On the one hand, this difference may seem to put measurements of the archaeological record beyond the scale at which we can examine the diffusion of a technology. With such an uncertainty it is difficult to isolate individual events of technology adoption. In contemporary studies one may observe examples of technology diffusing through a community, often in a decade or less. Such examples suggest that archaeological descriptions may not provide good material for the study of prehistoric diffusions: our archaeological data may be at such a coarse scale that we cannot effectively observe and track a diffusion event. If so, a diffusion event will appear as a flash, with little evidence for "innovators," "early adopters," "laggards," and the like.

On the other hand, there is reason to believe that prehistoric diffusions occurred over longer periods of time. In the historic and modern cases, mass communication (e.g., radio, television), rapid transportation (e.g., automobiles, trains), and a greater degree of interconnectedness of people within communities rapidly spread information and knowledge about a technology over