Behavioral Ecology and Optimality:

Seeking alternative views

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Abstract: Compositional analysis were undertaken to understand if Tusayan Virgin Series ceramics were being traded between southern Nevada and the St. George Basin during the Pueblo III period to counteract the loss of a diverse resource base after the collapse of the trade networks with the Arizona Strip . This study suggests that Tusayan Virgin Series ceramics were not traded between the two regions and that ecological models of the economy may not fit preconceived notions of logical responses or optimality. The Uncertainty Avoidance Index is explored as a useful tool for understanding the psychological reasons behind less than optimal behavior.

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1.1 Introduction

Human behavior is unusually complex and seemingly patterned leading many anthropologists to assume that behavior is adaptively designed. If behavior is adaptive, we can expect to test hypotheses that explain human behavior under precise ecological conditions. In this framework, behavior is adaptive when it deals with ecological variations in ways that increase an individual's predilection to survive and reproduce (Bird and O'Connell 2006:143). In developing ecological predictions of advantageous behavior, adherents borrow heavily from the microeconomics of rational decision-making, specifically under circumstances of limited resources (Bettinger 1987:131). For instance, in foraging economies behavioral decisions are made to maximize net gain per unit of time and energy expenditure. This paper explores the usefulness of such claims by testing the hypothesis that groups will minimize risk and scarcity by expanding trade networks to different ecological zones - a proposition common in risk minimization in Behavioral Ecology research (Winterhalder 1990, 1997; Winterhalder et al 1999; Halstead 1989). Results from this study suggest that the breadth of trade networks in southern Nevada did not increase with growing risk or scarcity implying that human decision-making may not always be optimal or rational.

1.2 Behavioral Ecology and Optimization

Human Behavioral Ecology (HBE) has been used to study subsistence strategies among foragers ethnographically and archaeologically for over three decades (Thomas 2007; Broughton 1994; Smith 1991; Simms 1986; Bayham 1979) and to a lesser extent the origins of agriculture (Keegan 1986; Winterhalder and Goland 1993; Piperno and Pearsall 1998). HBE has been characterized by many as the phenotypic gambit (Bird and O'Connell 2006: 146; see

Winterhalder and Smith 1992; Grafen 1984) where natural selection favors efficient foraging behaviors to facilitate focus on other fitness related goals (Winterhalder and Kennett 2006). Therefore, phenotypes (in this case behaviors) are expressed by the interaction of the physical, social, and biological environments. Moreover, the phenotypic gambit assumes that it is irrelevant to understand if behaviors are enculturated or biological. Thus HBE's intrinsic purpose is to develop hypotheses that test the persistence of fitness-related behaviors in particular ecological settings and not to understand the mode of transmission behind behaviors (Bird and O'Connell 2006:146).

HBE hypotheses are developed by borrowing models from economics based on optimization analysis. Optimality models evaluate human behavior by gauging what the most rational decision would be for known ecological circumstances. Robust HBE models take into account risk sensitive behaviors that recognize the degree of luck innate to subsistence activities. As a consequence, these optimization models account for long term averages and unforeseeable shortfalls (Winterhalder and Kennett 2006:12). For food-producers, many optimization models assume that trade networks are established in other ecological zones to optimize resources and minimize risk (Halstead 1989; Winterhalder 1990; Winterhalder et al 1999; Connelly 1979; Ford 1983; Abruzzi 1989). The hypothesis tested in this study predicts that when trade networks dissolve, new networks will form in a different ecological zone as a way to minimize risk.

The assets of optimality models are their generalizability and their simplicity, but this may also make them culpable of being one-dimensional and difficult to test. Critics have argued that humans may not always behave in ways that optimality models expect (Sih and Chirstenson 2001). Detractors argue that HBE is flawed because it ignores cultural norms which guide economic behavior (Polanyi 1957; Binford 1983). However, Bettinger (1987:135) contends that

explanations of economic behavior grounded on enculturated norms become purely descriptive because they do not account for the origin of cultural norms. This paper seeks to remedy this situation by arguing that psychology may be the underlying reason for humans not behaving optimally or rationally.

1.3 Background Research and Hypothesis

Current research in the Virgin Branch Puebloan region indicates that during the middle Pueblo II period there were strong socio-economic mechanisms linking the lowlands in southern Nevada to the uplands in the Arizona Strip (Figure 1). Ties between these two areas are demonstrated by the presence of large numbers of ceramics produced in the uplands that have been recovered from lowland sites. Previous research on Virgin Branch pottery exchange has focused on the production zones and distribution networks of ceramics manufactured in the uplands (Harry et al 2013; Allison 2000; Larson et al 2005); to date, however, little work has been conducted explicitly on lowland ceramic production and trade. This study focuses on ceramics believed to have been produced in the lowland Virgin Branch region of southern Nevada.

Figure 1: Map of the Virgin Branch Puebloan Region

During the Pueblo II period, as many as half of the ceramics used at lowland sites in southern Nevada are believed to have been produced in upland areas (Harry 2005; Harry et al 2013; Allison 2000; Lyneis 1995); however, by the end of the early Pueblo III period (A.D. 1250) the trade networks with the uplands had collapsed. Coincident with the collapse of these networks there was an increase in the production of sand tempered ceramics in the lowland Virgin area (Lyneis 1992:41-43). This may be evidence for an increased amount of exchange between lowland households after the collapse of ties with the upland areas.

According to research in Behavioral Ecology, we can expect a balance between resource unpredictability and mechanisms that reduce this variation. Once exchange with the uplands had disappeared, lowland Virgin Branch Puebloan resources could have become more unpredictable

than before. As ecological studies have shown, one way to reduce risk is to diversify resource use to many different environmental zones (see Abruzzi 1989). For instance, if one zone experiences low agricultural yields, another zone may be able to make up the difference. Without the connection with the uplands, the lowland inhabitants could have had an increased risk of subsistence stress due to the loss of a more diverse resource base. Yet for any given society, we may expect a number of different risk reducing strategies. Many different ethnographers have shown that sharing, exchange, and ritual redistribution were important coping mechanisms for agriculturalists living in the harsh marginal environment of the American Southwest (Connelly 1979; Ford 1983). Moreover, archaeologists (Hegmon 1990; Kohler and Van West 1996) have also argued for exchange and sharing based models for the prehistoric Hopi and Chaco. Thus, the lowland Virgin Branch Puebloan, who had a very similar subsistence economy to ethnographic tribes, may have also used exchange or sharing as a risk avoidance mechanism.

The results of this study were used to evaluate the hypothesis that after the collapse of exchange relationships with the uplands, lowland households in southern Nevada began trading more with the St. George Basin in an effort to reduce the amount of resource variation. The St. George Basin was chosen because there are numerous Virgin Branch Puebloan settlements in the Basin presumably producing ceramics and trading throughout the region and the St. George Basin is ecologically distinct from the rest of the lowlands in southern Nevada and the uplands in the Arizona Strip. Neutron Activation Analysis was undertaken on fifty Tusayan Virgin Series ceramics from both House 47 and Main Ridge settlements in the Lost City Complex of southern Nevada and eleven clay and three sand samples from the St. George Basin, Utah and the Moapa Valley, Nevada in an effort to establish general areas of production.

1.4 Study Area and Environment

The lowland Virgin region examined here is situated in the Moapa Valley in southeast Nevada and the St. George Basin in southwest Utah. Generally, these areas are in the northern part of the Mojave Desert within the Colorado River drainage. Consequently, valley elevations tend to be lower and temperatures are higher than the Great Basin Desert to the northwest. The region is characterized by north to south trending mountains with peaks up to 10,000 feet above elevation and valleys that reach 246 feet below sea level (Fenneman 1931).

The environment of the Moapa Valley is characterized by hot short summers with temperatures reaching over 100 degrees F and short mild winters where temperatures can drop to freezing. Average precipitation is around 12cm a year with most falling in the winter (Houghton et al 1975). The growing season is relatively long, about 180 days. The Muddy and Virgin Rivers drain the region and may have attracted migratory water fowl, reptiles, rabbits, and other small animals (Sakai 2009:142). Vegetation includes creosote brush, bursage, and many varieties of mesquite and other riparian plants (Lyneis 1995: 204).

The environment of the St. George Basin supports Mohave Desert scrub including creosotebrush in the valleys and ponderosa pine forests, Great Basin Conifer Woodlands, Great Basin Desertscrub, and Interior Chaparral in the surrounding uplands. Average precipitation is close to 21 cm per year and mostly falls during the winter months. The growing season is long, over 200 days. The Virgin River and Leeds Creek-Quail Creek drainage meet within the Basin and along with numerous surrounding springs, creating a rich environment for numerous animals including rabbits, reptiles, and mule deer (Lyneis 1995:203-204).

Environmental Changes in the Greater Southwest

Site Descriptions

The Main Ridge Community dates to approximately the Pueblo II period and includes Houses 1-42, 44, and 45 of Lost City. The houses are situated on Main Ridge, a northeast to southwest ridge emanating from the Mormon Mesa. The ridge allows easy access to the Muddy River Floodplain and Virgin Valley below and presumably would have been used for farming or gardening. The Main Ridge Community does not have a site layout in the strictest sense; houses are situated on every available flat part of the ridge. The houses consist largely of multi-room with a few single independent room adobe and rock structures of varying shapes and sizes. The multi-room structures may loosely enclose a circular outside work space. Assuming that smaller structures were used as storage facilities, the multi-room houses can be divided into 32 habitation rooms and 87 storage rooms, thus suggesting a population of about 100 people most likely organized into small familial units (Lyneis 1992).

House 47 is a collection of 62 habitation and storage rooms set into two broad arcs enclosing two outside courtyards. Shutler (1961:15) places House 47 during the Mesa House Phase which is equivalent to the early Pueblo III period in the Pecos Classification. Until recently, House 47 was entirely covered by Lake Mead making it nearly impossible for further research to be conducted there.

Ceramic Assemblages in Southern Nevada

Three wares comprise the majority of the ceramic collections from sites in southern Nevada. These are the sand-tempered Tusayan Virgin Series ceramics, believed to have been produced somewhere in the lowland region; and the Shivwits Ware and Moapa Gray Ware

ceramics, both of which are believed to have been produced on the western end of the Colorado Plateau. These ceramics, and the implications of their changing frequencies over time, are discussed below.

Early archaeological research based on ceramics has shown that there are early and strong economic ties between southern Nevada and the Arizona Strip. These ties are present as early as the Pueblo I period, but reach their peak during the middle Pueblo II period (ca. A.D. 1000-1100) (Allison 2000; Lyneis 1992). More recent compositional work supports this notion of an increase in non-local ceramics and an expansion of trade networks into other ecological zones. Petrographic work by Margaret Lyneis has shown that Moapa Gray Ware is tempered with two different types of xenoliths that are both present near Mount Trumbull and in the Toroweap Valley on the Uinkaret Plateau. It is likely that Moapa Gray Ware was produced near these two locations (Lyneis 1988:2-4; see Figure 1). A pilot study utilizing Neutron Activation Analysis (NAA) has shown that Shivwits Ware pottery belongs to one compositional group and is chemically distinct from other ceramics found in the region. Based on these results, the authors concluded that Shivwits ware pottery was produced with a single basic paste recipe in the same area. The authors argue that Shivwits Ware pottery was produced on the southern part of the Shivwits Plateau in the Arizona Strip based on the criterion of abundance and the presence of dark firing iron rich clays which Shivwits Ware is likely produced from (Harry et al 2013; see Figure 1). Red wares also seem to be imported from the Kayenta region far to the east (Shutler 1961, Lyneis 1992).

The distribution of Moapa Gray and Shivwits Ware pottery shows that to the north and east of the production locations, there is a clear and substantial drop in the frequency of both of these wares; whereas both are found in abundance in southern Nevada to the west. Current

understanding of these distribution patterns do not currently support a simple gravity-model distribution where the interaction between two locations decreases with increased distance, time, and cost. Harry (2005), Allison (2000), and Lyneis (2005) have argued that the formation of this directional trade network likely was due in part to a lack of fuel wood for firing pottery in the Virgin lowlands. Allison (2000) has further argued that these trade networks were based on interactions between families across the landscape. Ethnographically, it has been shown that trade allows for social networks to remain open so that resources may be accessed should the need arise (Ford 1972). However, by the end of the early Pueblo III period (A.D. 1250) the trade networks with the uplands in the Arizona Strip had presumably collapsed because of the lack of Moapa Gray Ware and Shivwits Ware in assemblages in southern Nevada. Coincident with the collapse of these networks there was an increase in the production of sand tempered ceramics in the Virgin lowlands (Lyneis 1992:41-43). This may be evidence for an increase in exchange between lowland households after the collapse of ties with the upland areas.

1.5 Tusayan Virgin Series Pottery

Tusayan Virgin Series ceramics are a sand tempered, gray or white firing pottery that occurs in both plain and decorated forms (Colton 1952). Distribution studies indicate that during the middle Pueblo II period Tusayan Virgin series ceramics make up around 60% of site assemblages in the Moapa Valley; with Moapa Gray Ware, Shivwits Ware, and occasional red wares comprising the rest. In late Pueblo II and early Pueblo III site assemblages, Moapa Gray Ware and Shivwits Ware ceramics all but disappear, and Tusayan Virgin series ceramics increase in frequency to comprise more than 95 percent of the assemblage (Lyneis 1992:41-43).

Current archaeological research suggests that at least some of these ceramics were locally produced in the Moapa Valley (Lyneis 2005). Margaret Lyneis has shown that there are at least two different subtypes present, as reflected by the aplastic inclusions. One subtype consists of sherds tempered predominately with well-rounded, clear to white quartz sands, while the other subtype consists of mixed sands. Thin-section analysis suggests that the quartz sands come from Pleistocene gravels underneath the Yamashita sites in the Moapa Valley and that the mixed sands derive either from the Virgin Mountains or the St. George Basin (Lyneis 1992, 2005).

In addition to the variation in the sand temper, refiring experiments conducted by Jim Allison (2000) demonstrate that there are at least eight different color groups and thus at least eight different clays associated with Tusayan Virgin Series ceramics. All of these studies hint that there is sufficient geologic variability within the lowland Virgin region to compositionally differentiate the archaeological ceramics and thus the changing exchange networks among lowland households.

1.6 Results of Neutron Activation Analysis

As a first step, the data was compared to the results from previous NAA studies from the Virgin Branch region (Harry et al 2013; under preparation). These studies resulted in the identification of one compositional group for Shivwits Ware pottery and three compositional groups for Moapa Gray Ware pottery. This study presents the addition of two more compositional groups of Tusayan Virgin Series pottery to the enlarged Virgin Branch dataset (Figure 2). Membership probabilities based on Mahalanobis distance from group centroid show a clear statistical separation between Tusayan Virgin Series ceramics and the rest of the Virgin Branch database.

Figure 2: Plot showing the now enlarged Virgin Anasazi database with the Tusayan Virgin Series ceramics clearly separated from the other wares.

Tusayan Virgin Series Group Structure

Although Tusayan Virgin Series ceramics are chemically very similar, A principal Component plot (Figure 3) and membership probabilities both show separation between the two macro compositional groups. Although two small outlier groups (Groups 3 and 4) were also identified, groups with small numbers of specimen should be considered tentative because robust statistical techniques cannot be used to evaluate them.

Figure 3: Principal component plot showing group separation.

Further investigations of Group 1 in elemental space showed that Group 1 could be separated into two subgroups (Figure 4). The subgroups were validated by performing a principal component analysis of Group 1 and using the resulting PC's to calculate the membership probabilities. Overall, these data suggests that Tusayan Virgin Series ceramics may have been produced in two different locations within the same general area or had two slightly different paste recipes. Comparisons with raw clay and sand temper mixtures show that these ceramics

may have been produced in southern Nevada, although more geologic samples are needed to fully evaluate the validity of this conclusion (Figure 5).

Figure 4: Bivariate plot of Tantalum and Europium showing Group 1 separation.

Figure 5: Canonical discriminant function comparing compositional groups to clay and sand samples.

1.7 Discussion

From a generalized perspective, the data tentatively suggest that many of the sherds from both House 47 and Main Ridge were being produced in southern Nevada and possibly in the Moapa Valley. It is interesting that no sherds had any kind of chemical similarity with clays and sands originating in the St. George Basin. This suggests that local production and exchange may have been more important than previously thought for the Virgin Branch Puebloan in southern Nevada. However, more samples will need to be analyzed from both the St. George Basin and

from other sites in southern Nevada to see if there was a lack of trade between the two regions or directional trade between southern Nevada and the St. George Basin.

Relative frequencies of sherds within each group and subgroup suggest changing trade ties from the Pueblo II to Pueblo III period. Tusayan Virgin Series ceramics found at Main Ridge tend to be dominated by chemical Groups 1 and 2, whereas, House 47 tends to have ceramics overwhelmingly assigned to chemical Group 1 (Table 1). According to the criterion of abundance, ceramics are produced where they are most frequently found. Since most of the sherds from Main Ridge and House 47 make up chemical Group 1, it suggests that chemical Group 1 may represent the sherds that are being locally produced in the vicinity of Main Ridge and House 47. Furthermore, Arnold (1981, 1985) predicted that the average ethnographic resource procurement zone was approximately 7 km around the manufacturing location. Since House 47 and Main Ridge are within two miles of each other, it seems likely that Group 1 contains locally made ceramics. Group 2 on the other hand may be from a much farther distance in southern Nevada such as the Mesquite, Nevada locality. If these assumptions are correct, this suggests that Main Ridge and other Pueblo II settlements may have been trading broadly in southern Nevada at the same time as the trade with the uplands in northern Arizona was at its peak.

Table 1: Number of samples in each compositional group separated by site.

Sherd frequencies in subgroups show that House 47 emphasized both Group 1A and Group 1B; whereas Main Ridge emphasized Groups 1B and 2 (Table 2). This in turn suggests that during the Pueblo III period there was either a realigning of trade ties to emphasize the acquisition of Group 1 ceramics over that of Group 2 or the increased production of ceramics in the surrounding areas of House 47. Thus House 47 and other Pueblo III period settlements seem to have been trading less with other settlements in southern Nevada at the same time that the trade connections with the uplands were lost. In this case, Pueblo III settlements may have become more insular during the later years of occupation. The dissolution of trade networks with the uplands could have made the resource base in southern Nevada so unpredictable that households became more concerned with their own survival. This has been noticed in ethnographic cases,

where families tend to look after their own instead of trying to help other members of a community in times of stress (Colson 1979).

Table 2: Number of samples in each subgroup separated by site.

More importantly, this research tested the hypothesis that there were increased ties with the St. George Basin to reduce the risk of food stress in the lowland Virgin Puebloan region during the early Pueblo III period. The data suggests that Tusayan Virgin series ceramics may not have been moving between the St. George Basin and southern Nevada. As a result, the risk reducing hypothesis was invalidated.

It is possible that the insular nature of Pueblo III settlements contributed to the abandonment of the region because of the lack of subsistence risk reducing strategies or possibly, from a lack of social connections with other settlements. Jim Allison (2000) has argued that the

trade with the uplands may have taken the form of social rituals based around agriculture. If this is the case, then the breakdown of social rituals, which have been shown to be very important to the ethnographic pueblos, and the increasing isolationism of settlements may have been detrimental to the continuance of Puebloan society in southern Nevada. Further compounding the issue would be the lack of exogamous families or clans for young individuals to marry into.

The question now becomes, why did the Virgin Branch Pueblos not start trading with peoples living in the St. George Basin as the Behavioral Ecology literature suggests. To answer this question, it may be useful to use the Uncertainty Avoidance Index (UAI) developed by social psychologists (Hofstede 2001; House et al 2004). These indices reflect how uncomfortable a society feels with ambiguity or uncertainty. While this paper makes no attempt to directly assign UAI scores to ethnographic or archaeological cultures, UAI studies have shown that cultures that score similarly also possess related traits. Cultures with strong UAI indices tend to exhibit ideas of strong social control and are intolerant of eccentric behaviors. Cultures with low UAI behaviors tend to be comfortable with unstructured environments with little regulations.

In the case of the American Southwest, ethnographic pueblos tend to have a high degree of social control and intolerance of peculiar behavior. Among the Tewa Pueblos, for instance, war chiefs guarded the village, maintained religious hegemony, and guarded against deviations in ideology. War chiefs could punish anyone who refused to participate in ceremonies or who were neglecting social obligations (Arnon and Hill 1979:300-302). This suggests that ethnographic Pueblos had a relatively high avoidance index given that similar traits are found among modern cultures that scored high on the UAI. This is not surprising considering the high degree of risk involved in pursuing agriculture in a desert environment with low moisture patterns. A lack of risk/uncertainty management behaviors would spell almost certain catastrophe

for maintaining an appropriate level of food. As Ford (1972) has pointed out, exchange was used as a way to manage the risk of not having enough food in a highly variable environment.

Consequently, the Virgin Branch Puebloan may have also had a strong Uncertainty Avoidance Index and it is possible that they also used exchange as a way to buffer against uncertain resources during the Pueblo II period as many archaeologists have argued (Harry et al 2013; Allison 2005, Lyneis 2005). Therefore, it is interesting that they did not trade with the St. George Basin as a way to continue to use exchange as a risk-reducing strategy. However, the hypothesized strong UAI may aid in explaining the divergence from the St. George Basin. As mentioned previously, high UAI cultures tend to not like change. If as Allison (2000) suggests, trade networks were based on agricultural rituals between southern Nevada and Arizona, the breakdown of these social rituals would have been detrimental to Puebloan society. Therefore exchange with the St. George Basin may not have been a perceived option because those households were not originally included into the directional exchange system between southern Nevada and Arizona.

Although optimal modeling can be useful for studying baseline data and understanding the general adaptability of behaviors and decisions, we must also take into consideration that perceptions may weight down or change these same optimal computations. In other words, ideology and culture may skew the rationale behind optimization and allow groups to seemingly choose the less rational or adaptable path.

1.8 Conclusions

Many ecological studies propose that exchange works best as a buffering strategy when communities are situated in different environmental zones (see Abruzzi 1989; SOURCES). It was hypothesized that southern Nevada would have increased the breadth of their trade networks

to include settlements located in the St. George Basin during the Pueblo III period to stymie the loss of trade with the Arizona Strip. Current data suggests that trade may not have occurred between southern Nevada and the St. George Basin. A hypothesized high Uncertainty Avoidance Index further proposes that exchange may not have occurred between these two regions because of the conservative nature of Puebloan society. This contradicts many ecological and economic theories based on optimization that assumes people are logical and take the most rational and beneficial action. This paper proposes that this is not always the case. That culture or psychology may get in the way of people acting in the most rational ways.

1.9 Acknowledgements

I am grateful for feedback on drafts of this paper from the editors, anonymous reviewers, and Dr. Karen Harry. Mike Glascock, Jeff Ferguson, and Wes Stoner have been invaluable with their technical expertise. This research was supported in part by a grant from the National Science Foundation (#1415403) to the Archaeometry Lab at MURR, The Graduate and Professional Student Association at the University of Nevada Las Vegas, and the Angela Peterson Research Fellowship. Finally, I would like to thank the staff of the Lake Mead National Recreation Area, National Park Service and the Parashant National Monument for providing the ceramics used in this study.

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