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PAPER

ANTHROPOLOGY

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Theory and the Scientific Basis for Forensic Anthropology*

ABSTRACT: Forensic anthropology has long been criticized for its lack of a strong theoretical and scientific foundation. This paper addresses this problem by examining the role of theory in forensic anthropology at different hierarchical levels (high-level, middle-range, and low-level) and the relevance of various theoretical concepts (taphonomic, agency, behavioral archaeology, nonlinear systems, and methodological theories) to the interpretation of forensic contexts. Application of these theories to a case study involving the search for the WWII Goettge Patrol illustrates the explanatory power these theories offer to the interpretation of forensic events as the end product of an often complex set of environmental constraints and behavioral interactions and choices. It also emphasizes the importance of case studies in theory building and hypothesis testing. A theoretical foundation does indeed currently exist in forensic anthropology; however, a recognition and broader implementation of anthropological (archaeological) theory is warranted and will further define forensic anthropology as a scientific endeavor.

KEYWORDS: forensic science, forensic anthropology, high-level theory, middle-range theory, low-level theory, archaeology, case studies, Guadalcanal, WWII Goettge Patrol

Defining and Demystifying Theory

Dirkmaat et al. (1, p. 34) note in their recent review of the current state of the discipline that forensic anthropology has, in the last 20 years, undergone a "genuine paradigm shift." This shift is characterized as a change in the entire contextual framework and perception of the discipline, encompassing not only the types of questions being asked and the ways in which they are answered, but the very definition of the discipline itself. No longer seen merely as a laboratory-based applied subfield of physical or biological anthropology centered around the determination of the biological profile, its definition is broadened to include the scientific study of an individual's pre and postlife history as well as "the physical and forensic context" in which he or she is found (1, p. 47).

Before recognition of this new paradigm can proceed, a consideration of the theoretical underpinnings of the discipline must be addressed. A sound theoretical foundation lies at the heart of all scientifically credible disciplines. With the challenges of scientific validity brought forth from the *Daubert* (2) and *Kumho* (3) rulings (also see 4, 5) as well as recent criticisms of the scientific basis for forensic science in general (6), it is extremely important to address this issue for the future health and vitality of our discipline.

At its most basic, a theory is simply an explanation of observations. Theories are variously defined as "…particular ways of thinking, analyzing, and reflecting…" (7, p. xi) and as "…the tools anthropologists [and others] use to give meaning to their data" (8, p. 1). Following Schiffer (9), theories are defined here as a set of basic premises or postulates that can be used to explain empirical phenomena. As the character Ben Cortman said in the classic horror film *The Last Man on Earth*, "Theory is the beginning of solution" because it can lead to answering questions raised by the empirical data.

Theory in Forensic Anthropology

Forensic anthropology has long been critically perceived as lacking in theory (10). Although theory has been an integral part of the discipline of anthropology since its beginning in the 19th century (7,8,11), a broader theoretical basis for much of what forensic anthropologists do has been under debate; for example, Ubelaker (12) states that "Broad anthropological knowledge is almost always needed to properly interpret a forensic case" (p. 49). However, Nordby (10), when discussing forensic taphonomy, asks the question: "Are the forensic taphonomic cases before us so particular, with conditions so unique to specific circumstance that no general bodies of theory, or no specific theoretical models, can even apply?" (p. 39). He (10) goes on to state: "Facing multivariate, apparently unique factors, familiar in death assemblages and disease processes alike, remains the rule rather than the exception in the development of a scientifically bound theoretical structure" (p. 39). Is a comprehensive, unified theory in forensic anthropology possible?

We propose here that, given the often separate goals in forensic anthropology of reconstructing biological profiles and reconstructing past behavioral events (and considering the uniqueness of many of these biocultural events), we cannot simply rely on the traditional approach of thinking about theory as a single overarching explanatory statement. In actuality, just as there are multiple and hierarchical levels of personal identification used for individuation (e.g., presumptive, tentative, and positive), so too are there multiple and hierarchical levels of theory that can address these often disparate goals in forensic anthropology. Following Schiffer's (9)

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organization of archaeological theory, these can be characterized as high-level, middle-range, and low-level and vary in usage according to the contextual circumstances of the forensic scene and the forensic questions being asked. As will be seen, many of these theoretical approaches are already being utilized by forensic anthropologists (albeit unrecognized), while others we propose here are derived from the field of archaeology and adapted to the special needs of forensic anthropology.

High-Level Forensic Anthropology Theory

Theories that serve as broad, all-encompassing abstract explanations for a multitude of specific circumstances are designated as High-Level (9). By definition, higher-level theories hierarchically subsume lower-level ones. The overarching theoretical umbrella governing biological anthropology is that of biological evolution following the Darwinian (phyletic gradualism) as well as punctuated equilibrium models (13–16). This, to some extent, may also be said to be true of forensic anthropology, particularly in terms of evolutionary explanations for human biological variation. Determination of the biological profile rests upon our understanding of the evolutionary forces affecting human variation, which, in turn, include theoretical bases for the biological processes of skeletal growth, development, degeneration, and microevolutionary (secular) change (17). For example, secular changes not only in height and body proportions (18–22) but also in cranial shape and form (23–25) over the past century and a half have had significant impact upon our interpretation of ancestry and stature and have been explained through a combination of genetic change (particularly the effects of natural selection) and environmental (phenotypic) plasticity.

While these evolutionary processes form the foundation for understanding *population* variability and change (the level at which evolution works), the focus in forensic anthropology is often on the *individual*—whether it be the determination of his or her biological profile or reconstruction of perimortem and postmortem events affecting that individual. This requires an inferential extrapolation of population data to isolated cases. Because of these necessary inferences, "uniquely configured methodological approaches" (1, p. 47) in forensic anthropology have been called for, in contrast to other anthropological subfields. We argue here that unique *theoretical* approaches are also needed. These operate at the middle- and lower-range levels to more specifically address the needs of interpreting the individual in a forensic context.

Middle-Range Forensic Anthropology Theory

A concept originally developed in sociology (26) and applied to archaeology (9,27), the goal of middle-range theory is to transform the static, observed archaeological or forensic record into inferential statements about the dynamic activities that produced that record. While these theories are not considered "high-level" theories (such as those of natural selection and evolution), they do serve to link material remains, their context, recovery, and interpretation to human behavior and ultimately to the explanation of that behavior. This is often accomplished through actualistic studies, or "documentation of modern processes and the visible effects and patterns they produce" (28, p. xix). Such experimental studies are relevant based on the concept of uniformitarianism, which states that geophysical processes observed today are comparable to those of the past. There are multiple expressions of theory in forensic anthropology and archaeology that could be characterized as "middle-range." These include taphonomic, behavioral, agency, and nonlinear systems theories.

Taphonomic Theory

Taphonomic studies in forensic anthropology can be defined as examples of middle-range theory because they link static observations to the dynamic natural and cultural processes in the past that created them (27,29). These theories have also been referred to as "reconstruction" theories (9), dealing with the impact of site-formation processes (natural and cultural transformations of the archaeological record) that affect our interpretation of the past.

There have been numerous discussions of the theoretical basis for taphonomy (30–32). While initially developed in paleontology to factor out biases in the fossil record because of differential preservation (28,33), in forensic anthropology, taphonomy is used to examine the roles of human as well as nonhuman natural forces as taphonomic agents affecting the forensic scene. Taphonomic forces are not seen as merely sources of bias but as important sources of information aiding the reconstruction of forensic events (1). Forensic taphonomic research thus focuses on processes of decomposition and decay, animal and plant disturbance, and a host of other environmental influences (as they are observed in modern, experimental settings) to enhance inferences about the effects of these processes in the past. Another important aspect of this research is contextual—observing differential decay and preservation of material remains on the surface, buried, wrapped in cloth, submerged in water, burned by fire, etc.

As regards context, the incorporation of archaeological field methods for recording and interpreting temporal and spatial context has enhanced the ability to reconstruct the taphonomic effects on crime scenes and other forensic settings. This includes the use of standard archaeological mapping equipment as well as geophysical remote sensing devices, such as ground penetrating radar (GPR).

Dirkmaat et al. (1) note the linkage between not only taphonomy and forensic archaeology but also trauma analysis as well stating that "…the data necessary for the interpretation of all of these elements (trauma and taphonomic factors) do not come exclusively from the human remains but also from the context in which they are found and require careful archaeological recovery" (p. 44). Thus, the collection and interpretation of contextual information about material remains—human and nonhuman—are vital in enhancing the interpretation of a forensic scene. This reinforces the "tightly knit" relationship (1, p. 45) linking archaeological, taphonomic, and laboratory analyses and the need for theories that incorporate and unify all these dimensions.

Agency and Behavioral Theories

Archaeological theory can provide broader applications to forensic anthropology beyond taphonomic theory—other elements of archaeological theory can be used to model, interpret, and explain specific behavioral events, their sequence, and consequences (34). Aspects of agency theory (35–39) as applied to archaeology have clear implications for forensic anthropology. Influenced by social theorists (40–44), this theory deals with the role of the individual in social situations. As Beekman (35) defines the theory, it involves agents "whose actions instantiate the wider rules and resources that constitute the structure of society (43), but who are in turn constrained or enabled by those structural features in a recursive or dialectical relationship." Thus, in some situations, the individual agent can act independently because he "maintains some autonomy" (36, p. 89), but in other situations, social institutions, norms, or other factors limit, control, and channel the behavior of individuals or small groups. Following this perspective, we can conceptualize agents "so as to fully appreciate their folly,

rationality, short-sightedness, inaction, perspicacity, will to power, and uncontrolled desires'' (35, p. 69) without losing sight of the role of society in directing or filtering human behavior.

The roles of several individuals or agents should be recognized when interpreting a forensic scene. Agency theory thus links to another form of middle-range or reconstruction theory—behavioral archaeology (45). Schiffer and Skibo's (46) concept of a behavioral chain is recognized by agency theorists (38) as being a fruitful middle-range application of agency theory. Here, different agents, along a sequence of production events, evaluate and alter various items (raw materials and tools) based on their performance characteristics at each stage in the sequence. Schiffer and Skibo (46) note that ''In identifying the causal factors at work in a specific case, the investigator must focus analytically on activities—that is, on people–people, people–artifact, and artifact–artifact interactions—and on the performance characteristics relevant to each'' (p. 27). While Schiffer and Skibo (46) specifically focus on the explanation of archaeological artifact variability, the concepts of performance and revision can be directly applied to modeling the forensic scene and the actors (agents) involved. Behavioral chain segments that are relevant to crime scene interpretation include analysis of procedures for procurement, transport, use, and disposal of material remains (both human and nonhuman); for example, if we are dealing with a crime scene (e.g., homicide), the perpetrator and the victim are clearly agents whose interaction and the material remnants of that interaction are elements creating the scene. The physical context of the scene—its structure, as defined by its environmental (e.g., temperature, humidity, topography, and vegetation) and cultural (in or near a home, building, and car) setting can either constrain or enable these agents during the course of their interaction. Performance characteristics of material items (e.g., clothing, weapons, and furniture) may affect their use as items of aggression or defense; in contrast, they may have a neutral impact on the event.

All of these elements and their interaction during the course of the crime affect what is seen by law enforcement officers and forensic anthropologists who later investigate the scene. Moreover, these investigators are also significant agents in that they decide how to process the scene, collect data, and record context and other information. Their role as information collection agents in the present will ultimately determine the interpretation of the past forensic event. The investigators not only need to reconstruct the roles of the agents involved in the original, perimortem event but also to recognize *their* role as agents in its postmortem interpretation. Furthermore, natural forces (e.g., decay, soil chemistry and humidity, animals, and plants) are active natural agents that need to be evaluated in terms of their perimortem and postmortem effects on all human agents and their interaction. Time (length of event, time since death, time since deposition, etc.) and space (location of material remains) are therefore meaningful dimensions for all agents—perpetrators, victims, and investigators.

As Kirk (37) states, ''The interrelationship between social action and spatiotemporal locales is therefore not predetermined but dialectical: practices [actions] form and are formed by locales; locales form and are formed by practices'' (p. 113). Behavioral chains, as applied to the actions of various agents, can therefore serve as very powerful means of modeling and interpreting the temporal/spatial sequence of a forensic event.

Nonlinear Systems Theory

Nonlinear systems theory, also related to complex systems theory, chaos theory, and catastrophe theory in archaeology, looks at the interaction of multiple variables and their consequences (47). These theorists reject the traditional Newtonian model of scientific testing, wherein one variable is isolated to study its effect, while all other variables are controlled. Instead, nonlinear systems theorists emphasize multivariate analysis because complex properties (or consequences) result, in real-life situations, from the interaction of many factors: ''Systems with very few variables can show surprising transformations and nonlinear trajectories, depending upon their interaction'' (47, p. 3). Thus, this interaction produces a result that is ''more than the sum of its parts.'' The importance of human agents as well as what Schiffer (9) calls situational factors are equally recognized. Beekman and Baden (47) state: ''Historical pathways and contingency are deeply rooted elements of chaos theory…[but] even the most irregular trajectory is defined by causal forces'' (p. 3). Often relying on computer simulation or modeling as well as actualistic case studies, the multivariate factors affecting forensic scenes are recognized and considered in this theoretical approach. When applied to forensic anthropology, an examination of multiple variables such as soil type and pH, ambient temperature and humidity, type of clothing on the victim, botanical and insect evidence, type of interment, and taphonomic effects can produce a more complete reconstruction of forensic events. These data, along with data from other case studies, can provide the multivariate information base for computer simulations like those championed by nonlinear systems theory and provide a theoretical basis for explaining future cases.

Nonlinear systems theoretical approaches have already characterized some forensic anthropological research. This has, for example, been illustrated by computer simulation models for probable locations of human remains in the Northwest Coast Puget Sound (48) as well as the Magdalena River in Colombia (49). Multiple variables such as wind and tidal current speed and direction are incorporated into hydraulic models, which have accurately predicted the location of bodies in fluvial environments. These types of predictive models based on simulation have the potential, in the future, to also incorporate human decomposition data from decay studies to improve the accuracy of our time-since-death estimations.

In sum, the middle-range forensic anthropological and archaeological theories discussed earlier can provide valid interpretations of forensic events by:

- Using the archaeological recordation of specific temporal and spatial contexts to define the sequence of events leading to the current, observed scene;
- Using this contextual information to define the roles of agents (human and nonhuman) and their transformation in the creation of the forensic scene and its interpretation;
- Defining the significance of material objects as they relate to the sequence of events and actors (agents) involved in the forensic scene;
- Giving theoretical value and meaning to case studies, because inductive case studies ''are theory in their own right'' (38, pp. 161–162), suggesting new ways to see and make sense of data.

Low-Level Forensic Anthropology Theory

Komar and Buikstra (17) in their volume entitled *Forensic Anthropology: Contemporary Theory and Practice*, tether theory in forensic anthropology primarily to the hypothetico-deductive method. This traditional scientific approach involves developing hypotheses from inductive data, deducing the probable outcomes of testing, and then evaluating the results of hypothesis testing to see whether predictions can be supported or falsified. Thus, the

scientific theories that result are built through the repeated successful testing of falsifiable hypotheses.

The traditional relationship between theory and method is therefore seen as:

$$\text{Theory} \rightarrow \text{Methods } (\rightarrow \text{methodology})$$
$$+ \text{ data} \rightarrow \text{interpretation/explanation.}$$

However, many recent theorists, especially in archaeology, have seen the relationship between methodology and theory as more intertwined. Dobres and Robb (38) state: "A methodology is as much a way of thinking about material culture and its patterning as it is a way of seeing and measuring it. There is, [therefore], no useful distinction between theory and methodology" (p. 160). Beekman (35) states, "…data are theory-laden…," (p. 52) while Schiffer (9) notes the close connection between theory and method in the following: "If we agree that method consists of tools (conceptual and otherwise) applied to achieve certain goals, then it must be granted that a theory—any theory—can function as method" (p. 478). In fact, Schiffer (9) defines a level of theory he calls methodological theory, which encompasses the rationale and explanations behind the use of specific recovery and analytical methods in archaeology (or forensics) and the inferential processes affecting the interpretation of recovered data. Thus, there is an underlying intrinsic theoretical basis for everything a forensic anthropologist does—from data collection in the field to analysis and interpretation in the laboratory. Examples of low-level methodological theory in forensic anthropology are recovery theory and statistical induction theory.

Recovery Theory

The increased use of forensic archaeological methods in the search for and recovery of human remains has recently been noted (1). Field documentation and recovery are necessary components of the definition of forensic anthropology as a scientific discipline. Thus, recovery theory, which provides a basis for the selection of search methods, is an example of low-level methodological theory; for example, some researchers (50) have clearly defined the procedural steps in conducting searches for both surface remains and those in clandestine graves. Such attributes as the physical setting of the forensic scene, environmental factors (temperature, humidity, and soil type), available search personnel, and postmortem interval will dictate decisions about whether to use cadaver dogs, remote sensing devices, or any other search technique. Knowledge about the effectiveness of certain techniques and the justification of their application to a specific forensic investigation also reflect what we would define as recovery theory.

Statistical Induction Theory

As Adams and Byrd (51), Konigsberg et al. (52), and Steadman et al. (53) note, the development of the biological profile is based on statistical induction. Inductive arguments are those that are based on empirical generalizations derived from a limited sample of previous experiences (54). From the statistical analysis of this (or these) sample(s), reliable statements can be made about the characteristics of the entire population of interest (54). Population-based procedures (involving documentation of discrete or continuous variables) for the determination of age, sex, stature, and ancestry are applied to specific cases with the goal of identification of an individual. Techniques such as regression, Bayesian, and discriminant function analyses are used to derive statistical formulae and determine the probability of accurate assessment of these characteristics. Statistical induction theory, in essence, revolves around probability theory and measures of mathematical likelihood. It is a form of what Schiffer (9) calls "analytic theory."

Statistical inductions are always dependent on both the quantity and spatial and temporal diversity (representativeness) of past observations. Thus, a main goal of statistical induction in forensic anthropology has been to amass substantial samples of known individuals for observation and measurement, so that the accuracy and reliability of statistical formulae for individuation can be enhanced. It is in this context that documentation of large human skeletal samples (e.g., the William M. Bass skeletal collection [55] and the Forensic Data Bank [56]) and questions of their representativeness have become major research foci in the discipline.

Considering statistical induction and statistics in general as low-level theory reinforces their importance in forensic interpretation in that statistical theory provides the guidelines and rationale for the selection of appropriate statistical methods for data recovery, analysis, and interpretation (57). This, in turn, creates a sound theoretical basis for the conclusions reached from such analyses, one that satisfies at least portions of the Daubert requirements. Thus, it becomes clear that our selection of a particular statistical measure or algorithm to address a specific problem shapes all further analyses and interpretations. Designation of this type of analytic theory as "low-level" does not imply that it is of lesser importance in comparison to the other levels. In fact, it can be of greater importance, as the methods used to collect and analyze data can critically affect the interpretation of that data. And, this type of theory is often interconnected (and sometimes inextricably intertwined) with the other levels. As already noted, accurate estimation of the biological profile depends upon both high-level (understanding human skeletal variation and evolutionary change) and low-level (data collection and analysis) theory, with each one shaped by the other.

Case Study

Rather than dismissing case studies as being too "particularistic" to be of value in theory, as noted earlier, Dobres and Robb (38) stress their importance in exemplifying the actualistic application of theoretical approaches and in developing baseline data for a discipline. Beyond serving as examples of behavioral reconstructions, case studies are actually an integral part of theory building. Such studies, with the application of a theoretical approach, can lead to the generation of testable hypotheses regarding peri- and postmortem events. We present just such a case study involving the recent search for the missing remains of the WWII Goettge Patrol and apply theoretical perspectives to illustrate not only the value of case studies but also the necessity of using a theoretical approach to understand and reconstruct forensic contexts.

The Goettge Patrol, Guadalcanal, Solomon Islands

The World War II Guadalcanal Campaign (August 7, 1942 to February 9, 1943) was initiated by U.S. forces to capture and hold the nearly completed Japanese airfield on the Solomon Islands. While a successful campaign for the Allies, total ground forces killed included 1600 American Marines and soldiers and 24,500 Japanese troops (58). On August 12, 1942, the 1st Marine Division's intelligence officer, Lt. Col. Frank B. Goettge, led a patrol of 24 men into the area west of the Mataniko River to effect the surrender of the Japanese forces. As Col. Goettge and the other Marines moved inland, they were fired upon—Goettge was killed immediately. The others were pinned down on the beach, where

they were picked off by the Japanese. By the next morning, of 22 of the 25-man patrol were dead—the three survivors escaped by swimming to the allied lines. An eyewitness account from the last escapee, Sgt. Frank Few, describes Japanese mutilation of the dead Marines on the beach as he swam away under fire (59). The dismembered remains of the Goettge Patrol were reportedly partially buried in sand and were seen by many Marines after the first battle of the Mataniko (August 18–19) 1 week later, but none were officially noted as being recovered. The Goettge Patrol victims are still listed as Missing in Action (MIA) (60).

In July 2008, an interdisciplinary team of forensic anthropologists, archaeologists, historians, and physicists conducted the Goettge Patrol Guadalcanal Survey in the Solomon Islands. The 2008 Radford University Forensic Science Institute Geophysical and Archaeological Survey focused on a portion of the island using a variety of remote sensing techniques—GPR and soil resistivity—combined with more traditional archaeological testing. The overarching goals of this survey were to locate (using geophysical remote sensing techniques followed by archaeological test excavations of identified anomalies) the Japanese defensive trenches where members of the patrol were reportedly buried and to evaluate the effectiveness of these techniques in a variety of burial environments and longer interment periods (61).

Based on several years' historical research, including archived maps, aerial photos and oral histories of both U.S. and Japanese veterans (61), an area was identified where the remains of the Goettge Patrol were most likely located. This area was, in 1942, the location of Mataniko village (Fig. 1). Today, it is the center of Honiara, the capital city of Guadalcanal and the Solomons (Fig. 2). This most likely area covers six acres. Nearly 8000 square meters of the target area were surveyed using the GPR. In addition, a capacitively coupled resistivity system (OhmMapper; Geometrics, San Jose, CA) was used to survey a 2400 m^2 area of high burial probability.

Several anomalies identified by the GPR and OhmMapper were investigated through the excavation of four test pits that crosscut them (Fig. 3); for example, the 1.2–1.3 m GPR depth slice shows the beginnings of a subtle feature that extended to greater depths (Fig. 4). This area had been a gently sloping beach when the Allies invaded in 1942. Soon after that invasion, this area was filled in to make a flat area for off-loading troops and supplies. This feature is consistent with erosion of the filled-in area that was reported to have occurred in the 1960s and early 1970s with refilling of the area in the early 1970s. Test Unit 3 (Fig. 3), nearest to the ocean, confirmed evidence of recent (1970s) fill to build a sea wall and, below that, wave and tidal turbation, with the deposition of post WWII artifacts below 1 m in depth. Test Unit 4 possibly identified a natural fault and the ocean's edge prior to filling 30 years earlier. The observed anomalies were thus both natural and cultural features.

Three 1 × 4 m trenches (labeled Trenches A, B, and C) were also excavated to the depth of groundwater to investigate the presence of any pits, trenches, or other human-created features (Fig. 3). Groundwater did affect the radar signal, causing it to disperse when it hit water, which it did in each trench at a depth of about 70 cm. No bones or clear burial areas were defined for any of these test units or trenches.

Given the intensity of the survey methods, the best conclusion is that, as regards Guadalcanal, the remains of Goettge and his men are *not* in the area we surveyed. GPR and electrical resistivity provided complementary data that were supported by archaeological testing. Although the clandestine graves of the Goettge Patrol were not identified, interpretation of the anomalies was instructive in understanding the history and soil stratigraphy of the site and the impact of natural and human factors on the area since WWII (e.g., ground water accumulation and depositional fill). These investigations also helped narrow the future search area for the Goettge Patrol.

Theoretical Linkages

The previously discussed theories can help us to interpret where the Goettge remains may in fact be. This is particularly true for the middle-range agency and behavioral theories. Numerous agents significantly altered the recoverability of the Goettge remains, either intentionally or unintentionally. There are several classes of agents that were encountered in Guadalcanal. First, there were a multitude of human agents, which might be classified as active (those possessing cognition and intent in their actions) and passive (those lacking cognition and intent). The "honored dead" we were searching for—the 22 massacred Marines from the Goettge Patrol—are passive agents located in the archaeological context. This category may be broadened to include the Japanese WWII dead as well as native aboriginal Solomon Island dead, which might be encountered in any search for the Goettge Patrol. These individuals spend varying lengths of time in their archaeological context before entering a dynamic systemic (a current behavioral) context and in some circumstances re-enter the archaeological and systemic contexts several times (through natural and human disturbance). Even though they are not living, these agents, like other material items

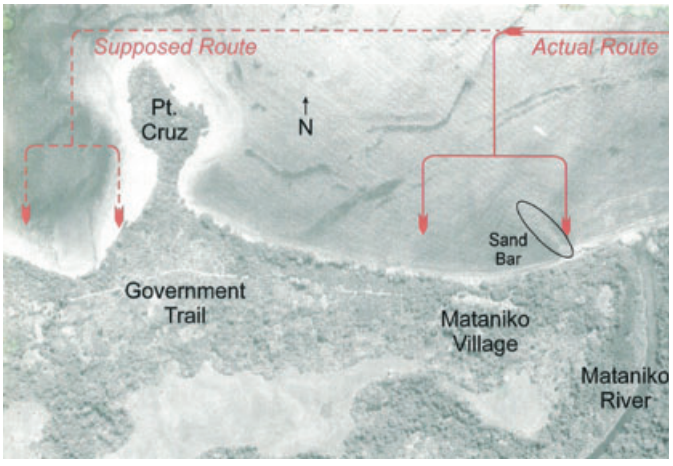

FIG. 1—*1942 Aerial photograph of Goettge Patrol location (Source: Bishop Museum Reconnaissance Photo SP 203197).*

FIG. 2—*Modern aerial photograph of Goettge Patrol location, now Honiara, Solomon Islands (Source: Google Earth).*

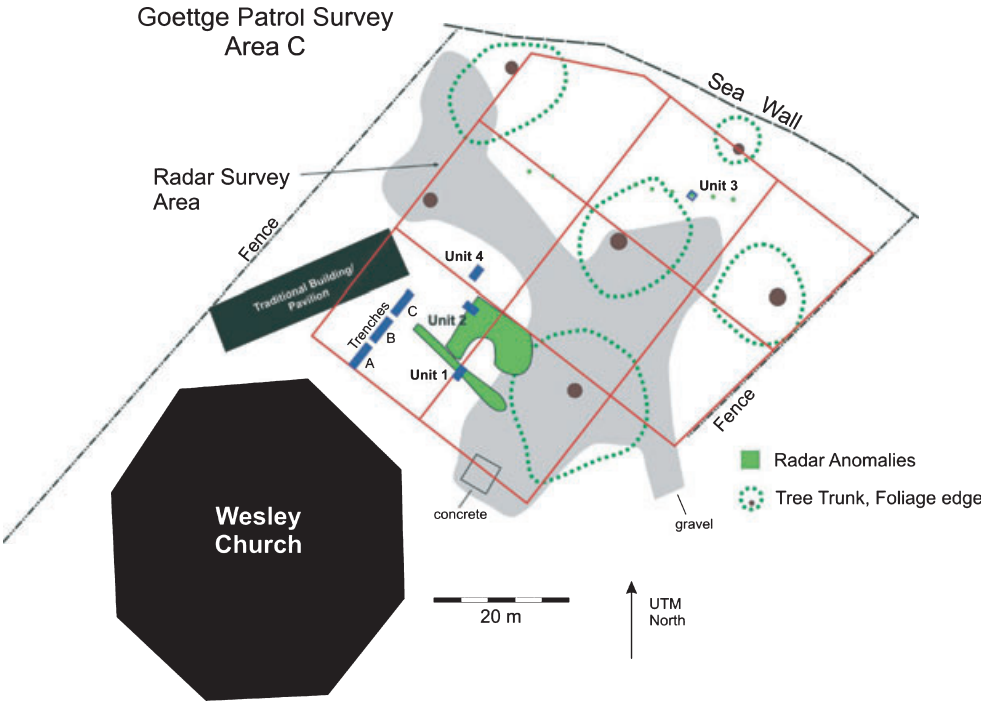

FIG. 3—*Plan map of major 2008 search area, showing test units and trenches.*

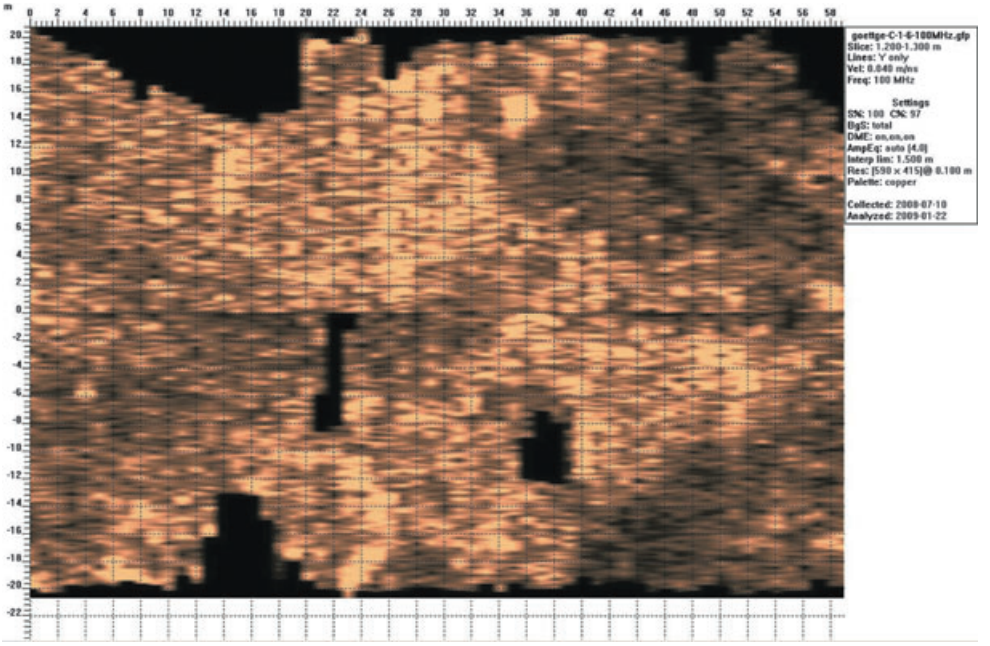

FIG. 4—*Ground penetrating radar survey image, showing 1970s fill anomaly (right portion of figure).*

(e.g., sacred artifacts, symbols), clearly have an impact on living humans.

Active agents are alive, interacting with each other and the passive agents, resulting in interpretation of the passive agents in a variety of ways. In Guadalcanal, they were numerous and include the following:

- The native Solomon Islanders.
- The historians (Greatest Generation MIA Recoveries).
- The investigators (including Radford University professors and students).
- WWII veterans who served in Guadalcanal and their loved ones and descendants.
- The Japanese Government.
- The U.S. Government.

In terms of the 2008 field survey, there were always friendly, helpful Solomon Islander bystanders at the site intently observing excavations and in some cases helping dig. In addition, several volunteered ethnographic details about either the whereabouts of possible burial sites or human remains previously removed. It was

native testimony from elderly residents about the WWII-era environment and events that helped shape our search area and increased our understanding of the observed archaeological record. At the same time, other natives saw the dead as an economic opportunity to be exploited by digging up and attempting to sell human remains and artifacts.

The Radford University and Greatest Generation MIA investigators also served as agents. The Greatest Generation historians' search through historical documents, photographs, and contact with native informants delineated the survey area. Their historical research served as the basis for the 2008 Radford University Survey and affected all subsequent logistical and methodological decisions. For Radford University, the goals were as follows: (i) to honor these Marines by finding their remains and, if encountered, immediately notify the Joint POW Accounting Command (JPAC) Central Identification Laboratory details regarding their location, so they could organize a recovery; (ii) to test the effectiveness and utility of state-of-the-art remote sensing equipment in this environment; and (iii) to train students in archaeological survey methods and use of remote sensing equipment. These goals affected our actions in planning and executing this project, especially low-level theoretical methodological decisions regarding equipment, personnel, and survey and excavation strategies (in other words, Recovery Theory). The use of these low-level theoretical perspectives directly influenced what was seen and how it was measured.

Other agents are U.S. veterans and their families who continue to visit Guadalcanal and tour the battlefield locations. Some deceased veterans have chosen to enter the archaeological record of Guadalcanal several decades after their combat experience, to join their comrades in this final resting place. Other veterans' loved ones are willing to pay hundreds or even thousands of dollars for artifacts or even a small bag of soil from Guadalcanal.

The Japanese and U.S. Governments also comprise a significant group of agents. Although the Japanese Government encouraged repatriation of Japanese soldiers' remains to government representatives, bones donated to them were often cremated near their peace memorial on Guadalcanal. Any native or U.S. remains mistakenly identified as Japanese and given to the Japanese would probably suffer the same fate. In terms of the U.S. Government and the specific branch charged with the recovery of U.S. war dead—JPAC—this entity was informed of the project plans and goals for work in Guadalcanal well in advance of the 2008 expedition and would have directed the disinterment and repatriation of the Goettge remains had they been located by our survey.

There are literally dozens of types of other unintentional agents—those which act unconsciously. These include natural forces and their taphonomic effects, including decay, animal disturbance, soil chemistry, and fluvial action. The most important that we encountered were first, the tropical environment that includes soil acidity, heat, and humidity—these variables are not kind to bone preservation even in the best of circumstances. Even more significant for the Goettge remains may be the movement of ocean currents and the shoreline. There is stratigraphic as well as ethnographic evidence for this change in shoreline since WWII (e.g., compare Figs 1 and 2). A major change was because of a typhoon that was known to have hit the island in 1957, crossing the island twice and causing significant damage, including an incutting into the mainland in the area near where the Goettge Patrol may have landed.

As can be seen, there are potentially a myriad of transformational processes which the Goettge remains may have gone through. These transformations were activated by passive but also active agents that significantly affected their context and interpretation. Many of these agents have quite different goals and methods, but all impact the transition of Guadalcanal human remains from the static archaeological to the dynamic systemic record.

Because the Goettge patrol victims were in shallow graves in sandy soil near the coast, post-WWII disturbances have obliterated their original context and remains. Each of these postdepositional disturbances may explain the ultimate fate of the Goettge Patrol—it is possible, for example, that the Goettge remains:

- Have completely decayed in the tropical environment;
- Have been washed out to sea because of the change in shoreline;
- Have already been unofficially recovered by native Solomon Islanders and sold or curated in piecemeal fashion either on or off the island or given to the Japanese who have cremated them;
- Remain *in situ* in their burial environment in the area surveyed, but remain "invisible" to remote sensing equipment;
- Remain *in situ* in their burial environment in a different location yet to be investigated fully.

It is also possible that a sequence of multiple agents affected these remains, forming a behavioral chain.

After initial shallow burial by the Japanese, the Goettge Patrol dead quickly decayed, were exposed and washed from their primary context by the tides, possibly reburied by the Japanese or their Marine comrades (as has been reported for one individual), and possibly covered by fill during subsequent construction or beach stabilization. Although archaeological, geological, historical, and ethnographic research currently offers strong support for the possibility that, because of natural and artificial changes in the shoreline, the Goettge remains may have been washed out to sea, additional surveys of the Goettge area in the near future should help clarify which of these scenarios is more likely. These additional surveys will involve computer simulation (nonlinear systems theory) and hydraulic models that will allow predictive modeling for the probable location of the Goettge remains, given changes in shoreline configuration and other taphonomic variables such as ocean currents and tides.

This case study illustrates the myriad of variables that can impact a forensic scene, particularly one of greater time depth. It also shows the importance of theoretical perspectives, such as middle-range agency theory and low-level recovery theory, in interpreting such variables and in generating further hypotheses to test. Application of theory can lead not only to improved interpretation but also to a more precise scientific explanation of a forensic event by reference to taphonomic and archaeological concepts and models.

Summary

Forensic anthropology theory does indeed exist at multiple levels; theoretical concepts underlie much of what forensic anthropologists do on a daily basis, ranging from their choices regarding methodology to their reconstruction of forensic events. However, we believe that further acknowledgment, development, and application of theory to forensic anthropology are needed. Depending on the type of forensic anthropological question being asked, a variety of theoretical models or approaches are available to forensic anthropologists. This encompasses not only high-level evolutionary theory, but also important multivariate linkages to other anthropological theories, enhancing both our methods and our interpretation of data. They offer the additional advantage of potentially supporting the mandates dictated by the *Daubert* and *Kumho* rulings (2–5)

in presenting more flexible expert testimony about evidence that may be considered unique but still scientifically rigorous and testable.

These theories, although hierarchically structured on different levels, are not mutually exclusive. In fact, they are often interconnected and interdependent. Some of these derive from other disciplines, while others are unique to forensic anthropology. It should be noted that some forensic anthropologists already (perhaps unconsciously) incorporate many of these elements in their interpretations of a forensic event. However, formal recognition of the application of this theoretical structure firmly grounds forensic anthropology in established anthropological and archaeological theory and provides a mechanism for not only the reconstruction of past forensic events but also their scientific explanation as the end product of a sequence of human, artifactual, and natural interactions. This broadens the theoretical base of forensic anthropology beyond investigation of the largely natural taphonomic factors affecting remains postmortem to engaging all agents affecting the creation and interpretation of the forensic scene. In addition, the realization that there are many different approaches to theory encourages us to consider science and knowledge in general as an on-going, living process, in part dependent upon the thinking of individuals engaged in that process.

Dirkmaat et al. (1) refer to a bright and vibrant future for forensic anthropology and we agree. We believe that many of the new developments in the field that we have witnessed and they review (e.g., innovations in DNA and polymerase chain reaction, quantitative methods, forensic taphonomy and archaeology, and trauma analysis) usher in a new age for forensic anthropology. Critical for the development of this "new forensic anthropology" is a solid foundation in theory. In this article, we offer such a foundation. Rather than considering forensic investigations a collection of multidisciplinary methods and little else, the more liberal views of theory we have discussed here open avenues for building a broad and solid theoretical (and ultimately scientific) basis for forensic anthropology and prepare it for a sound entry into a new age.

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