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Decision-Making Concepts in Postmortem Identification

REFERENCE: Lorton, L. and Langley, W. H., **"Decision-Making Concepts in Postmortem Identification,"** *Journal of Forensic Sciences*, JFSCA, Vol. 31, No. 1, Jan. 1986, pp. 190-196.

ABSTRACT: Concepts of the decision-making process in mass casualty identification are discussed. The importance of the correct data type, the correct data format, and the appropriate decision paths are emphasized. Also discussed are the hidden dangers in the use of changeable physical characteristics for sorting factors. A suggested decision process for use in postmortem identification is outlined, along with its application to computer-assisted identifications.

KEYWORDS: pathology and biology, odontology, human identification, computers, postmortem identification, mass casualty, forensic dentistry, dental characteristics, teeth

Body identification is a science and art which is practiced in two distinct forms—identification of single unknown persons and identification of a large number of persons after a mass disaster. The identification of a single unknown person is usually done by a forensic investigator who abstracts data from discovered remains and then matches them with clues from existing or collected records. These records are often collections of missing persons reports or collected data from at-risk populations. The second, more complex process is practiced by teams at the site of a mass disaster where, because of the identity masking effects of the disaster, the team may find a large number of similarly disfigured postmortem remains and a great volume of antemortem records which must be culled to match the remains of each victim with the correct identity. The records may be incomplete or radically different in form or content, thus complicating the task.

The literature of identification is concerned mainly with forensic science techniques. Only a very few papers are concerned with the management of identification procedures or the decision-making process itself.

McMeekin [*1*], in a successful attempt to provide some method in the organized confusion that follows a mass disaster, describes four phases in the identification process. In describing the first two, *preliminary analysis* and *data collection*, he makes the point that antemortem fingerprints, long considered the ultimate identification tools, are not always available and that the dental examination is a reliable and increasingly important tool. The third phase, *data analysis*, is sorting or

Received for publication 30 Jan. 1985; accepted for publication 28 Feb. 1985.
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> logical manipulation of the records into groups that have characteristics in common . . . . Lists of these matches and groups of possible matches should be recorded and made available to the working groups for *confirmation. No positive identification should be based solely on this preliminary match.*

He also notes that the logical nature of these investigations should lend themselves to computer analysis. He suggests that this has not been done because of the effort required to convert the data to an acceptable format for the computer. Increased efficiency in the record sorting would also increase the efficiency of the *final verification* of the identity, the fourth phase. McMeekin has recognized a vital area, that the question of what decision process is applied and in what manner may be functionally as important as the presence of the data.

There are circumstances where postmortem remains must be identified by selecting the "best match" records from a large base of possible identity matches. Searching missing person records for a match to a discovered remains is an example of this situation. Another example is in mass casualty situations, such as an airline crash or other disasters where there are a large number of deaths and the correct identity matches must be made from a data base limited to those individuals known to be in the area and at risk. In addition to this situation, there are also known at-risk populations where a relatively high chance of individual fatalities exists and where there is a recognized need for identification data independent of personally held records. The military population is the prime example of this type of population.

In the course of an extensive research and development effort for the U. S. Army, the authors have explored the decision process in identification and, from empirical results, have developed concepts of decision-making in identification in mass disasters or large data base searches. This paper will discuss criteria for data and data formatting, the standards for decision making, and the worth of various data types to the identification process.

The Identification Process

Identification can be understood as a succession of distinct processes, each of which can be optimized for the greatest efficiency. The processes are *data gathering, data comparison/selection,* and the *final verification* of identities.[3] The *data gathering* encompasses the transmittal, organization, and collation of the "known" and "unknown" identification records into usable *similar* forms. During data *comparison/selection*, characteristics of the postmortem remains are compared with those of each record in the antemortem or "known" data base. In this stage no possible matches are excluded, only those records with definite, disqualifying mismatches are deferred from immediate consideration. For this comparison and selection the most valuable tool is often not the complete record of the postmortem remains but a smaller selection of facts, chosen for their identification efficiency, which are well-standardized in format and location. Thus the researcher is able to make a standardized set of comparisons and decisions in each case. This is the *comparison/selection* phase of the body identification where the identification teams scan the antemortem records and select all those that fit some loose qualification index for the unknown under question. These records are the most promising for a successful match in the *final verification*.

Criteria for Optimized Searching Methods

SEARCHING during the comparison/selection phase is most efficiently performed, by person or by machine, *on ordered data* where the *same decisions* are made at *each examination of a record*.

[3]These categories are equivalent to Phases two, three, and four of McMeekin [*1*].

Criteria for a method that will optimize a search through a set of records to retrieve those with certain designated features are as follows:

(1) information must be in a standard form,
(2) data points must be in the same field on each record, and
(3) the same decision logic should be applied to the same data field for each record.

When comparisons and sorting are optimized for human use, the requirements for use by computers are also satisfied. *If, because of the size of the identification problem, the optimization of the sorting process is desirable, at this point the use of computer-assisted identification becomes efficient.*

Data Format

For optimum efficiency both conceptually and physically, all of the data records should be similar in size and content, so that the investigator finds the same information in the same location in each record and is faced with the same decision each time.

Which task would an investigator find easier:

(a) remove from 1000 slips of paper of varying sizes, shapes, and textures those slips which had a word containing an "sh" written somewhere on the surface?

or

(b) remove from a set of 1000 standard index cards those cards which had the word "gunshot" written on the upper left-hand corner?

Intuitively, one would say that the second task would be easier to perform because of the uniformity of the physical manipulation, the opportunity to develop a routine task, and the constancy of the decision process. This optimization of the process for manual sorting by a person also describes the requirements for a computer process.

Standards for Data in Computer Analysis

What kind of data are appropriate for a simple decision process as mentioned in (3) above? The same decision logic should be applied to the same data field for each record. For comparison/selection purposes only, data should be used about which exact constant decisions can be made. The data should be almost exclusively objective and the categorization or classification of the factors should be as little susceptible to evaluator opinion as possible. This will permit the correct decision processes to be programmed. A computer only knows what it has been told, and human intuitive judgements that cannot be codified *cannot* be described to a computer.

The objective of the comparison and selection process is to exclude *only the certain mismatches* and reorder the possible identity matches in order of probability. All of the possible matches should be included in the resultant batch of records which is subject to the last phase, verification. The mechanics of the verification process are complex and certainly outside the scope of this work because of the huge variability of the methods and information available. What can be examined at more length is the optimization of the comparison/selection process, potentially the site for the greatest increase in efficiency in identification procedures.

Appropriate Data and Decision Paths

The preeminent criteria that must apply in judging suitability of data types are: Are the levels of the data (that is, the possible answers) well-defined, mutually self-exclusive, and do they cover the total range of possible answers? Variables should be selected that are not subject to coding differences because of interpretation or opinion. The efficiency to be gained in comparison/selection comes from avoiding arguable decision processes. Decision paths which are not clearly "right" or "wrong" leave room for error.

Clear-cut decision paths and completely defined boundaries for each level of data *are essential*. Even seemingly clear-cut descriptors can cause unintentional errors because of the haziness of certain answer categories. For example, the decision of a person of mixed ethnic background as to his or her proper racial category may or may not be obviously confirmed by physiognomic factors, or the postmortem changes may obscure ethnic characteristics and cause miscategorization. Rather than use race as a primary comparison/selection factor, it would be better to reserve its use for the verification process where more attention can be given to individual cases.

Any factors that are readily changeable in a nonordered way are not suitable for the comparison/selection process. For example, hair color is susceptible to miscategorization in both antemortem and postmortem records. Weight or height estimations within narrow limits can be misleading and can be sources of error. Sex is a prime descriptor, of course, and is rarely miscategorized.

In searching the data base, the aim of the initial comparison/selection is to cull out the certain mismatches while retaining all possible matches. A set of simple, clear decisions produces a smaller set of records which can then be subjected to more complex decisions in the identification-verification process. Reducing the size of the data base is a measure of the success of the selection process. This can be considered as the specificity of the system. This success depends on the number of selection factors per records, the selectivity of these factors, and the homogeneity of the original set of records.

The ultimate goal in choosing factors to be used in the comparison/selection is to provide information which can be used to subdivide the data base unequivocably. Any factor that cannot provide consistent, categorical answers should not be used to *exclude* identities from consideration. Thus factors can be divided into two general groups: those other factors that may add weight to a decision process but are subject to some uncertainty (hair color, weight, height); and those for which exact decisions can almost invariably be made (such as sex, tatoos, and so forth). Dental characteristics, such as missing or restored teeth, provide ideal verifying factors because of their diversity, stability, and the universality of the nomenclature which is used to describe their state.

Dental Characteristics Quantified as Sorting Factors

Dental characteristics, such as restorations, crowns, and missing teeth, are nearly ideal as comparison factors. Each tooth has 5 surfaces available for comparison which makes a total of 160 comparison points (edentulous people have 160 data points worth of missing teeth). The direction of the change of status of a tooth is fixed; that is, a tooth cannot have filling on a surface and then proceed to a state in which there is no filling on that surface. It can only go from having no filling on a surface to a state in which there is one. A human dentition has 32 teeth, thus there are 32 decisions of equal weight and validity which can be used as selection factors.

Dental characteristics can be described by an internationally accepted code which has several uniquely mutually exclusive categories. Decision processes about matches or mismatches between these categories are simple, logical, and consistent. The code carriers, the teeth, are highly resistant to destruction by any of the natural means which are so destructive to human life. Individual teeth are identifiable, and so each subsection of the dentition can serve as a portion of the identification system; the dentition does not have to survive intact to function *well* in the identification role. Dental records are simple to record, and are routinely made for dental care purposes. The entire administrative system for recording and maintaining these dental records exists. In short, a marvelously intricate identification apparatus already exists and it need only to be implemented.

In an extensive research study, an institute report by Lorton and Langley for the Institute of Dental Research, values of dental characteristics in concert with certain physical characteristics have been established.

Mass Casualty and Individual Identification

Typically the identification process from a mass disaster requires gathering *extremely* heterogeneous sets of data on the possible identities. There is, after all, no requirement that any standardized set of identification data be maintained on the general public in anticipation of this type of need. The enormous cost of maintaining this type of data when compared to the relative rarity of the use obviates any thought of starting this type of data base. The identification team gratefully accepts any types of identification information and they will use any clues for inclusion or exclusion to encourage the ultimate correct matching of identities. Such situations do not profit from computer sorting *until* the number of records becomes an unwieldy physical problem or the decision process becomes cumbersome. It is then that the capacity of a computer to hold and sort large amounts of information merits the effort to convert the data to a form usable by such a machine.

Wolcott et al [*2*] wrote about the enormous administrative burden of identification in a mass disaster where hundreds or thousands of records overwhelm the physical facilities and tax the mental capacity of the investigators.

There do exist certain populations which are "at-risk," and where the need may arise to identify a single anonymous individual. A number of systems, intended to eliminate the necessity for antemortem records, have been suggested. A Swiss team [*3*] suggested a disc implanted into the tooth enamel with the necessary identifying data engraved on it. The feasibility of such a system is questionable because: (a) will anyone realize that the implant is there at all? (b) will that particular tooth survive the disaster? (c) will the equipment necessary to retrieve the disc and read it be available? and (d) will any country provide the monies to make and maintain this device? In large but finite groups the gathering of a data base for identification purposes may be justified if: (1) the possibility of need is judged to be high enough and (2) the cost of obtaining the data is acceptable.

Computer Effects on the Identification Process

A connection between the identifying power of dental characteristics and the singular ability of computers to hold and manipulate large amounts of data without confusion occurred in the early years of the computer revolution.

A paper that emphasized the value of the identifying code inherent in the dentition and the usefulness of a computer search appeared in 1974 [*4*]. The authors, Kogon et al, used a primitive punch card system to identify the remains in an exercise to simulate the identification of victims from an aircrash. They used records from an actual air disaster. Although their system required the records to be transferred to the main computer by teletype and the cards recorded only teeth restored (rather than the actual surface restored) and teeth missing, the identifications were done in less than 30% of the time needed by the teams of traditional examiners.

Some ground work has been laid for the understanding of the power of dental characteristics as an identification tool by Keiser-Nielsen [*5*]. He has attempted to show that the chance of two individuals having extensive but similar sets of dental characteristics is small indeed. The calculations in his paper are misleading because they rely to some degree on the assumption of the independent occurrence of various conditions. Based on empirical evidence, the incidence of dentally significant characteristics, such as restorations, prostheses, and missing teeth, does not occur randomly, but is correlated within areas of the mouth, individuals, and population groups. His point is well taken, however, that it takes little deviation from perfection in the human dentition to produce a set of dental characteristics that will provide a stringent identification tool.

Siegel et al [*6*] introduced the concept of creating a data base that would hold the dental records of a large group at-risk from which the computer would select the best match or matches. Their record format was quite extensive and described the dentition and restorations in great detail. In simulations the algorithm produced the correct identification 85% of the time.

Pierce et al [*7*] have developed a complex computer coding scheme "to aid in the positive identification of human remains." There were 80+ numeric codes available for the characterization of each tooth. In addition, the categories were not mutually exclusive and thus the order in which one approached the coding list was of critical importance. The amount of data incorporated and the certain difficulty in coding large numbers of records with such a complicated system precludes the use of this type of data base management program for an efficient comparison/selection system.

A comprehensive paper by Morlang [*8*] outlined the complete role of forensic odontologists in a mass disaster, and described how the use of computers in a practical application saved great amounts of time and resources. This paper provides an excellent text for the management of dental resources in mass disasters.

Perhaps the only group to approach a computerized dental record as truly a select/sort mechanism was Cohen et al [*9*]. These investigators used dental examination data and showed, on a limited population, that rather simple low-level dental charts can be used successfully for identification purposes. They used two weighting methods that gave the best results within their population. Their decision to use weighted methods to generate what they knew to be the correct answers can be questioned. There is no evidence that the features, which caused the weighted factors to produce "correct" identifications for their target group, will be correct for other population groups. Siegel et al [*6*] also suggested a weighting system for different situations although the basis for the assignment of the weights was not given. This weighting system worked empirically with the population they tested but they admitted that the proper weightings were developed from studying the correct matches for that group. They accepted that each population may have its own particular weighting factor *which cannot be known until all unknowns can be matched with the correct identities.* Keiser-Nielson [*5*] made a point about a weighting system when he wrote about the "discrimination potential" of dental characteristics. The actual discrimination potential or importance of factors can only be known when the entire data base is analyzed. As he says:

> . . . we have little data permitting us to assess the individual discrimination potential of singular dental features. . . . Accordingly, . . . to assess the discrimination potential of a given feature, we would have to have background knowledge of its frequency of occurrence. . . ; it is only after identification that we have this knowledge.

Comments

The main obstacle to the creation of a multifactor computerized identification data base for a large known population in anticipation of a need is the cost. If the population is large enough to require a computerized selection system, then the cost of data collection and storage of complete traditional medical and dental records becomes astronomical. This cost becomes conceptually even more onerous because a high percentage of these collected data are never used.

Any identification system should serve as a comparison/selection device and should be capable of searching a large data base quickly to select those records which provide the best matches using the dental and other criteria. These chosen records would then provide the best possibility of an identity match that could be subsequently verified by the identification teams using the X-ray or more detailed records. The system should not attempt to provide the positive identification but merely guide the forensic science team to the best possible matches first to maximize their effectiveness.

In another paper, we will discuss a computer identification system based on the concepts outlined in this paper. This second paper will also present details of the research study which used the computer software and the quantitative effectiveness of the dental characteristics as identification factors. We have obtained evidence that a simple visual examination of dental characteristics, which can be made at virtually no examination cost, can provide the basis for an identification data base of incredible selectivity.

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