A Method for Measuring Relative Abundance of Fragmented Archaeological Ceramics

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Archaeologists commonly use simple counts of specimens as a measure of relative abundance for various fragmented archaeological materials. Simple counts, however, are prone to error due to the differential size of fragments. A more valid measure that approximates surface area is the effective area (EA). This measure offers a simple solution to the problem of quantifying ceramics from archaeological contexts.

Introduction

Archaeologists have long been using simple sherd counts as a measure of the relative abundance of ceramic types (cf. Kidder 1931; Ford 1952). The simple sherd count is derived by counting the fragments of broken ceramic vessels. Researchers using simple counts often encounter errors due to varying sherd size (Orton, Tyers, and Vince 1993; Childress 1992; Ford 1952; Gifford 1951, cited in Baumhoff and Heizer 1959), particularly when sherds of one type are highly fragmented while others are not. In most cases it is assumed that varying sherd sizes will have a minimal effect on the analysis (e.g., Ford 1952; Childress 1992). Some archaeologists (e.g., Orton, Tyers, and Vince 1993: 21; Chase 1985: 213; McNutt 1973: 45; Solheim 1960: 325; Gifford 1951: 223, cited in Baumhoff and Heizer 1959: 309) have expressed concern with this assumption and have questioned the use of sherd counts as a measure of the quantity of pottery (Orton, Tyers, and Vince 1993: 21; Chase 1985: 213).

A central theme of this paper is that sherd counts have a low degree of validity (Nance 1987) as a measure of relative abundance. A measure’s validity is determined by how well it measures what it is intended to measure (Nance 1987: 280); thus, it is necessary to state that the assumption here is that measures of the relative abundances of specific classes of ceramic materials are generally intended to measure the quantity of ceramic material belonging to each class (not necessarily the number of items such as pots or bowls).

Orton, Tyers, and Vince (1993: 23) have identified three important types of evidence commonly provided by ceramic analyses in archaeology: dating evidence, distributional evidence, and evidence for function and/or status. The full development of these areas of research involves the use of measures of relative abundance. In sites where ceramics are plentiful, they are often the primary means of dating the context in which they are found as well as the materials recovered in association. Date ranges are assigned based on the proportions of types with known temporal distributions. Distributions of ceramic types can shed light on specific aspects of past lifeways such as trade practices (Orton, Tyers, and Vince 1993: 23). An effective means of analyzing type distribution data is to present the data in a quantitative distribution map where proportions of respective types at various sites are displayed (Orton, Tyers, and Vince 1993: 201). Information relating to the function of individual pots can naturally lead to an interpretation of site function when proportions of different functional types present in an assemblage are ascertained (Orton, Tyers, and Vince 1993: 29).

Gifford (1951) was one of the earliest researchers to attempt to improve upon the simple sherd count as a measure of relative abundance. He employed sherd weight and found that “weighing sherds seems to give more accurate statistical results than counting them” (Gifford...
that is simple to apply and free of the problems encountered with more traditional measures.

**Fragmentation and Sherd Count**

The mathematical relationship between fragmentation and sherd count can be described verbally. Consider a hypothetical case in which a single vessel is broken in half, then the two fragments each break in half to produce 4 sherds, the 4 sherds break into 8, the 8 sherds break into 16, the 16 fragment into 32. We are observing an exponential increase in sherd count with each fragmentation event, along with a concomitant decrease in sherd size. The relationship between sherd count and fragmentation in the above example (where in each fragmentation event the sherds break in half) is

\[ N = 2^x \]

where \( N \) is the sherd count and \( x \) is the fragmentation episode. The number 2 results from the sherds breaking into 2 pieces each fragmentation episode. Thus, we begin with no fragmentation and a sherd count of 1, which is predicted by \( 2^0 \). The third fragmentation episode should produce \( 2^3 = 8 \) sherds and the fifth episode will produce \( 2^5 = 32 \). These numbers match those given for the hypothetical example. Note that as the sherd count increases, the sherd size decreases exponentially and the amount of ceramic material remains the same.

In reality sherds do not necessarily break into a set number of fragments (such as 2) with each fragmentation event. Nevertheless, it is this exponential increase in the number of fragments as they fracture into smaller and smaller pieces that distorts the simple sherd count and compromises its validity when applied to assemblages with variable sherd size.

**Methods**

Surface area is one attribute of ceramics that can provide a reliable measure of relative abundance (McNutt 1973: 45; Chase 1985: 218; Childress 1992: 39). Advantages to using surface area include the fact that it is not affected by external effects such as fragmentation, which distorts relative abundances determined from sherd counts, or varying paste characteristics of ceramic types, which can affect relative abundances figured from sherd weights. On the other hand, measuring the surface area of individual sherds and whole vessels can be an arduous task (Childress 1992: 39; Chase 1985: 218) and will not likely be adopted by archaeologists unless a relatively simple technique is developed for obtaining such data. The technique described below can be used to obtain an estimate of surface area.
Table 1. Percentage sherd counts per series from Test Unit C, Davenport Site, 31BR39.

<table>
<thead>
<tr>
<th>Context</th>
<th>N</th>
<th>Mt. Pleasant</th>
<th>Mockley</th>
<th>Deep Creek</th>
<th>Croaker Landing</th>
<th>Marcy Creek</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I</td>
<td>46</td>
<td>2</td>
<td>7</td>
<td>80</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Zone II</td>
<td>161</td>
<td>2</td>
<td>1</td>
<td>79</td>
<td>12</td>
<td>1</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Zone III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>68</td>
<td>3</td>
<td>33</td>
<td>49</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Level 2</td>
<td>124</td>
<td>1</td>
<td>29</td>
<td>46</td>
<td>22</td>
<td>2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Level 3</td>
<td>89</td>
<td>4</td>
<td>27</td>
<td>25</td>
<td>39</td>
<td>5</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Level 4</td>
<td>45</td>
<td>0</td>
<td>24</td>
<td>9</td>
<td>67</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Though the exact surface area of fragmented vessels is not obtained, a close and consistent approximation is demonstrated.

A measure named effective area (EA) can be obtained for a sherd by dropping it through a set of nested screens and assigning the area of the opening on which it comes to rest as the EA value. Standard hardware cloth with varying mesh size is recommended because it is cheap, readily available, and already commonly used by archaeologists. The finer the gradation of the screen sizes the more precise the EA will be.

Sherds can be quickly sorted into size classes by a set of screens with graded mesh sizes. Once sherds are sorted the number caught in each screen can be multiplied by the square of the screen size and then summed. The equation for the effective area can be expressed in an expeditious form as

$$EA = \sum n(z^2)$$

where $n$ is the number of sherds in a given screen and $z$ is the screen size.

Experimental Application

A simple experiment was conducted to demonstrate the improved validity of the EA over simple sherd counts. Nine terracotta vessels, each 4.25 in tall and 4.4 in in diameter, were painted to create three artificial types. Included as types were 3 red vessels, 3 black vessels, and 3 white vessels. The white vessels were broken into large fragments, the black vessels were broken into much smaller fragments, and the red vessels were smashed into even smaller fragments. All sherds were sorted by a screen set ranging from 0.5–4.0 in and graded every 0.5 in. The simple sherd counts for the three types varied greatly (18 white, 113 black, and 381 red sherds) as did the distributions of sherds in the five screens. EA values (100.8 for the red, 115.5 for the black, and 115.25 for the white) exhibited considerably greater equitability among the three types. The lower value for the red sherds results from many of the small sherds (EA < 0.25) having fallen through the bottom screen; these received values of 0. If these experimental vessels were an actual archaeological assemblage, the percentages calculated from simple counts would clearly present a distorted picture of the relative abundance.

Archaeological Application

The experimental application of the new method has allowed control over conditions such as the original number of vessels. It is also necessary to demonstrate that the proposed method can be successfully applied to genuine archaeological materials. The example selected for analysis here will be familiar to most archaeologists and will highlight the differences between results obtained by sherd counts and those obtained by EA.

A collection of 533 sherds from the Davenport Site (31BR39) on Albemarle Sound in eastern North Carolina was selected as the study sample. Testing at the Davenport Site was conducted by the Archaeology Laboratory, East Carolina University in 1992–1993. The site contained intact midden deposits spanning the Late Archaic through Middle Woodland periods. The sample used was excavated in Test Unit C, a 3 x 1 m trench. The stratigraphy of Test Unit C consists of five distinct zones, the top three of which contained prehistoric ceramics. Zone I and Zone II were excavated as individual units and Zone III was excavated in arbitrary 5 cm levels.

Percentages per level resulting from ceramic analysis are presented in Table 1. A total of four previously defined ceramic series were identified in the sample: Marcy Creek (Egloff and Potter 1982), Croaker Landing (Egloff et al. 1988), Deep Creek (Phelps 1983), and Mount Pleasant (Phelps 1983). A fifth type, consisting of flat bottom jars (Egloff and Potter 1982), is yet to be formally defined. These types represent a span of time from the Early Woodland period through the late Middle Woodland period
Table 2. Percentage EA per series from Test Unit C, Davenport Site, 31BR39.

<table>
<thead>
<tr>
<th>Context</th>
<th>EA</th>
<th>Mt. Pleasant</th>
<th>Mockley</th>
<th>Deep Creek</th>
<th>Croaker Landing</th>
<th>Marcy Creek</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I</td>
<td>13.75</td>
<td>2</td>
<td>4</td>
<td>79</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Zone II</td>
<td>25.25</td>
<td>4</td>
<td>8</td>
<td>62</td>
<td>16</td>
<td>10</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Zone III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>31.75</td>
<td>3</td>
<td>25</td>
<td>60</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Level 2</td>
<td>6.0</td>
<td>0</td>
<td>16</td>
<td>48</td>
<td>36</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Level 3</td>
<td>111.75</td>
<td>0</td>
<td>33</td>
<td>23</td>
<td>42</td>
<td>2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Level 4</td>
<td>41.25</td>
<td>0</td>
<td>15</td>
<td>7</td>
<td>78</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

(Egloff and Potter 1982; Phelps 1983; Egloff et al. 1988).

The sherds for each type were sorted through a screen set containing 4, 3.5, 3, 2.5, 2, 1.5, 1, and 0.5 in screens. The EA values were calculated and used to obtain the percentage representation of each type per level (Table 2).

A chi-square test for goodness of fit was applied to the ceramic data where the percentages calculated from EA values were used to derive expected values for sherd counts. The test results ($\chi^2 = 204.86, p = 0.00$) clearly indicate that the relative abundances based on EA are significantly different from those determined from sherd counts. Sherd count percentages and EA percentages from the excavated units in Test Unit C were next used to conduct frequency seriations to order the respective levels. Frequency seriation techniques were developed for ordering archaeological units for which there existed no other means of relative dating, such as stratigraphic context (Dunnell 1970; Marquardt 1978). The ceramic types from the levels in Test Unit C are already temporally ordered by their stratigraphic positions as well as by research conducted at other sites. It is assumed (problems with seriation notwithstanding, cf. Dunnell 1970) that if one or both of the measures is not providing a valid measure of relative abundance, a frequency seriation using that measure will not order the levels correctly. This independent check is intended to permit one to determine whether the relative abundances obtained using sherd counts or EA are more desirable.

Frequency seriations were conducted with the sherd count data and EA data using Gelfand’s Method II (Gelfand 1971; Marquardt 1978). The method involves the construction of similarity matrices, based on Robinson’s (1951) index of agreement (IA) for each pair of units. The index of agreement between each pair of units was calculated by subtracting from 200 the summed absolute values of the differences between the percentages for the respective types, where 200 represents the maximum possible agreement. The order for each row should be ordered to follow the Robinson pattern of monotonic decrease from the principle diagonal (Marquardt 1978).

The similarity matrices are given in Table 3. It is readily apparent that the IA values in the matrix calculated with the EA (Table 3) decrease neatly off the diagonal in all directions while those in the sherd count similarity matrix (Table 3) do not. The EA data produce the correct order of the excavated units, while the sherd count matrix incorrectly orders Zone II before Zone I.

The Relationship Between EA and Surface Area

Childress (1992) has discussed the problem of comparing type frequencies represented by sherd counts to those represented by whole ceramic vessels. He converted whole vessel quantities to measures comparable to sherd frequencies by estimating the surface areas of whole vessels and then dividing by the mean sherd size to get an estimated number of sherd per type (Childress 1992: 39). Childress lists one potential source of error arising from the variability in sherd size in the samples from which the means were

Table 3. Similarity matrices resulting from frequency seriation of excavation units. Matrices based on simple counts or on effective area values.

<table>
<thead>
<tr>
<th>Seriation</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple counts</td>
<td>200</td>
<td>189</td>
<td>134</td>
<td>130</td>
<td>90</td>
<td>50</td>
</tr>
<tr>
<td>A</td>
<td>189</td>
<td>200</td>
<td>133</td>
<td>127</td>
<td>87</td>
<td>49</td>
</tr>
<tr>
<td>B</td>
<td>134</td>
<td>133</td>
<td>200</td>
<td>182</td>
<td>140</td>
<td>96</td>
</tr>
<tr>
<td>C</td>
<td>130</td>
<td>127</td>
<td>182</td>
<td>200</td>
<td>154</td>
<td>110</td>
</tr>
<tr>
<td>D</td>
<td>90</td>
<td>87</td>
<td>140</td>
<td>154</td>
<td>200</td>
<td>144</td>
</tr>
<tr>
<td>E</td>
<td>50</td>
<td>49</td>
<td>96</td>
<td>110</td>
<td>144</td>
<td>200</td>
</tr>
<tr>
<td>F</td>
<td>200</td>
<td>166</td>
<td>157</td>
<td>130</td>
<td>84</td>
<td>48</td>
</tr>
<tr>
<td>Effective area</td>
<td>166</td>
<td>200</td>
<td>165</td>
<td>144</td>
<td>98</td>
<td>62</td>
</tr>
<tr>
<td>A</td>
<td>157</td>
<td>165</td>
<td>200</td>
<td>153</td>
<td>121</td>
<td>69</td>
</tr>
<tr>
<td>B</td>
<td>130</td>
<td>144</td>
<td>153</td>
<td>200</td>
<td>150</td>
<td>116</td>
</tr>
<tr>
<td>C</td>
<td>84</td>
<td>98</td>
<td>121</td>
<td>150</td>
<td>200</td>
<td>128</td>
</tr>
<tr>
<td>D</td>
<td>48</td>
<td>62</td>
<td>60</td>
<td>116</td>
<td>128</td>
<td>200</td>
</tr>
</tbody>
</table>
calculated, as indicated by the large standard deviations (Childress 1992: 39).

EA values of sherds, along with estimates of whole vessel surface area, make possible a simpler, more accurate approach to the problem of converting sherds to a measure that can be combined with whole vessel quantities. This approach rests on the fact that EA can be predicted from surface area. Ceramic vessels of ten different shapes and sizes were assembled to investigate the relationship between EA and surface area. Surface area for all vessels was estimated (in square inches) and the vessels were subsequently broken to varying degrees and the EA measured. Surface area and EA for the three vessels in the previous experiment were included.

A simple linear regression analysis was done with surface area as the independent variable and EA as the response variable. Because there are several values of EA for each value of surface area, it is necessary to formally test for linearity (see Zar 1984: 282). The one-tailed F-test for linearity described in Zar (1984: 282) was used to test the null hypothesis that the data are linearly distributed. The null hypothesis was accepted ($F = -3.92$, $p > 0.25$). The regression analysis resulted in a correlation coefficient of 0.996 ($R^2 = 0.991$) and an overall significance level of $p = 0.000$ ($F = 4666.279$). It is clear that total EA for an archaeological assemblage can be effectively estimated by employing a regression model to convert vessel surface areas to EA. The model presented here (FIG. 1),

$$EA = 0.831 \times (surface \ area)$$

is generally applicable to most ceramic vessels, but more precise models can be calculated by using data obtained from vessels of the specific shapes of interest.

**Discussion**

Analytical procedures in archaeology have traditionally involved using simple sherd counts for respective types as a measure of relative abundance. When such a procedure is applied to the experimental types above, it results in a distorted picture of the ceramic assemblage where the relative abundances are red 74.5%, black 22%, and white 3.5%. These percentages suggest that there are considerable disparities in the quantities of ceramic in each type. Percentages based on EA produce a drastically different picture with the red composing 30% of the assemblage, while black and white constitute 35% each. It is clear that EA provides a more accurate measure of relative abundance.

The archaeological application included a statistical test that showed that relative abundances based on EA were significantly different from those based on simple counts.

![Figure 1. Regression model with EA predicted from surface area that was calculated from an experimental assemblage with vessels of varying sizes and shapes.](image)

This finding verifies the impression of the authors that sherds are not consistently the same size but vary, sometimes considerably. The frequency seriation using sherd counts shows that varying sherd sizes can indeed lead to errors in interpretation that are archaeologically significant.

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Orton, Clive  

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