Assessment of the Cortext Ration Model to an Epipaleolithic Assemblage From Jordan

Sarah Raffae MacIntosh
University of Pennsylvania

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ASSESSMENT OF THE CORTEX RATIO MODEL
TO AN EPIPALEOLITHIC ASSEMBLAGE FROM JORDAN

By
Sarah Raffae MacIntosh

In
Anthropology
Submitted to the
Department of Anthropology
University of Pennsylvania

Thesis Advisors: Harold L. Dibble, PhD and Deborah Olszewski, PhD

2011
Abstract
Intensity in cortex reduction and the transport of artifacts have been long discussed in archaeological assemblages. The cortex model proposed by Dibble et al., "The Measurement and Interpretation of Cortex in Lithic Assemblages" in American Antiquity (2005) provided a successful geometric method to quantify the expected and observed amount of cortex in a particular assemblage. The ratio of observed to expected can highly suggest, or not suggest, the likelihood that flakes and other lithic material were selected for transport to and from the site. A collection of lithics stored at the University of Penn Museum from the Early Epipaleolithic occupation (Area C) at the site of Yutil Al-Hasa (WHS 784) in Jordan, a site excavated by Dr. Deborah Olszewski in the 1980s and 1990s, was selected. This research resulted in an assessment of the applicability of this model to an Epipaleolithic assemblage. Even though the Epipaleolithic is classified by microlith technology, the cortex model was used to quantify the cortex ratio for the Area C occupation at Yutil Al-Hasa. It concluded that that the Area C occupation site, known as the Nebeckian, was a temporary occupation site during the Epipaleolithic. Therefore, it can be assumed that flakes were the choice of artifact material to transport out of Yutil Al-Hasa when the occupation group migrated.
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INTRODUCTION

Lithics, the material cultures of hominids, are stone tools that are found in prehistoric assemblages. As our hominid lineage evolved, the material culture became more complex and specialized, which paralleled the evolving species. Eventually our lineage evolved into the anatomically modern humans named *Homo sapiens*, which we classify ourselves by today, in Africa around 120,000 – 100,000 years ago. When studying early modern humans from the Middle East around 90,000 years ago (Gosden 2003: 40), lithics can indicate that our species had a different capacity of intelligence and had the ability to carry out material culture in the same fashion than human beings today can. However, lithics are much more than just an indicator of early modern human intelligence. They provide clues, information, and insight into the lifestyles of the earlier eras of fully modern humans and their occupation, technology, and mobility.

Lithics have various components and key traits to them that provide critical information. Characteristics that are generally used to identify and describe lithics are its length, width, raw material, tool type typologies, and also its surface material. This paper will focus on the surface material, known as cortex, and the observed length, width, and weight measurements of the lithic material to calculate the predicted and expected cortex ratios from the Early Epipaleolithic occupation (Area C) at the site of Yutil Al- Hasa (WHS 784) in Jordan, a site excavated by Dr. Olszewski in the 1980s and 1990s.

Cortex is the main focus of this paper, since the presence of cortex is used in examining core reduction and its intensity. More recently, cortex has been used as markers in the human time line for tracing mobility and migration patterns (Dibble et al. 2005; Lin et al. 2009; Douglass et al. 2008). To begin with, cortex is identified as the outer surface of a lithic and has a more calcareous composition than the interior material which is often highly siliceous flint
(Debénath and Dibble 1994: 10). Cortex can be as thin as a piece of skin or it can be several millimeters thick. Cortex is always on the outer surface of a lithic and, generally, does not cover the entire lithic. It frequently only covers a small percentage of the lithic, or none may even be present.

In theory, retention of cortex on lithic materials diminishes over time as lithic pieces are reused continuously. If cortex proportions are accurate, then the cortex would slowly be removed from the core leaving only non-cortical flakes and non-cortical byproducts from the core. Lithic assemblages have been quantified to determine the cortex ratio and proportions in analyzing the retaining cortex amount on lithics to evaluate if the lithic was made at the site or transported from another site of human occupation.

Cortex occurs naturally on lithics. By knowing the amount of cortex in addition to the sized lithic, it can then become a quantified measurement to determine if all the byproducts from a particular core are present in the assemblage. It can also determine if particular pieces from the core were desired and therefore specifically manufactured and then transported to another site, or occupation area, or imported from another site.

Lithic pieces can be used to understand mobility patterns of anatomically modern humans, because early modern humans selected lithics, based on tool function, and transported them from one occupation site to another. Lithic pieces, e.g. flakes, were usually the choice of lithic to transport due to its small size and it can easily be retouched into a new tool. It is plausible that the presence of missing flakes from an occupation site could indicate mobility for different occupation groups. The absence of flakes indicates that early Homo sapiens were transporting lithics in the anticipation of using it for future needs. Quantifying cortex is useful,
because it can mathematically calculate and determine whether all byproducts from a core are present within an assemblage, or if the core reduction pieces have been transported to another site.

Cortex analysis will never be able explain how, where, and why the material came from to rest in a particular archaeological context, but cortex analysis can estimate the rate at which material is transported based on the cortex ratio. This was explained by Lewis Binford who stated that lithics that were used more than once and transported for future needs would be underrepresented at the occupation site where they were made. It should be noted that cortex analysis is not the only way to measure mobility, for mobility can be measured and determined in alternative ways.

The cortex model proposed by Dibble et al., “The Measurement and Interpretation of Cortex in Lithic Assemblages” suggests that cortex, knowing it is “an indicator of core reduction and transport” (Dibble et al. 545), can be quantitative in predicting the expected percentage of cortex and then compared to the observed percentage of cortex in a lithic assemblage. The goal is to determine whether, or not, flakes were transported from Yutil al-Hasa and at the rate by which they were transported. A second factor to be considered in this experiment is the choice of using an Epipaleolithic assemblage and does that contribute to the results.
Background to the Research Problem

In order for a cortex ratio to be quantified, an assemblage is needed to be studied and produce results. Dibble et al.’s experiment in 2005 was the first to determine a quantified experiment that used geometric shapes to calculate the expected and observed amount of cortical surface area in an assemblage. Following the experiment’s results, other archaeologists have applied the cortex ratio method to other archaeological assemblages. Douglass et al.’s experiment in 2008 took Dibble et al.’s method and applied it to an actual archaeological assemblage in New South Wales, Australia and concluded that transport of lithics were occurring at the tested sites. In 2009, Lin et al. took the method a step further by reducing human error in recording measurements by using a 3D laser scanner to record precise measurements. This experiment determined that a more accurate result occurred for quantifying the cortex ratio model when a large sample size is used. Holdaway et al. uses the cortex ratio model in his 2008 article “Identifying Low-Level Food Producers: Detecting Mobility from Lithics”. Be using the cortex ratio model, lithics are used to determine the degree that flakes were missing from the assemblage to suggest mobility when early human occupation groups had to deal with food and resources. One of the assemblages from this experiment comes from Egypt, which acts as a relatively comparative site to Yutil al-Hasa in Jordan.

Dibble et al.’s (2005) model and experiment focused on a lab created assemblage that successfully modeled the hypothesis that the cortex ratio model could be quantified by calculating the expected amount of cortical surface area to the actual represented amount of cortical surface area in the assemblage. This experiment hoped to use the cortex ratio model to determine if transportation of lithics to a site could be distinguished archaeologically, rather than ethnographically, and to see if there was an explanation for a particular tool type being
transported, if any existed. Furthermore, the experiment hoped to eliminate other factors that could affect the lithic assemblage, such as the human species' behavioral factor of actively choosing particular raw material to transport and the intensity by which a core was reduced to a large flake and then from that large flake to smaller flakes.

As a controlled experiment, 33 nodules were used to create the artificial assemblage. Each lithic greater than 1.5 cm was observed and had its dimensions and percentage of cortex recorded. The predicted amount of cortex in an assemblage was determined by comparing it to one of three geometric shapes: cube, sphere, and right cylinder. Geometric shapes allowed the amount of cortex to be determined by its volume and surface area and then easily summed to give a total for the lithics that contained cortex. Applying the geometric model to the assemblage allowed it to be quantified in a systematic way to determine the cortex ratio.

In Douglass et al.'s article “An Assessment and Archaeological Application of Cortex Measurement in Lithic Assemblages” (2008), Dibble et al.'s method was applied to an actual archaeological assemblage from western New South Wales, Australia. This experiment assessed the behavioral factor of selectively removing artifacts and transporting them away from their original location of manufacture. It was specifically interested in “how and where material came to rest in archaeological context” (Douglass et al. 2008: 513). By drawing on Lewis Binford's theory that lithics that could be used for a future purpose were transported while those that had no potential future use remained at the manufacturing site. Therefore, occupation sites where tools were made contained fewer of these tools since they were transported elsewhere for future use. By using the cortex ratio model that quantified the surface are and volume of geometric shapes, Douglass et al. hoped to find a means that gauged the over or under supply of reduction
debris in a particular assemblage. Furthermore, this experiment would test the cortex ratio on raw material from an archaeological assemblage rather than a lab created assemblage.

Five locations in New South Wales, for its history was noted for occupation sites, were studied for this experiment. The recorded assemblage was different than the lab created assemblage from Dibble et al.'s experiment. However, the geometric solid shapes could be applied to their data. The results given, since the ratio was below 1, indicate that cortex is underrepresented in the assemblages. Therefore, "artifact transport was a factor influencing assemblage formation" (Douglass et al. 2008: 520). Though specific to New South Wales, Australia, it should be noted that when comparing the ratio of core mass to total assemblage mass that the raw materials used to make cores were less intensively reduced (Douglass et al. 2008: 521). The overall interpretation is the underrepresented amount of cortex in the assemblage is due to mobility of the human group that occupied the site, since they were transporting artifacts to other sites to use them for later.

Lin et al.’s article “The Application of 3D Laser Scanning Technology to the Assessment of Ordinal and Mechanical Cortex Quantifications in Lithic Analysis” decided to quantify the expected and observed cortical surface area by using 3D last scanning. Like Dibble et al.’s experiment, 31 complete lab created assemblages was used to test (Lin et al. 2009: 700). Each artifact was measured using the method described in Dibble et al.’s article and they were also scanned. Each scan took points on a complete 360° rotation to record the measurements of maximum length, width, and thickness. Errors were identified to occur most likely when mechanical measurements of surface area and the ordinal measures of cortex percentage were recorded. Also, for flakes and flake fragments, irregularity in their form could cause over-estimation of their actual cortical surface area, which could be corrected the 3D laser scanner.
The results showed that 3D laser scanning provided more accurate measurements, since mechanical measurements generally over-estimate the amount of cortical surface area. Also, by using geometric shapes as basis of comparison for the cortex ratio model, one is assuming that the original nodules, or cores, were perfect geometric shapes before reduction. Over estimation of the values can affect the cortex ratio by calculation a slightly higher ratio. A slightly higher ratio would suggest that lithics were transported from one occupation site to another at a lower rate, since the observed percentage of cortex is closer to the expected percentage of cortex.

Holdaway et al. in 2009 claimed that early modern humans were “low-level food producers”, which suggests that they were neither wholly hunter-gathers nor wholly agriculturalists (Holdaway et al. 2009: 185). Lithics are used to test his theory using the same concept that the cortex ratio model suggests: the degree of artifact transport from an occupation site. This article looks at missing flakes from an assemblage to indicate mobility, which would then suggest “how people coped with the unpredictable appearance of food resources” (Holdaway et al. 2009: 185). Using Dibble et al.’s cortex ration model, two case studies are put under the experiment: one from western New South Wales, Australia and the other from the Fayum region of Egypt.

In New South Wales, the interpretation led to the conclusion that while transporting cores would be easier for the purpose of creating more varied tools in the future, transporting flakes was easiest due to efficiency in mass. Resources were frequently exploited; therefore, materials imported to the site were retouched more than local raw materials. This would make sense due to the limited range of resources and flakes made it possible to deal with “the uncertainty of food resource availability (Holdaway et al. 2009: 189).
In Egypt, high amounts of Neolithic remains have been found containing food artifacts and fauna. Moreover, geographically, location near the Nile River caused human occupation to be short lived due to the constant flooding of the river. Observations on the amount of cortex present on flakes suggest that materials, like flint pebbles, were imported to the Fayum region. Also, flake mobility is lower at this site in comparison to the Australian site since the cortex ratio at the three sites in Egypt (Kom K: 0.5; Kom W: 0.5, and XB11: 0.4) are higher (Holdaway et al. 2009: 191). However, a higher cortex ratio does not mean the occupation groups were not mobile. It signifies that the degree of mobility is less than other occupation groups. The cortex ratio numbers from the three sites in Egypt will be compared to the Yutil al-Hasa site in Jordan. Though the dates and occupation types do not parallel from the selected sites in Egypt and Jordan, the approach is to compare two site in the Levant region that have analyzed by method of the cortex ratio model.
Information about the Yutil al-Hasa Site

The lithic material that will be observed, recorded, and quantified is stored at the University of Pennsylvania Museum of Archaeology and Anthropology. These lithics are from the Early Epipaleolithic occupation (Area C) at the site of Yutil Al-Hasa (WHS 784) in Jordan (see figure 1), a site excavated by Dr. Deborah Olszewski in the 1980s and 1990s. The material chosen from Area C has already been analyzed and studied by Dr. Deborah Olszewski. However, analysis regarding the percentage of cortex in the assemblage has not been taken and applied to the cortex ratio model.

The Wadi al-Hasa region of Jordan houses an abundance of human occupation sites that have been extensively used from the Paleolithic times to the Ottoman period (Olszewski 1997: 171). Starting from the Pleistocene, human groups were settling along the drainage lake by the eastern portion of the Wadi. The best preserved sites date to the late Upper Paleolithic and most of the Epipaleolithic period. Based on two excavations, 1984 and 1993, Yutil al-Hasa has documented three time frames: late Upper Paleolithic (Ahmarian), early Epipaleolithic (Nebekian), and late Epipaleolithic (early Natufian). At Yutil al-Hasa, 6, 107 artifacts were excavated, whereby 393 (6.4%) of these artifacts are tools (Olszewski 1997: 175).

Distinctively concerning Yutil al-Hasa (WHS 784), this site is located within 10 km of a Pleistocene lake and close to the drainage basin, in west-central Jordan. It is a collapsed rock shelter, and it is surrounded by boulders that were used extensively by hunter-gatherer societies from approximately 19,000 to 11,000 bp (Olszewski 1997: 171). Site occupancy for this particular site has been dated during the late Upper Paleolithic and during at least two Epipaleolithic periods (Olszewski 1997: 171). 64% of the tool assemblage is manufactured on blade or bladelet blanks, and majority of the debitage is flakes. It should be noted that most of
the flakes are smaller than 2 cm, which can equate to 34 to 43% of the assemblage. Most interesting is the infrequency of cores, which will be a contributing factor when calculating the volume of cortex per core for the cortex ratio. Variation in the tool assemblage, if compared to other sites, would account for site function or a chronological change (Olszewski 1997: 174).

The early Nebekian material of the Epipaleolithic, excavated in 1993, was dug from a 1x1 m test unit. The dates for the Nebekian periods are ca 19,800 ± 350 bp to as late as c. 12,680 ± 320. Unit C is most likely early in time sequence for the Nebekian time period. Its early occupancy is characterized by its lithic assemblage composed mostly of narrow non-geometric microliths with microburin technique. Regarding nonlithic material, fauna was excavated from the test unit, resulting primarily in gazelle and onager remains with some Bos primigenius and tortoise remains. The spring-fed pond and marsh biomes made it possible for a few arboreal species, like the Pinus, Pistacia, Ceratonia, etc, to grow, but more often were arboreal species rare.

Little variety exists among the lithic materials. 83% of the Nebekian, section Unit C, are tools of microburin technology and non-geometric forms. Around 20% of the remaining assemblage consists of notches and denticulates and retouched pieces. The diversity in the assemblage indicates that the tools were most likely curated and transported to other sites. This is inferred from the limited number of reshaped tools and small flakes present, whereby small flakes are usually the byproducts of retouched pieces. Most importantly, as related to the cortex ratio, there is a low diversity of cores and core types in the Nebekian assemblage. Low number of cores indicates limited flintknapping activity occurring at the site; thus, it provides an explanation as well to why there is little variety.
Upper Paleolithic and Epipaleolithic sites in the eastern Wadi al-Hasa, Jordan.

This map illustrates the placement of Yutil al-Hasa to other sites in Jordan.

(Figure: Olszewski 1997: 172)
The limited variety of lithic tools during the Nebejian period heavily suggests that there were infrequent occupations at the rock shelter. These short occupation stays can be supported by the rock shelter’s actual size and the limited variety in lithic tool types. In short, the infrequent occupation use of this site is “the typical archaeological signature of a relatively mobile population” (Olszewski 1997:176).
Table 1

*Summary of tool assemblages from Yuitl al-Hasa* (Olszewski 1997: 173)

<table>
<thead>
<tr>
<th>CLASS</th>
<th>LATE AHMARIAN</th>
<th></th>
<th>NEBEKIAN</th>
<th></th>
<th>EARLY NATUFIAN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COUNT</td>
<td>%</td>
<td>COUNT</td>
<td>%</td>
<td>COUNT</td>
<td>%</td>
</tr>
<tr>
<td>Scraper</td>
<td>20</td>
<td>7.4</td>
<td>7</td>
<td>1.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Burin</td>
<td>21</td>
<td>8.1</td>
<td>7</td>
<td>1.8</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Borer</td>
<td>5</td>
<td>1.8</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Backed Piece</td>
<td>3</td>
<td>1.1</td>
<td>1</td>
<td>0.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Truncation</td>
<td>6</td>
<td>2.2</td>
<td>4</td>
<td>1.0</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Notch/Denticulate</td>
<td>45</td>
<td>16.6</td>
<td>24</td>
<td>6.1</td>
<td>16</td>
<td>23.9</td>
</tr>
<tr>
<td>Retouched Piece</td>
<td>69</td>
<td>25.5</td>
<td>24</td>
<td>6.1</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>Special Tool</td>
<td>3</td>
<td>1.1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Nongeometric</td>
<td>98</td>
<td>36.2</td>
<td>315</td>
<td>80.1</td>
<td>21</td>
<td>31.3</td>
</tr>
<tr>
<td>Geometric</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>2.8</td>
<td>17</td>
<td>25.4</td>
</tr>
<tr>
<td>Varia</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>270</td>
<td></td>
<td>393</td>
<td></td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>
METHODS

The purpose of this experiment is to use the cortex ratio model proposed by Dibble et al. and apply it to the Early Epipaleolithic occupation (Area C) at the site of Yutil Al- Hasa (WHS 784) in Jordan. The results and observations will be shown quantitatively. Dibble et al. verified that the different surface area to volume ratios of nodules can be quantified into percentages of cortex regarding their average size and their three dimensional solid geometric shapes. The cortex ratio conveys the observed quantity of cortical surface area to the quantified expected quantity of cortical surface area. It can also indicate the degree of artifact transport; that is, if there is any.

The ratio can be affected by two actions: [1] the removal of cores and cortical pieces from the assemblage with a high percentage of cortex and [2] the removal of cores and cortical pieces from the assemblage with a low percentage of cortex (Dibble et al. 2005; Lin et al. 2009). The removal of lithics with a high percentage of cortex will be lower the ratio while the removal of lithics with a low percentage of cortex will increase the ratio. Thus, the assemblage can be used to interpret the site’s use: was it a high production site or was it only a temporary occupancy stay.

In order to assess the cortex ratio, raw material from an archaeological assemblage will be used instead of nodules from a lab created assemblage. Understanding there is room for potential error (Lin et al. 2009) for mechanically measuring the lithic material, the material will be recorded mechanically with calipers. Measured and quantified in a consistent and precise way, the data followed a similar data recording procedure as described by Dibble et al. Observations were first recorded based on its typology and raw material. If a piece had no cortex, then no length or width measurements were taken – only the weight was recorded. If a piece had
cortex and was 2.5 cm or greater, then it was measured individually by its length, width, and weight. Then, the percentage of cortex was observed based on an interval scale (recorded as 0 percent, 1-10 percent, 11-25 percent, 26-40 percent, 41-55 percent, 56-70 percent, 71-85 percent, and 86-100 percent). Pieces that were smaller than 2.5 cm, even those that contained cortex, were already pre-grouped according to their [1] specimen number and [2] typology. Therefore, they were counted and collectively weighed so their volume could be included in the total assemblage.

After observing and recording measurements, surface area and volume were calculated for expected and observed cortical value. The expected value represents all the elements of the site that should be present if they have not been transported. To calculate the expected volume, the lithics are compared to three geometric shapes: cube, sphere, and right cylinder (see figure 2). The geometric shapes provide a comparative basis for quantifying this measurement. In this particular experiment, the expected volume was expressed by the solid sphere shape, because this geometric shape reflects the closest original shape of the original nodule. Selecting the cube would overestimate the amount of cortex while the right cylinder would have underestimated the expected volume.

The cortical surface area of the sphere was calculated by the formula \( S = 4\pi \left( \frac{3V}{4\pi} \right)^{2/3} \). V stands for volume which was calculated in several parts: [1] dividing the weight of each lithic by its density (2.46, as determined by water displacement for both chert and obsidian) and [2] summing the weight of each lithic divided by its density to get a total volume. [3] This total volume is then divided by the number of cores to quantify the amount of volume per core. [4] This number is then inserted into the sphere formula for V.
Three Geometric Solid Shapes used to model surface area to volume ratios.

(A) Cube; (B) Sphere; (C) Right Cylinder

The geometric shapes provide a comparative basis for quantifying this measurement. In this particular experiment, the expected volume was expressed by the solid sphere shape, because this geometric shape reflects the closest original shape of the original nodule. Selecting the cube would overestimate the amount of cortex while the right cylinder would have underestimated the expected volume.

(Figure: Dibble et al. 2005: 548)
For the observed cortical surface area, calculations first must be done by multiplying the surface area (length of the lithic multiplied by the width of the lithic) to the midpoint of the proportion of cortex as observed on the piece. This value was then summed for all the lithic pieces that contained cortex and were 2.5 cm or greater.

It should be noted that the surface area for cores was calculated differently. To account for the size and the more 3D dimensional surfaces area of cores, as compared to relatively flat flakes, the surface area of each core was multiplied by two (length x width x 2).

Once the expected value and observed value was quantified, the cortex ratio was calculated by dividing the observed cortical surface area over the expected total amount of cortical surface area. For the final step of obtaining the cortex ratio, the observed number divided by the expected number is ultimately divided by 100 to make it a percent.

The resulting number is expressed as a ratio, which means the result will most likely be either higher than one or lower than 1. A higher ratio would indicate low transport of lithics at the occupation site, while a lower ratio would indicate high transport of lithics at the occupation site.
Results

In total, 673 data sets, containing both individual pieces and collective groups of pieces, were entered into the computer program ‘New Plot,’ which sorts and catalogues the site’s information in an Access database. This equates to a total of 5,476 lithic pieces that were observed, recorded, and quantified. Of these lithic pieces, 5,059 pieces contained either no cortex or were smaller than 2.5 cm. There were 390 pieces that were 2.5 cm or greater, and these had cortex and were measured for length and width and also the percentage of cortical surface area.

Just as Douglass et al. (2008) and Holdaway et al. (2009) were successfully able to apply the methods and techniques described in Dibble et al.’s experiment to an archaeological assemblage, this application of the cortex ratio method to an Early Epipaleolithic assemblage was successful as well. By comparing solid geometric shapes to the shape of what the original cores would have looked like, the cortex ratio method was capable of quantifying an expected value for the cortical surface area and comparing it to the observed cortical surface area to calculate the cortex ratio, which in this case was 0.31.

Having a cortex ratio of 0.31 is significant in terms of where it stands on the ratio scale. Having a value that is very close to 1 would indicate that almost no transport of lithic artifacts was occurring at the occupation site, because that means all the tools and debitage from the original core would have remained at the site. Having a value that is close to 0 heavily suggests that there was a high volume of transport of lithic artifacts occurring at the occupation site, because most of the tools and debitage from the original core are not present in the assemblage.
Therefore, Yutil al-Hasa during the Nebekian occupation era can be interpreted as a temporary occupation site due to the rate of cortex material that was being transported from the site.

Table 2

*Summary of the calculations used for the cortex theory based on 28 cores*

<table>
<thead>
<tr>
<th>Summed Volume of Expected Cortex</th>
<th>1023.57 cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cores</td>
<td>28.00</td>
</tr>
<tr>
<td>Volume per Core</td>
<td>36.56 cm³</td>
</tr>
<tr>
<td>Expected Cortical Surface Area</td>
<td>1806.80 cm²</td>
</tr>
<tr>
<td>Observed Cortical Surface Area</td>
<td>56327.55 cm²</td>
</tr>
<tr>
<td>Cortex Ratio</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Discussion and Conclusion

Results can be justified based on the characteristics of the Epipaleolithic and the
deposition of lithics in the assemblage. The lithics would fit the composition, since most lithic
types in the Epipaleolithic are microliths. And, specifically in the Nebeian occupation, the
lithic assemblage is characterized by narrow non-geometric microliths with microburin
technology (Olszewski 1997). With little variety already in the assemblage, it is not surprising to
learn that most of the lithics do not contain cortex and are smaller than the cut off chosen at 2.5
cm. This should not affect the final results, since Dibble et al. stated that the cortex ratio will be
“unaffected by technological variation and different rock types” and “it is a method that can be
applied to lithic materials from anywhere and anytime” (Dibble et al. 2005: 558).

However, Dibble et al.’s theory focused more on large flakes that were selected for
transport, since they provided the most efficient means of creating retouched pieces. Perhaps in a
lab created assemblage or in New South Wales, Australia would the practicality of transporting
flakes be more efficient in to carry, since the flakes provide a bigger surface area per unit weight
for manufacturing future tools. In analyzing the cores from the Epipaleolithic, their size would be
more practical in transporting due to their relatively small size and their capacity to create future
tools. The average observed volume of the cores that had cortex was 822.48 cm$^3$. The average
observed volume of flakes that had cortex was 119.19 cm$^3$. Transporting cores would create
more weight per unit surface area than the flakes.

As discussed in Olszewski’s article (1997), it was already discussed that tools from the
assemblage were most liked “curated to other locales” (Olszewski 1997: 175). Due to the small
and limited number of small flakes present in this particular assemblage, it was already
concluded that artifacts were transported since tools that could be retouched are not present. Furthermore, the number of cores limits the assemblage to be a specialized one, since the quintessential tools of the Epipaleolithic are not present. However, Dibble et al.’s (2005) experiment used only 33 nodules, which would dissuade the belief that low numbers of nodules could potentially affect the result of the ratio.

A note should be made on the number of cores present in Unit C. In 1997, Olszewski documented 30 cores (Olszewski 1997: 174) in the assemblage. When observations took place, only 28 cores were documented. Two of the cores may have been overlooked while observations were made. Or, two of the cores may have been misplaced in the collection. If those two cores were accounted for and estimated lengths and measurements were made, then the results would have produced a cortex ratio of 0.30. This cortex ratio only differs by 0.01 from the quantified in the actual assemblage, which was 0.31. This concludes that even though two additional cores were added to the observed assemblage, the cortex ratio is not affected greatly. However, it should be noted that less volume is attributed to the cores since the same volume has to be distributed to a higher number of cores.

If this experiment were to be performed again, one way for improvement would be to use the methodology discussed in Lin et al.’s article and scan each lithic artifact to observe more accurate measurements. Using a caliber to take the mechanical measurements allows room for potential error, since “mechanical measurements tend to slightly overestimate the actual Cortex ratio due to inherited variability from the mechanical surface area movement” (Lin et al. 2009). However, limitations would then be pressed due to the relatively small size of the majority of pieces in the assemblage being under 2.5 cm. If those pieces could be recorded in a systematic
way to calculate their cortex percentage, then a better cortex ratio of observed to expected could be quantified.

It should be restated that though the cortex method is helpful in ascertaining the rate at which core reduction took place. It also confirms Olszewski’s (2007) position that Yutil al-Hasa was a temporary occupation site during the Nebekian. One will never know “how and where material came to rest in archaeological context” (Douglass et al. 2008). The cortex model is supposed to mathematically determine how much cortex will be present in the assemblage. While it serves as a good basis for comparison, there are too many external variables that affect the observed value to conclude.

However, the cortex model can determine whether the occupation site tested functioned more as a temporary site or a long term site. A good test to confirm this for the Epipaleolithic would be to sample other assemblages from Jordan that make up to the Nebekian time period. For a wider sample, testing Epipaleolithic assemblages in other regions of the Levant would be plausible.
Table 3

*Summary of the calculations used for the cortex theory based on 30 cores*

<table>
<thead>
<tr>
<th>Summed Volume of Expected Cortex</th>
<th>1020.41 cm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cores</td>
<td>30.00</td>
</tr>
<tr>
<td>Volume per Core</td>
<td>36.44 cm$^3$</td>
</tr>
<tr>
<td>Expected Cortical Surface Area</td>
<td>1935.86 cm$^2$</td>
</tr>
<tr>
<td>Observed Cortical Surface Area</td>
<td>57260.59 cm$^2$</td>
</tr>
<tr>
<td>Core:ex Ratio</td>
<td>0.30</td>
</tr>
</tbody>
</table>
References


