How closely the Neolithic people of the site of Okhta 1 were related to the Neolithic people of the sites of Sarnate and Šventoji 43?

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Abstract

The Pit-Comb Ware from the Neolithic site Okhta 1 is much alike that from the Neolithic sites located on the territories of the Baltic states. The degree of relatedness of the Neolithic people of Okhta 1 to those of Sarnate and Šventoji 43 can be estimated by calculating the degree of resemblance of the corresponding assemblages of potsherds. The degree of resemblance between the assemblages of potsherds from Okhta 1 and from Sarnate is 0.32. The degree of resemblance between the assemblages of potsherds from Okhta 1 and from Šventoji 43 is 0.42. The degree of resemblance between the assemblages of potsherds from Sarnate and Šventoji 43 is 0.39. It means that the regularity of contacts of the Neolithic people of Okhta 1 with those of Šventoji 43 was the same as the regularity of contact between the Neolithic people of Šventoji 43 and those of Sarnate.

Keywords: Pit-Comb Ware; Neolithic period; Neolithic pottery; ornaments of pottery; Mathematical Semiotics

1. Introduction to the problem

The Neolithic site of Okhta 1 (its location can be seen in Fig. 1) was discovered in 2008 (Gusentsova & Sorokin 2011: 421). The site was dated to the 4th millennium – the beginning of the 3rd millennium BCE (Gusentsova, Sorokin 2011: 422).

The site of Okhta 1 was not a settlement since in the Neolithic era, it was a shallow bay of the Litorina sea into which Paleo-Okhta and Paleo-Tosna flowed (Nikitin 2010: 163; Akulov 2022a) see also fig. 1, and the territory of the site was used as a fishing place by the Neolithic people (Bazarova et al. 2010: 173–174).

Upon the site were found fragments of pottery with characteristic ornamentation (the so-called Pit-Comb Ware), stone tools, fragments of fishing traps, and amber items.

As far as there is no amber in the eastern part of the Gulf of Finland, so all amber items were brought from the territories of the modern Baltic States. It is interesting to note that some amber items seem to be fishing lures and that amber items, found on the site of Okhta 1, look much like items that were found on Neolithic sites located on the territories of the modern Baltic States (Efimova 2020). It is possible to say that there were relatively close contact between the Neolithic people who practiced fishing upon the site of Okhta 1 and the Neolithic inhabitants of the territories of the modern Baltic states.

Another evidence of contacts is the similarity of ceramic traditions: it is noted that the ceramics of Okhta 1 is rather close to the Neolithic ceramics of Baltic States in the way of ornamentation (Gusentsova, Sorokin 2011: 427).
Usually, conclusions about the resemblance of certain ceramic traditions are extremely speculative, however, there are methods that allow one to estimate the degree of resemblance of ceramic traditions precisely and express it in a numerical form. Also, I am to note that archaeologists who study ceramics like to write about the chemical composition of clay, different organic additives, about different types of dung that were added to the clay, and on this material they often try to conclude about the possible relatedness of different ceramic traditions.

Fig. 1. A map showing the landscape of the territory of Okhta 1 site in the Neolithic period superimposed on the map representing the modern landscape of the area; Paleo-Tosna flowed along the future bed of Neva (drawn by the author)

The study of the chemical composition of the clay used for procuring a certain ceramics is completely useless for the study of degrees of relatedness of different ceramic traditions since people of the same ceramic tradition living in different territories usually use the clay that was available in their area, and different types of clay existing in different areas evidently can differ in their chemical composition, and also in different territories, different additives to clay can be used.
Estimating the degrees of similarities of different ornamental traditions is the matter that allows us to see the degree of relatedness of different groups of people: ornamental traditions are a form of the Neolithic art and the resemblance of artistic traditions directly shows the degree of relatedness of the corresponding local groups. By estimating the degrees of resemblance of different ornamental traditions we can see the structures of Neolithic communities/tribes, we can draw a map of Neolithic tribes/ethnic groups. And it is the matter that makes archeology the science of ancient societies, and not just the bookkeeping of potsherds and flakes.

In this article I am going to answer the question of how closely the Neolithic people from Okhta 1, Sarnate, and Šventoji 43 were related by estimating the degree of resemblance of the corresponding assemblages of potsherds (the method is described below).

The site of Sarnate was dated to 4700 ± 250 – 4490 ± 250 (Vankina 1970: 138–139), the site of Šventoji 43 was dated to 3900 – 3650 cal BCE (Piličiauskas et al. 2019: 67), i.e.: Sarnate and Šventoji 43 existed in the same period as Okhta 1.

Fig. 2. A map showing the location of Okhta 1, Šventoji 43, and Sarnate sites (drawn by the author)
2. The method of dating

2.1. The general idea of the method

If there are two randomly selected assemblages of randomly broken potsherds with fragments of a certain ornament, it is possible to conclude about the most frequent ornamental imprints. The most frequent imprints are supposed to be the most characteristic imprints of a certain local ceramic tradition. And thus, comparing the frequency of different imprints, it is possible to conclude about the degree of resemblance of assemblages of potsherds and about the degree of relatedness of the corresponding groups of people.

To estimate the degree of resemblance of two assemblages of potsherds should be done the following procedures: 1) to estimate the degree of correlation of sets of represented ornamental imprints, 2) to estimate the degree of correlation of frequencies of common imprints (imprints represented upon potsherds belonging to each of compared assemblages), 3) to estimate the degree of exclusion of potential deviation/error, 4) to take a superposition of these three parameters. The closer are certain ornamental traditions, the higher is the corresponding degree of resemblance.

The formula for calculating the degree of resemblance of two assemblages of potsherds is the following:

\[
\frac{1}{2} \left( \frac{m}{N_{\text{imp}(A)}} + \frac{m}{N_{\text{imp}(B)}} \right) \times \frac{1}{m} \left( \frac{\text{lower frequency}_1}{\text{higher frequency}_1} + \ldots + \frac{\text{lower frequency}_m}{\text{higher frequency}_m} \right) \times (-0.88r^2 + 1.52r + 0.35)
\]

where:

- \(N_{\text{imp}(A)}\) – the number of imprints represented in A (first set),
- \(N_{\text{imp}(B)}\) – the number of imprints represented in B (second set),
- \(m\) – the number of common imprints,
- \(r\) – the ratio of numbers of potsherds in the compared assemblages.

The left component of the formula:

\[
\frac{1}{2} \left( \frac{m}{N_{\text{imp}(A)}} + \frac{m}{N_{\text{imp}(B)}} \right)
\]

shows the degree of correlation of sets of ornamental imprints represented on the potsherds of the compared assemblages.

The central component of the formula:

\[
\frac{1}{m} \left( \frac{\text{lower frequency}_1}{\text{higher frequency}_1} + \ldots + \frac{\text{lower frequency}_m}{\text{higher frequency}_m} \right)
\]
shows the degree of correlation of frequencies of common ornamental imprints (imprints represented upon potsherds belonging to each of compared assemblages).

And the right component of the formula:

\[-0.88r^2 + 1.52r + 0.35\]

shows how close the compared assemblages of potsherds are in the quantitative aspect, and to what extent the possibility of deviation/error is excluded.

For the sake of shortness and convenience, the method is sometimes named the Monte Carlo method since it is about comparing randomly selected assemblages of potsherds which in their turn were randomly broken. Actually, there are three moments of random over here: potsherds were randomly broken, a random amount of potsherds was picked up, and a random amount of the picked was published. Also the method can be named the method of frequencies since its main point is the comparison of frequencies of ornamental imprints. For more details about the method see Akulov, Nonno 2019; Akulov, Nonno 2022b.

2.2. An illustration of the method

Let’s imagine that we have three assemblages of potsherds: A, B, and C.

Assemblage A:

<table>
<thead>
<tr>
<th>1</th>
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Assemblage B:

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Assemblage C:

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It is important to note that one potsherd can bear more than one imprint.

To single out the basic elements of a certain ornament the following recommendations can be offered: each potsherd has a certain set of imprints; if this set consists of homogenous/similar elements only then the whole set is a basic element of ornamentation. If this set consists of several groups of heterogeneous elements that have no intersections, then each of these groups is a basic element (for more details see Nonno 2020).

In assemblage A there are two imprints: /// and ;
/// is represented on 6 potsherds of 6 and so its frequency/percentage is 1, and ⁞ is represented on 3 potsherds of 6, so its percentage is 3/6 = 0.5.

In assemblage B there are the same imprints: /// and ⁞
/// is represented on 5 potsherds of 5, so its percentage is 1, and ⁞ is represented on 2 potsherds of 5, so its percentage is 2/5 = 0.4.

In assemblage C there is only one imprint ///, so its percentage is 1.

The ratio of numbers of potsherds of A and B is 5/6 = 0.83, the ratio of numbers of potsherds of A and C is 6/7 = 0.86, and the ratio of numbers of potsherds of B and C is 5/7 = 0.71. According to the above-shown formula, the degree of resemblance between A and B is the following: 
\[
\frac{2/2 + 2/2}{2} \times \frac{1/1 + 0.4/0.5}{2} \times \left( -0.88 \times 0.83^2 + 1.52 \times 0.83 + 0.35 \right) = 0.9.
\]

The degree of resemblance between A and C is the following:
\[
\frac{1/2 + 1/2}{2} \times \frac{1/1}{1} \times \left( -0.88 \times 0.86^2 + 1.52 \times 0.86 + 0.35 \right) = 0.76.
\]

And the degree of resemblance between B and C is the following:
\[
\frac{1/2 + 1/2}{2} \times \frac{1/1}{1} \times \left( -0.88 \times 0.71^2 + 1.52 \times 0.71 + 0.35 \right) = 0.76.
\]

2.3. Threshold values

When two assemblages of potsherds are compared, then appears the question of threshold values that allow interpreting the received degree of resemblance. There are two different schemes of threshold values that can be used.

The first scheme is a standard set of assemblages that can be used as a source of threshold values.

A standard set of assemblages is a set of assemblages of potsherds that originate from certain undoubtedly related sites, and the values of the degree of resemblance demonstrated by such a set of assemblages can be used as a base for interpreting the values of the degree of resemblance of other assemblages of potsherds. If certain assemblages of potsherds demonstrate the same or close values of the degree of resemblance as the standard set of assemblages, then it means that such assemblages are as close as the assemblages belonging to the standard set.

In the case of the Pit-Comb Ware of the Northwest of Russia and the neighboring areas, the set of assemblages of potsherds from the Neolithic sites of Sestoretskii Razliv can be used as a standard set of assemblages. This set of assemblages of potsherds consists of eight assemblages that originate from geographically very close sites (see Fig. 3). And also all the Neolithic sites of Sestoretskii Razliv are dated to the late/final Neolithic period. It is possible to state that all these eight sites belonged to pretty close groups, and so the values of the degree of resemblance demonstrated by different pairs of the Razliv sites (Table 1) are the values of the degree of resemblance that can be shown by a set of pretty closely related assemblages of potsherds.
Fig. 3. A map showing the location of Neolithic sites of Sestroretskii Razliv. A triangle means sites with stone tools of late types, a circle means sites of the late Neolithic stage, and a square means Mesolithic site (the upper image was drawn by the author, the lower image source – Gurina 1961: 415)
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<tr>
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<th>R1</th>
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<th>R4</th>
<th>R5</th>
<th>R7</th>
<th>GR</th>
<th>SG</th>
<th>Tar</th>
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<tr>
<td>R1</td>
<td>0.28</td>
<td>0.27</td>
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<td>0.15</td>
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<td>R2</td>
<td>0.51</td>
<td>0.27</td>
<td>0.3</td>
<td>0.31</td>
<td>0.27</td>
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<td>R4</td>
<td>0.47</td>
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<td>R5</td>
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<td>R7</td>
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<td>GR</td>
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Table 1. Values of the degree of resemblance of assemblages of potsherds of the following sites: R1 – Razliv 1, R2 – Razliv 2, R4 – Razliv 4, R5 – Razliv 5, R7 – Razliv 7, GR – Glinanyi Ruchei, SG – Sosnovaya Gora, Tar – Tarkhovka

The values, represented in Table 1, form a diapason from 0.13 to 0.51. The average of the values represented in Table 1 is 0.3. If a certain particular value of the degree of resemblance is higher than 0.3 or close to 0.51 it means that the compared assemblages of potsherds are pretty close.

And the second scheme is the scheme of local threshold values. Let there be three assemblages of potsherds: A, B, and C, and it is known that A and B belong to pretty closely related groups, then if the value of the degree of resemblance of A and C (or B and C) is higher than that of A and B or close to that of A and B, then it means that all these three groups (A, B, and C) are pretty closely related.

3. Assemblages of potsherds from Okhta 1, Sarnate, and Šventoji

3.1. The assemblage of potsherds from the site of Okhta 1

In the assemblage of potsherds from the site of Okhta 1 there are 12 potsherds (Fig. 4).

And can be singled out 7 ornamental imprints:

1) comb (potsherds 1, 6, 7, 8, 10, 12, Fig. 4) its frequency is $6/12 = 0.5$;
2) elongated pit (potsherd 6, Fig. 4), its frequency is $1/12 \approx 0.08$;
3) ‘flower’ ornament (potsherd 9, Fig. 4), its frequency is $1/12 \approx 0.08$;
4) pit (potsherds 1, 2, 3, 5, 8, 11, Fig. 4), its frequency is $6/12 = 0.5$;
5) rhomboid structures (potsherd 5, Fig. 4), its frequency is $1/12 \approx 0.08$;
6) stroke (potsherds 2, 3, Fig. 4), its frequency is $2/12 = 0.16$;
7) triangle pit (potsherd 4, Fig. 4), its frequency is $1/12 \approx 0.08$. 
Fig. 4. The assemblage of potsherds from the site of Okhta 1 (image source – Gusentsova, Sorokin 2011: 441)
3.2. The assemblage of potsherds from the site of Sarnate

On the site of Sarnate were found many different potsherds of different types of pottery. In the current paper for estimating degrees of resemblance is used a set of potsherds that were identified as samples of the typical Pit-Comb Ware (see Vankina 1970: 121). In the assemblage of potsherds from the site of Sarnate there are 47 potsherds (fig. 5 – fig. 7). In the case of the assemblage of potsherds from the site of Sarnate is used an end-to-end numbering of potsherds in the illustrations.

Fig. 5. The assemblage of potsherds from the site of Sarnate, part 1 (image source – Vankina 1970 Table/Illustration VXXXII)
Fig. 6. The assemblage of potsherds from the site of Sarnate, part 2 (image source – Vankina, 1970 Table/Illustration VXXXIII)
Fig. 7. The assemblage of potsherds from the site of Sarnate, part 3 (image source – Vankina, 1970 Table/Illustration VXXXIV)
And can be singled out 5 ornamental imprints:

1) comb is represented upon the following 31 potsherds: 8, 9, 10, 11, 12, 13, 14, 15 (Fig. 5) 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29 (Fig. 6), 30, 31, 32, 36, 40, 41, 42, 43, 44, 45, 46 (Fig. 7), so its frequency is 31/47 ≈ 0.66;

2) pit is represented upon the following 25 potsherds: 1, 2, 3, 6, 7, 8, 11, 13, 14 (Fig. 5); 16, 19, 20, 21, 22, 23, 29 (Fig. 6); 30, 31, 33, 34, 35, 38, 39, 44, 45 (Fig. 7), so, its frequency is 25/47 ≈ 0.53;

3) stroke is represented upon the following 14 potsherds: 1, 2, 3, 4, 5, 6, 7 (Fig. 5); 22, 23 (Fig. 6); 33, 34, 35, 38, 39 (Fig. 7), so its frequency is: 14/47 ≈ 0.3;

4) short stroke is represented upon 1 potsherd: 16 (Fig. 6), so its frequency is 1/47 ≈ 0.02;

5) triangle pit is represented upon 2 potsherds: 10 (Fig. 5) and 37 (Fig. 7), so its frequency is: 2/47 ≈ 0.04.

3.3. The assemblage of potsherds from the site of Šventoji 43

In the assemblage of potsherds from the site of Šventoji 43 there are 20 potsherds (Fig. 8).

And can be singled out 5 ornamental imprints:

1) comb (potsherds 2, 7, 8, 13, 16, 17, 20, Fig. 8), its frequency is 7/20 = 0.35;

2) elongated pit (potsherd 15, Fig. 8), its frequency is 1/20 = 0.05;

3) pit (potsherds 5, 6, 17, 18, Fig. 8), its frequency is 3/20 = 0.15;

4) stroke (potsherds 3, 4, 5, 12, 18, Fig. 8), its frequency is 5/20 = 0.4;

5) triangle pit (potsherd 14, Fig. 8), its frequency is 1/20 = 0.05.
Fig. 8. The assemblage of potsherds from the site of Šventoji 43 (image source – Piličiauskas et al. 2019: 78)
4. Calculating degrees of resemblance

4.1. Okhta 1 and Sarnate

The assemblage of potsherds of Okhta 1 has 12 potsherds, and the assemblage of potsherds of Sarnate has 47 potsherds, so the ratio of numbers of potsherds is $12/47 \approx 0.25$.

And there are 4 common imprints: comb, pit, stroke, and triangle pit.

And thus, the degree of resemblance between the assemblage of potsherds from the site Okhta 1 and that of Sarnate is the following:

$$\frac{4/7 + 4/5}{2} \times \frac{0.5/0.66 + 0.5/0.53 + 0.16/0.3 + 0.04/0.08}{4} \times (0.88 \times 0.25^2 + 1.52 \times 0.25 + 0.35) \approx 0.32$$

4.2. Okhta 1 and Šventoji 43

The assemblage of potsherds of Okhta 1 has 12 potsherds, and the assemblage of potsherds of Šventoji 43 has 20 potsherds, so the ratio of numbers of potsherds is $12/20 = 0.6$.

And there are 5 common imprints: pit, comb, stroke, elongated pit, and triangle pit.

And thus, the degree of resemblance between the assemblage of potsherds from the site of Okhta 1 and that of Šventoji 43 is the following:

$$\frac{5/7 + 5/5}{2} \times \frac{0.15/0.5 + 0.35/0.5 + 0.16/0.4 + 0.05/0.08 + 0.05/0.08}{5} \times (0.88 \times 0.6^2 + 1.52 \times 0.6 + 0.35) \approx 0.42$$

4.3. Sarnate and Šventoji 43

The assemblage of potsherds of Sarnate has 47 potsherds, and the assemblage of potsherds of Šventoji 43 has 20 potsherds, so the ratio of numbers of potsherds is $20/47 \approx 0.42$.

And there are 4 common imprints: comb, pit, stroke, and triangle pit.

And thus, the degree of resemblance between the assemblage of potsherds from the site of Sarnate and that of Šventoji 43 is the following:

$$\frac{4/5 + 4/5}{2} \times \frac{0.35/0.66 + 0.15/0.53 + 0.3/0.4 + 0.04/0.05}{4} \times (0.88 \times 0.42^2 + 1.52 \times 0.42 + 0.35) \approx 0.39$$

5. Conclusion. Interpretation of the received values

As it is said in 2.3 the values of the degree of resemblance of the standard set of assemblages form a diapason from 0.13 to 0.51; the arithmetic mean of the values of degrees of resemblances shown by the standard set is 0.3. And if a certain particular value of the degree of resemblance is higher than 0.3 or close to 0.54; it means that the compared assemblages are pretty close.

The value of the degree of resemblance of the assemblages of potsherds of Okhta 1 and Sarnate is 0.32; that of Okhta 1 and Šventoji 43 is 0.42; both values are higher than the arithmetic mean of the values of degrees of resemblances shown by the standard set of assemblages: 0.32 > 0.3, and 0.43 > 0.31. It means that the people who created the Pit-Comb Ware that was found on the site of Okhta 1 were pretty close to the people who created pottery that was found on the sites of Sarnate and Šventoji 43; all these people belonged to the same cultural tradition and had pretty regular contact. However, as far as the received
values are significantly lower than the highest value of the degree of resemblance demonstrated by the standard set of assemblages, it is possible to conclude that these groups of people were not in a very close relationship.

Also in the case of Okhta 1, Sarnate, and Šventoji 43 it is useful to employ the so-called local threshold in order to understand the degree of relatedness of the corresponding groups better. As it is said in 2.3 if there are three assemblages of potsherds: A, B, and C, and it is known that A and B are rather closely related, then if the value of the degree of resemblance of A and C (or B and C) is higher than that of A and B or close to that of A and B, then it means that all these three assemblages (A, B, and C) are pretty closely related.

It is quite evident that the sites of Sarnate and Šventoji 43 belonged to pretty closely related groups of people. And it is noteworthy that the value of the degree of resemblance of the assemblages of Okhta 1 and Šventoji 43 is slightly higher than that of Sarnate and Šventoji 43: 0.42 > 0.39.

The value of the degree of resemblance of the assemblage of Okhta 1 and Sarnate is lower than that of Sarnate and Šventoji 43: 0.32 < 0.39, but in this case should be taken into account the fact that the numbers of potsherds in the compared assemblages differ about four times and that gives a rather significant deviation/error.

However, the fact that the value of the degree of resemblance of the assemblages of Okhta 1 and Šventoji 43 is slightly higher than that of Sarnate and Šventoji 43 means that the regularity of contacts between the Neolithic people of Okhta 1 and the Neolithic people of Šventoji 43 was the same as the regularity and intensity of contact between the people of Sarnate and the people of Šventoji 43.

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