Percentages in the Study of neolithic Pottery*

Ion Pâslaru, Vitaly Pozhidaev

Abstract: This article discusses examples of percentages in the archaeological research of pottery from the Neolithic period. The use of percentage reports does not always lead to correct results, and thus significantly reduces the value of the authors' conclusions and undermines the credibility of their study. In order to correct this situation, researchers need to accompany the samples used in their studies by information on the size of the samples in question and the way they were computed. This allows one to calculate the empirical percentage of probable error (ΔP) and the confidence intervals (min-max).

Keywords: pottery, percentage, percentage reports, probable error, sampling, confidence interval, statistical methods.

In order to process common archaeological material, either made of stone, flint, bone, or ceramics, specialists often employ certain statistical methods, among which the most often encountered is the use of percentages in order to extract various conclusions. Some researchers envisage percentages in such a simplistic manner that they cease to be a statistical method and this has negative consequences.

The efficiency of using mathematical and statistical methods in archaeological research is no longer doubted. Nevertheless, they are not always used correctly by the archaeologists and thus the credibility of the conclusions part of such studies is disputable. This is the topic of our studies[1].

For the beginning, we will analyze the work of a French researcher from the University of Provence that focused on the technology and morphology of Neolithic pottery from Southern France[2]. The author is well acquainted with statistical methods and uses, together with percentages, certain computer programs in order to process pottery produced during the Late Neolithic. Analyzing the pottery from the site in Mourre du Tendre, the author employs a sample consisting of 6387 fragments among which he stresses 761 structural elements that provide the basis for the typology employed. After researching the morphology of the artefacts, the author ended up stressing 28 types, defined with the aid of various structural elements of the vessels and of the decorative elements. According to the quantity of items included, the types are very different; some include a single item, while others have up to several hundreds. For each type the author under discussion calculated the corresponding percentages. Unfortunately, he was not very careful in rendering the computing exact, in that he ignored the hundreds in the decimal expansion and rounded the values of the tens. At first glance, it seems that the hundreds are insignificant, but in case there are several small samples, the hundreds turn into tens and then into integer parts. Thus, a table presents[3] 78 samples that show the complex out of 761 units. We shall hereby present some data in this table, to which we have added the probable error (±ΔP) and the confidence intervals (min-max).

	N=761	n	% author	% actual	Difference	±ΔP	Min.	Max.
1	Str,95	1	0.1	0.13	-0.03	0.25	0	0.38
2	Str,96	68	8.9	8.93	-0.03	2.02	6.90	10.96
3	Str,99	8	1.1	1.05	+0.05	0.72	0.32	1.77
4	Str,100	9	1.2	1.18	+0.02	0.76	0.41	1.95
5	Str,101	5	0.7	0.65	+0.05	0.57	0.08	1.23

* English translation: Ana M. Gruia.

[1] Pyslaru, Pozhidaev 1982; Pyslaru 1982; Pâslaru 2006; Pâslaru, Colesniuc 2007; Pâslaru, Pozhidaev 2014.

[2] Cauliez 2011.

[3] Cauliez 2011, 132, tab. 69

6	Str,105	21	2.8	2.75	-0.05	1.16	1.59	3.92
7	Str,106	3	0.4	0.39	+0.01	0.44	0	0.83
8	Str,108	6	0.8	0.78	+0.02	0.62	0.16	1.41
9	Str,109	7	0.9	0.91	-0.01	0.67	0.24	1.59
10	Str,113	9	1.2	1.18	+0.02	0.76	0.41	1.95
11	Str,113/114	4	0.5	0.52	-0.02	0.51	0.01	1.03
12	Str,114	7	0.9	0.91	-0.01	0.67	0.24	1.59
13	Str,115	5	0.7	0.65	+0.05	0.57	0.08	1.23
14	Str,127	17	2.2	2.23	-0.03	1.05	1.18	3.28
15	Str,128	3	0.4	0.39	+0.01	0.44	0	0.83
16	Str,129	24	3.2	3.15	+0.05	1.24	1.91	4.39
17	Str,129/132/137	8	1	1.05	-0.05	0.72	0.32	1.77
18	Str,131	1	0.1	0.13	+0.03	0.25	0	0.38
19	Str, 134	1	0.1	0.13	+0.03	0.25	0	0.38
20	Str, 137	2	0.3	0.26	+0.04	0.36	0	0.62
21	Str, 138	96	12.6	12.61	-0.01	2.35	10.25	14.97
22	Str, 139	12	1.6	1.57	+0.03	0.88	0.69	2.46
23	Str, 141	16	2.1	2.10		1.01	1.08	3.12
24	Str, 142	15	2	1.97	+0.03	0.98	0.98	2.95

Table 1. Percentual report on the Neolithic pottery discovered in Southern France. (with data provided by Cauliez 2011)

One must take into account the fact that the percentages calculated by the author are empirical percentages (P), with a probable error (±ΔP). After calculating the probable errors, we discovered that they ranged between ±0.25% and ±3.47% for the sample consisting of 761 units, between ±3.53% and ±8.80% for the sample consisting of 55 units, and between ±8.33% and ±11.51% for the sample consisting of 23 units.

Valorizing morphological and typological aspects of the sample consisting of 761 diagnosed elements, the author suggests a formula for calculating the minimum amount of elements indicator (MAEI) in percentages:

MAE / all diagnostic indicators *100 = MAEI.

Then, in order to determine the quantity of vessels, the author has counted the rims and thus calculated a minimum of 579 vessels or 76%. Among these, 353 items had structural elements that could be determined, plus the shape of the vessel, thus reaching a percentage of 61%.

These percentages have different probable errors as they are calculated according to different samples, though the author believes they are equal. One must mention the fact that the author has calculated empirical percentages (P). In fact, one should add the probable error to these values, thus obtaining: 76.08%±3.03% or 73.05%–79.11% and 60.96%%±3.87% or 56.99%–64.94%.

In the work under analysis, the author also employed bar charts in order to illustrate percentual proportions[4], though such charts do not reflect the actual value of the percentages.

The case analysis of Cauliez's work has indicated the fact that the percentages were carelessly computed, without the probable error and the confidence intervals; the readers should therefore be cautious and careful in accepting some of the author's opinions, i.e. those connected to the empirical percentages.

We shall now continue with another study that aimed at analyzing Neolithic pottery from the Volga Region[5]. The author presented the results of her technical and technological analysis of the pottery discovered in the settlement of Lebeajinka V, on the basis of 73 collected samples. These were represented by "Elșanskaya" pottery and "Srednevolzhskaya" Culture pottery; according to the decoration technique, they were divided into 13 types; one must note that these types are very numerous. Four of them consist of a single item, one type consists of two items, two types include just three items each, one other type includes four items, three types consist of six items each, and just two types group 12 and 21 items, respectively.

4 Cauliez 2011, tab. 20; 22.

5 Vasilieva 2011, 41–53.

This, nevertheless, does not prevent the author from analyzing the so-called types independently, believing each of them represented 100%. Thus, the author's approach is unacceptable and statistically incorrect (Table 2).

	N=73	NO	P or %	ΔP	Min.	Max.
1	Without inclusions	8	10.95	±7.16	3.79	18.12
2	SO	47	64.38	±10.98	53.39	75.36
3	SO +Ş1: 6 (<2 mm)	11	15.06	±8.20	6.86	23.27
4	SO + Ş1: 5 (<4 мм)	6	8.21	±6.30	1.91	14.51
5	SO +others	1	1.36	±2.66	0	4.03
	Total	73	100			

Table 2. Types of fabric of Neolithic pottery items discovered on the site of Lebeazhinka – V

Analyzing Table 2 one notices that the differences among types 1, 3, and 4 are imperceptible. It might be that types 3, 4, and 5 must be unified in a single type consisting of pottery items made of fabric with inclusions of organic matter as temper-material (OP). On the basis of the above mentioned observations, the table thus becomes:

	N=73	NO	P or %	ΔP	Min.	Max.
1	Without inclusions	8	10.95	±7.16	3.79	18.12
2	SO	47	64.38	±10.98	53.39	75.36
3	SO +Ş1: 6 (<2 mm) SO + Ş1: 5 (<4 mm) SO +others	18	24.65	±9.88	14.76	34.54
3a	SO +Ş1: 6 (<2 mm) SO +Ş1: 5 (<4 mm)	17	23.28	±9.69	13.59	32.98
3b	SO +others	1	1.36	±2.66	0	4.03
		73	100%			

Table 3. Types of fabric of Neolithic pottery items discovered on the site of Lebeazhinka – V after regrouping.

According to the author, the "Elşanskaya" pottery, represented through 30 vessels, was made, in 83% of the cases, of fabric with inclusions of organic matter (SO) – 83.33% ±13.33 or 69.99% – 96.66%.

The author concluded that in the making of pottery belonging to the "Srednevolzhskaya" Culture one can note "a clear process of spread and strengthening of the tradition of employing ceramic fabric with chamotte in complexes with prick-ornamented pottery – 18.5%, and in complexes with comb-decorated pottery – up to 43%."

	complexes	fabric	N	n	P или %	ΔP	Min.	Max.
1	Prick-ornamented pottery	OP+Ş	16	3	18.75	±19.12	0	37.87
2	Comb-ornamented pottery	OP+Ş	23	10	43.47	±20.25	23.21	63.73
			39					

Table 4. Percentual reports on the "srednevolzhskaya"-culture pottery from "prick-ornamented" and "comb-ornamented" pottery complexes".

We remind our readers that the author performed these calculations by rounding the percentages down to three decimals, thus ignoring the hundreds in the fractional part. Comparing the data provided by the author with those obtained after calculating the probable error for the empirical percentages, one reaches the opinion that the author's conclusions are not statistically confirmed since the confidence intervals overlap and thus cannot be distinguished.

Then, the author stated that the processing the materials from the site of Vilovatovo supported the following conclusion: "the influence of «Elşane» cultural traditions on the arrived population followed an ascending line: – the quantity of vessels with prick-ornamented decoration during the early period represents 19%; – during the middle period – 36%; and during the late period – 52%." On the basis of these data, the author stated that "the prick-ornamented pottery complex from the site of Lebeazhinka – V contains some indications of the «Elşane» tradition in pottery making: 64% of the prick-ornamented pottery is made of dusty clay and just 36% is made of silt." But, the real size of the samples from the sites of Vilovatovo and Lebeajinka V remains unknown. One can say that the author only relies on these materials when mentioning the prick-ornamented vessels from the site of Lebeajinka V that are made out of dusty clay and represent 81%. This percentage has a probable error (±ΔP) equal to ±9.03% and thus the value of the percentage calculated by the author should have between the following values: 71.79% and 89.85%.

Following the above analysis of the case study under discussion, we note that the researcher did not envisage the existence of probable errors (ΔP) for empirical percentages (P) that are described similarly to C14 radiocarbon data. By the way, this researcher also presents some C14 data for the "Elşane" pottery – 6820±80 BP, 6760±80 BP, and 6480±80 BP.

Sometimes, some researchers use percentages only in order to compare stressed groups from the material under analysis. In order to exemplify, we will subsequently study an article dedicated to the description of Neolithic pottery from Lithuania[6]. The authors have analyzed a total of 9440 pottery fragments, out of which just 361 were decorated, and thus, according to the authors' estimate, represent 0.38%. We mention the fact that the authors have erred in their calculation, making the sample ten times smaller. This fact made us pay closer attention to other percentages calculated by the researchers in question.

In the decoration of the chosen pottery lot, the authors distinguish between 12 elements of decoration; their frequency was expressed in percentages, starting from the total number of decorated fragments:

1 – long stroke impressions (22.16%), 2 – winding impressions (14.13%), 3 – big pits impressions (13.85%), 4 – quadrangular impressions (12.74%), 5 – small pits impressions (9.14%), 6 – knot-like impressions (7.2%), 7 – ellipsis-like impressions (6.09%), 8 – short stroke impressions (5.54%), 9 – triangle-like impressions (3.04%), 10 – wavy impressions (2.22%), 11 – incisions (1.94%), 12 – cord-like impressions (0.56%).

Naturally, the authors did not envisage the existence of a probable error, believing that the empirically calculated percentages are absolute. By employing just percentages, without mentioning the number of fragments, the authors force us to compute. Nevertheless, the sum of the percentages of all groups equals 98.51%; the other percentages up to 100% were not taken into consideration. We have re-calculated the quantity of fragments, adding the error margin and the confidence intervals (Table 5).

	N=361	n	P according to the authors	P	ΔP	Min.	Max.
1	long stroke impressions	80	22.16	22.16	4.28	17.87	26.44
2	winding impressions	51	14.13	14.12	3.59	10.53	17.72
3	big pits impressions	50	13.85	13.85	3.56	10.28	17.41
4	quadrangular impressions	46	12.74	12.74	3.43	9.30	16.18
5	small pits impressions	33	9.14	9.14	2.97	6.16	12.11
6	knot-like impressions	26	7.20	7.20	2.66	4.53	9.86
7	ellipsis-like impressions	22	6.09	6.09	2.46	3.62	8.56
8	short stroke impressions	20	5.54	5.54	2.35	3.18	7.90
9	triangle-like impressions	11	3.04	3.04	1.77	1.27	4.82
10	wavy impressions	8	2.22	2.21	1.51	0.69	3.73
11	incisions	7	1.84	1.93	1.42	0.51	3.36
12	cord impressions	2	0.56	0.55	0.76	0	1.31
	total	356	98.51	98.57			
	unaccounted	5		1.38	1.20	0.17	2.59
	Total	361	100	99.95			

Table 5. The decoration of ceramics.

6 Iršėnas, Butrimas 2011, 125–138.

The analysis of this table indicates that the authors were careless in calculating the percentages. The sum of fragments in the table is of 356, though all of the authors' calculations start from a sample of 361 units. The fact is also noticeable when the researchers state that the number of fragments ornamented with a single decorative element each is 34 (9.42%), while those containing two or three decorative elements represent 34: 9.42=360.9.

A researcher from Sweden chose another method, using percentages just in their graphic form[7]. The percentual proportion of Neolithic pottery discovered on the present-day territory of Sweden, Gotland, and the Netherlands is presented with the aid of horizontal bars. We remind the fact that this type of chart does not render the real proportion among the different types of pottery; three ceramic types are presented in this case: coarse, semi-coarse, and fine.

According to the above mentioned graph, one concludes that for the central-eastern region of Sweden, the sample consisted of 75 units, from 11 different sites, among which coarse pottery was predominant. There are only three fragments in the group of semi-coarse pottery.

In the Netherlands, the types of fine, semi-coarse, and coarse pottery are almost equally represented, having the sample of 39 units. In Gotland, the pottery is represented by 14 units; coarse pottery is predominant, while the groups of semi-coarse and fine pottery together do not surpass 20%.

One must observe the fact that these samples, estimated at representing 100% each, were considered equal, by ignoring the probable errors. We shall try to prove this in Table 6.

region	N		n	P	ΔP	Min.	Max.
East-Central Sweden		coarse	0	0	0	0	0
		semi-coarse	3	4	4.43	0	8.43
	75	fine	72	96	4.43	91.56	100
			75	100			
The Netherlands		coarse	9	23.07	13.22	9.85	36.30
		semi-coarse	16	41.02	15.05	20.84	50.95
	39	fine	14	35.89	15.26	23.19	53.73
			39	100			
Gotland		coarse	11	78.57	21.49	57.07	100
		semi-coarse	2	14.28	18.33	0	32.61
	14	fine	1	7.14	13.49	0	20.63
	128		14	100			

Table 6. Distribution of pottery types according to region.

		N	P	ΔP	Min.	Max.
1	fine	87	67.96	8.08	59.88	76.05
2	half-coarse	21	16.40	6.41	9.99	22.82
3	coarse	20	15.62	6.29	9.33	21.91
		128	100			

Table 7. Proportion of pottery types in Sweden, the Netherlands and Gotland.

Table 6 indicates that according to the semi-coarse pottery presented equally in the central-eastern area of Sweden and in Gotland, on the one hand, and in the central-eastern area of Sweden and the Netherlands, have intersecting confidence intervals. As for the group of fine pottery, one notes that the three regions are clearly different; according to the quantity of fine pottery, the east-central area of Sweden holds the first place (91.56%±4.43%), followed by the Netherlands (35.89%±15.26%) and Gotland (7.14%±13.49%). Coarse pottery is only predominant in Gotland (78.57%±21.49%).

As for the comparison between the types of pottery (Table 7), one must state that among the samples taken by the author, fine pottery is predominant, while semi-coarse and coarse pottery are equally present.

In the technology of pottery production, the author has identified different temper-materials; among them one can mention: granite, sandstone/quartzite, quartz, natural sand, grog (crushed

[7] Larsson 2009, 239–270, Fig. 10–5, Fig. 10–6, Fig. 10–7.

pottery), limestone, bone, and plant material[8]. In Fig. 10–7 the author presents the number of samples taken according to the temper-material used. As stated from the very beginning, the author takes into consideration 128 samples for microscope analyses. According to the data presented in the table one can note that the total number of samples was wrongly calculated, as the real number reaches 145 units.

Site		Components								Total according to author	Total
	Period	Granite	Sst Qzite	Quartz	Nat. Sand	Grog	Lime stone	Bone	Plant Mat.		
Postboda 2, Up	EN/ MN	6	0	0	0	0	0	0	0	7	6
Postboda I, Up	MN A	7	0	0	0	0	0	0	1	7	8
Kopingsvik	MN A	1	9	0	2	0	3	0	6	18	21
Ottenby. Ol	MN A	4	0	0	7	0	1	0	9	21	21
Ire, Go	MN B	1	0	0	0	2	13	0	9	14	25
Bollbacken, Vs	MN B	12	3	0	0	0	2	8	2	26	27
Braennpussen	MN B	1	2	12	3	0	0	19	0	20	37
Ttvper total		32	14	12	12	2	19	27	27	113	145
										134	

Table 8. Types of temper materials employed in pottery production. (Taken from Larsson 2009, Fig. 10–7. Temper materials used in pitted-ware ceramics divided by sites. Rough chronological order, with the oldest sites at the top).

According to Table 8, some quantities of pottery fragments from various sites do not add up. Thus, it is almost impossible to verify the data presented since one does not know the size of the samples used by the author in constructing the percentual proportions.

Through the graphs under discussion, the author wished to see how the pottery production technology during the periods represented by the Early/Middle and Middle A and B stages of Swedish Neolithic.

Describing a practical model of managing and interpreting databases, G. Lazarovici and D. Micle provided an example through their research of a Neolithic pottery collection from the site of Iclod, near Cluj[9]. The complex where the pottery in question has been discovered is one of the earliest; the filling contained, at a depth of – 80 cm, materials influenced by and technically typical to the Petreşti Culture, materials part of the Iclod I Group with strong influences from the previous stages, specific to the Middle Neolithic (the Cluj – Cheile Turzii – Lumea Nouă – Iclod Complex), characterized by good quality pottery, fine sand, strong firing, and very good quality polish.

The authors are right in saying that “most often archaeologists used to multiply the percentage of the most frequently encountered materials, believing they were directing elements.” By analyzing this complex, the authors performed a hierarchical classification. The material was divided into three groups: common, semi-fine, and fine pottery. The 1643 pottery fragments were divided into three categories: fine 871, semi-fine 615 and coarse 158.

	N–1643	N	P	ΔP	Min.	Max.
1	fine	870	53.01	2.41	50.59	55.42
2	semi-fine	615	37.43	2.34	35.09	39.77
3	coarse	158	9.61	1.42	8.19	11.04
	Total	1643	100			

Table 9. Pottery categories and their percentages.

Taking into consideration the fact that these categories were analyzed according to the number of fragments and their stratigraphic association, they were divided into three groups: 1) between –40 and –60 cm; 2) from –80 cm; 3) from –140 cm.

8 Larsson 2009, 239, Fig. 10–7.

9 Lazarovici, Micle 2001, 192–193.

	depth	fine	semi-fine	coarse	sum	P	ΔP	Min.	Max.
1	–40–60 cm	404	478	128	1010	65.07	2.37	62.70	67.44
2	–80 cm	287	116	26	429	29.12	2.26	26.86	31.38
3	–140 cm	105	6	2	113	7.28	1.29	5.98	8.57
		796	600	156	1552	100			

Table 10. Distribution of pottery materials according to depth, from the Late Neolithic site of Iclod.

Taking into consideration the quantitative data, the authors concluded that *fine pottery was most numerous at the depth of –80 cm* and *semi-fine pottery at –60 cm,* a fact that indicates the development direction of pottery categories, the dynamic evolution of the site. The presence of fine pottery at a depth of 0.80 cm *must be connected to the genesis process of the Iclod Group*.

We shall attempt to verify this opinion. In order to do this we will calculate the percentage of each category, adding the probable error and the confidence intervals.

	depth	categories	N	N	P	ΔP	Min.	Max.
1	–40–60 cm		1010					
		fine		404	40	3.02	36.97	43.02
		semi-fine		478	47.32	3.07	44.24	50.40
		coarse		128	12.67	2.05	10.62	14.72
2	–80 cm		429					
		fine		287	66.89	4.45	62.44	71.35
		semi-fine		116	27.03	4.20	22.83	31.24
		coarse		26	6.06	2.25	3.80	8.31
3	–140 cm		113					
		fine		105	92.92	4.72	88.19	97.64
		semi-fine		6	5.30	4.13	1.17	9.44
		coarse		2	1.76	2.43	0	4.20
			1552					

Table 11. Pottery categories and their percentages according to depth.

The analysis of this table shows that semi-fine pottery discovered at –60cm statistically equals the fine pottery, as the confidence intervals overlap. As for the authors' opinion on fine pottery discovered at the depth of –80 cm, it is substantiated. Correcting the authors' opinion triggers also changes in the interpretation of their results.

In his doctoral dissertation, S. Angeleski analyzed Neolithic pottery from Macedonia and Greece[10]. In Tables 19a and 19b he presented the situation of the categories of pottery from Macedonia compared to that from Greece, since the earliest stages of the Neolithic. The author sated that the analysis of Table 19a indicated the fact that pottery in the fine and semi-fine categories forms relatively equal proportions (37.2% and 34.8% respectively), followed shortly by coarse pottery (28%). One must keep in mid that these are empirical percentages, requiring clarification. We have thus added the probable error (ΔP) and calculated the confidence intervals (min.-max.), and this allowed us to correct the researcher's opinion (Table 12).

N–382	pottery	N	P	ΔP	Min.	Max.
	fine	142	37,17	4,84	32,32	42,01
	semi-fine	133	34,81	4,77	30,03	39,59
	coarse	107	28,01	4,50	23,50	32,51
		382				

Table 12. Proportion of the different types of Neolithic pottery from Macedonia and Greece (according to data provided by S. Angeleski).

10 Angeleski 2009.

Taking into consideration the fact that the confidence intervals overlap, one can say that none of the three ceramic categories predominate. This means that the above mentioned groups of pottery are almost equally represented.

The obtained result was probably constructed on the basis of insignificant samples: nine samples from the presented sites are very small, containing between four and 20 units; only five groups contain between 40 and 84 units. In order to verify our opinion, we have analyzed only the five representative samples:

N=287	pottery	N	P	P	Min.	Max.
1	fine	102	35.54	5.53	30.00	41.07
2	semi-fine	105	36.58	5.57	31.01	42.15
3	coarse	80	27.87	5.18	22.68	33.06
		287	100			

Table 13. Proportion of the different categories of Neolithic pottery from Macedonia and Greece.

As one can observe from Table 13, all pottery categories are equal from a statistic perspective. The fact that the author used small samples leads to arguable opinions. The author states for example, that *the distribution of pottery categories in Table 20a illustrates a clearly larger proportion of fine pottery as compared to coarse and semi-fine pottery; also, the latter two occupy relatively equal positions*. The table in question includes 13 samples from Bulgaria and Macedonia: nine samples contain between four and 20 units, three between 40 and 84 units; the pottery from Vaksevo I–II (Bulgaria) alone consists of 229 units.

Table 20a	fine	coarse	semi-fine	Sum	Percentage
Vaksevo I–II	205	24		229	47.8
Anza Ia	36	7	17	60	12.5
Anza Ib	26	15	8	49	10.2
Pešterica	8	12	24	44	9.2
Anza Ia B1n1	5	7	8	20	4.2
Anza Ib B1n3	2	6	10	18	3.7
Anza Ic	9	7	1	17	3.5
Anza Ib B1n2	3	3	5	11	2.2
Anza Ia B1n2	2	3	3	8	1.7
Rug Bair	6	1	1	8	1.7
Anza Ia Gr. 12	4			4	1
Anza Ia Gr. II	4			4	1
Anza Ia Gr. V	4			4	1
Sum	315	87	77	479	
Percentage	65.8	18.2	16.1		100

Table 14. Neolithic pottery from Macedonia and Bulgaria (according to data provided by S.Angeleski).

In another work that presents some connections between the Neolithic pottery from Macedonia and Transylvania, S. Angeleski included a table with data on the reducing and oxidizing pottery[11]. After analyzing the table that included a sample of 1148 units, the researcher concluded that good, reducing pottery predominated as compared to good oxidizing pottery, with 42.4% to 36.8%.

Due to the fact that the author based his arguments on comparing empirical percentages, we believe that his conclusion is not reliable. On the other hand, the table also includes pottery undifferentiated according to the reducing or oxidizing firing. For this reason we chose to exclude it from the table. Thus, only seven sites remained from the initial group of 13, providing the sample of 1039 units. Good reducing pottery consists of 468 units instead of 487, poor reducing pottery has 59 units, while good oxidizing pottery has 384 units instead of 422 and the poor oxidizing pottery has 128 units (Table 15).

[11] Angeleski 2011, 9–46.

		N–487 r and N–422 o	NO	P	ΔP	Min.	Max.
reducing	1	G.B. B1	112	22.99	3.73	19.26	26.73
oxidizing		G.B. B1	150	35.54	4.56	30.97	40.11
reducing		G.B. B20a	136	27.92	3.98	23.94	31.91
oxidizing	2	G.B. B20a	60	14.21	3.33	10.88	17.55
reducing		G.B. M1	105	21.56	3.65	17.90	25.21
oxidizing	3	G.B. M1	50	11.84	3.08	8.76	14.93
reducing		G.B. B10	59	12.11	2.89	9.21	15.01
oxidizing	4	G.B. B10	63	14.92	3.40	11.52	18.32
reducing		G.B. B2A	16	3.28	1.58	1.70	4.86
oxidizing	5	G.B. B2A	29	6.87	2.41	4.45	9.28
reducing		G.B. B9b	32	6.57	2.20	4.37	8.77
oxidizing	6	G.B. B9b	6	1.42	1.12	0.29	2.55
reducing		G.B. B8	8	1.64	1.12	0.51	2.77
oxidizing	7	G.B. B8	26	6.16	2.29	3.86	8.45
reducing		Total out of N–487	468	96.09	1.71	94.37	97.81
oxidizing	8	Total out of N–422	384	90.99	2.73	88.26	93.72

Table 15. Good reducing and good oxidizing pottery.

The analysis of data in Table 15 indicates that the proportion between good reducing and good oxidizing pottery varies from site to site. In the case of sites 1 and 7 the quantity of good reducing pottery is smaller than that of good oxidizing pottery. In the case of site 4 the two groups are equally represented. In the case of sites 2, 3, 5, and 6, good oxidizing pottery is represented by the largest quantity of pottery fragments.

One must also note that the difference between "good" and "poor" pottery was not made according to exact criteria; all depends on the researcher's point of view and experience. For this reason, in order to perform a more objective study, we have analyzed separately, but also together, each of the two groups, i.e. reducing and oxidizing pottery, that are included in the sample of 1039 units (Table 16).

	N – 1039	NO	P	ΔP	Min.	Max.
1	Good reducing	468	45.04	3.02	42.01	48.06
	Poor reducing	59	5.67	1.40	4.27	7.08
	Total	527	50.72	3.03	47.68	53.76
2	Good oxidizing	384	36.95	2.93	34.02	39.89
	Poor oxidizing	128	12.31	1.99	10.32	14.31
	Total	512	49.27	3.03	46.23	52.31

Table 16. Comparison of reducing and oxidizing pottery.

The analysis of Table 16 clearly indicates that reducing and oxidizing pottery are present in equal proportions: 50.72%±3.03% or 47.68% – 53.76% and 49.27%±3.03% or 46.23% – 52.31%. Even taking into consideration only the good reducing and good oxidizing pottery, one can still note that the proportion between them is at another level than the one declared by the author – good reducing pottery represents 45.04%±3.02% or 42.01% – 48.06% and good oxidizing pottery – 36.95%±2.93% or 34.02% – 39.89%.

In a work on the Early Neolithic in the area of Transylvania[12], the authors used percentages. In general, they employed 1245 fragments from five samples (188, 382, 141, 423, and 111) in order to *analyze the statistics of the pottery*. In their description of the ceramic material discovered inside dwellings, the authors prefer to use percentages alone, without stating the real quantity of the samples they used. Therefore, dwelling H10/2003 part of the Starčevo Culture contained according to the authors 83% fine and semi-fine pottery and 17% coarse pottery. (In their Table 1 the authors included the value of the three types of pottery – 155, 162, and 65 units) (Table 17).

[12] Luca, Suciu 2008, 39–56.

N=382	NO	P	ΔP	Min.	Max.
fine	155	40.57	4.92	35.65	45.50
semi-fine	162	42.40	4.95	37.45	47.36
coarse	65	17.01	3.76	13.24	20.78
	382	100			

Table 17. Percentual proportion of the types of Early Neolithic pottery from dwelling H10/2003 part of the Starčevo Culture (according to data provided by Luca, Suciu 2008).

One must note that uniting the two main groups of pottery is justified, as the quantity of fine pottery (35.65%–45.50%) is statistically equal to the quantity of semi-fine pottery (37.45%–47.36%). These two groups are clearly different from the group of coarse pottery (13.24%–20.78%).

The authors identify 13 colors of the pottery items, though they only provide the percentages for six of them. The most numerous fragments are reddish – 27%, followed by *the most often encountered ones*: roasting of brick colour – 19%, dark brown – 11%, whitish brown – 10%, and cherry-color –7%.

Since the percentages calculated by the authors are empirical (P), one needs to calculate the probable error (ΔP) and the confidence intervals (Min.-Max.) (Table 18).

N=381	NO	P	ΔP	Min.	Max.
reddish	104	27.29	4.47	22.82	31.76
brick	71	18.63	3.91	14.72	22.54
dark brown	44	11.54	3.20	8.33	14.75
grey	42	11.02	3.14	7.87	14.16
whitish brown	40	10.49	3.07	7.42	13.57
cherry-color	26	6.82	2.53	4.29	9.35
	327	85.60	3.52	82.08	89.12

Table 18. Percentual proportions of Neolithic pottery according to color, from dwelling H10/2003 part of the Starčevo Culture (according to data provided by Luca, Suciu 2008).

Analyzing Table 18 one can see that the authors were not very careful in calculating the percentages, rounding their values selectively. The authors are right in placing reddish pottery on the first place, but on the second place they place not only roasting of brick colour, but also dark brown fragments. The third place is reserved for grey, whitish brown, and cherry-color pottery fragments.

Describing a dwelling [H1 (B1)], part of the Starčevo Culture, the authors provide percentual data on the pottery, without mentioning the actual quantity of the fragments. They also fail to provide data on the size of the pottery sample recovered from the dwelling in question. Their tables alone inform the readers that the sample consisted of 141 fragments (Table 19).

N=141	pottery	NO	P	ΔP	Min.	Max.
1	fine	52	36.87	7.96	28.91	44.84
2	semi-fine	58	41.13	8.12	33.01	49.25
3	coarse	31	21.98	6.83	15.14	28.82
		141	100			

Table 19. R Percentual proportion of the types of Neolithic pottery according to color, from dwelling H1 (B1) part of Starčevo Culture (according to data provided by Luca, Suciu 2008).

Analyzing this table one must note the fact that coarse pottery (15.14%–28.82%) clearly differs from the other types of pottery. As for the groups of fine pottery (28.91%–44.84%) and semi-fine pottery (33.01%–49.25%), they are similar from a statistical perspective. Discussing the color of the pottery fragments' surface, the authors diminish the sample from 141 to 138 units. The largest percentage, according to their opinion, consists of brick-red pottery – 23%, while reddish fragments only represent 13%.

	N=138	NO	P	ΔP	Min.	Max.
1	Reddish	18	13.04	5.61	7.42	18.66
2	Grey	9	6.52	4.11	2.40	10.64
3	Dark brown	13	9.42	4.87	4.54	14.29
4	Whitish brown	26	18.84	6.52	12.31	25.36
5	Brick-red	32	23.18	7.04	16.14	30.22
6	Cherry-color	16	11.59	5.34	6.25	16.93
7	Brown-reddish	2	1.44	1.99	0	3.44
8	Yellowish	8	5.79	3.89	1.89	9.69
9	Black-grey	1	0.72	1.41	0	2.13
10	Light-brown	12	8.69	4.70	3.99	13.39
11	Brown	1	0.72	1.41	0	2.139
		138	100			

Table 20. Percentual proportion of the types of Neolithic pottery from dwelling H10/2003 part of the Starčevo Culture (according to data provided by Luca, Suciu 2008).

Data in Table 20 shows that the first position is held not only by the brick-red fragments (16.14%–30.22%), as the authors maintained, but also by whitish brown (12.31%–25.36%), reddish (7.42%–18.66%), cherry-color (6.25%–16.93%), and dark brown (4.54%–14.29%) fragments.

Referring to the analysis of the complex discovered inside the Cauce Cave, where a relatively small sample has been found, consisting of 111 units, one remarks that the authors present it as equal to the 114 units in Table 3 and the 110 units presented in Table 4. The proportion between the types of fine, semi-fine, and coarse pottery are presented in percentages – 37%, 57%, and 6%, that include 41, 63, and 7 fragments, respectively.

N=111	NO	P	ΔP	Min.	Max.
fine	41	36.93	8.97	27.95	45.91
semi-fine	63	56.75	9.21	47.54	65.97
coarse	7	6.30	4.52	1.78	10.82
	111	100			

Table 21. Proportion of the types of Neolithic pottery discovered in the complex inside the Cauce Cave (according to data provided by Luca, Suciu 2008).

According to data in Table 4, all the pottery groups strongly differ from a statistical perspective, since their confidence intervals do not overlap.

Passing on to the description of the first migration of the Neolithic population from Transylvania, the authors approach the issue from the perspective of animal herding, trying to show the dynamics of this phenomenon. Thus, on the site from Gura Baciului, the goats represent 33.2% of all domestic animals. Unfortunately, except for the percentual proportions, the authors do not provide other data on the basis of which they have calculated the empirical percentages. The authors proceed in a similar manner when they describe the second migration wave, stating the fact that in the complex from the Cauce Cave, goat and sheep bones represent ca. 75% of the entire bone material discovered; domestic pig bones represent 11.9%, while *boss taurus* represent only 3.5%.

The difference in percentages is so great that, involuntarily, one ranks the goats and sheep first, pigs second, and *boss taurus* third. Readers must trust the authors' words since he/she does not know if these percentages were calculated starting from the number of bones (NO) or the minimum number of individuals (MNI). In order to clarify things, we had to return to the source[13].

The analysis of the bone remains from the Starčevo-Criş Culture layer of the complex discovered inside the Cauce Cave is represented by a number of 727 units, out of which 631 are bones that can be determined. Among these, domestic animals represent 570 units, coming from 60 individuals. Since the authors of this work analyze the development level of animal husbandry we believe wild animals

[13] Luca *et al.* 2005, 98.

should be excluded from the calculations. Thus, the data can be presented according to the following table (Table 22).

Species	NO	P±ΔP	Min.-Max.	MNI	P±ΔP	Min.-Max.
Sheep/Goat	473	82.98±3.08	79.89 – 86.06	45	75.0±10.95	64.04–85.95
Pig	75	13.15±2.77	10.38 – 15.93	10	16.66±9.43	7.23–26.09
Bull	22	3.85±1.58	2.27 – 5.44	5	8.33±6.99	1.33–15.32
Total	570	100		60	100	

Table 22. Proportion of domestic animal species from the complex inside the Cauce Cave(according to data provided by Luca *et al.* 2005).

The analysis of the table indicates that according to the number of bones (NO) goats and sheep form up a percentage of 82.98%±3.08% or 79.89% – 86.06%, while according to the minimum number of individuals (MNI) they represent 75.0%±10.95% or 64.04% – 85.95%. No doubt, this species ranks first, but the authors have provide an inexact percentage, since it was calculated starting from the entire sample (N=631), that also included wild animal bone remains.

Domestic pig remains represent a percentage of 13.15%±2.77% or 10.38% – 15.93% while according to the minimum number of individuals (MNI) they represent 16.66%±9.43% or 7.23% – 26.09%; *boss taurus* individuals represent a percentage of 3.85%±1.58% or 2.27% – 5.44%; as for the minimum number of individuals (MNI), they consisted of 8.33%±6.99% or 1.33% – 15.32%. The above mentioned percentages indicate the fact that these two animal species are equally represented since their confidence intervals overlap. For this reason, the opinion according to which the percentage of bovine remains ranks last is incorrect.

One must note that through the present study we did not aim at analyzing the statements of some researchers, expressed in their works. For us it was important to follow the correct or erroneous use of percentages and percentual proportions on the basis of which researchers reach certain conclusions.

Making a short abstract of the results of our analysis of the studies presented above, one must state that due to the erroneous use of percentages and the hiding of actual data regarding the samples under analysis, the value of some authors' opinions and one's trust in their research is strongly diminished.

It would be very important for researchers employing percentages and percentual proportions to present details on the size of their samples based on which they computed such percentages. Since the samples used by archaeologists are almost always partial, the percentages calculated starting from these samples represent empirical percentages (P). This type of percentages requires corrections through computing the probable error (±ΔP) and the confidence intervals (min.-max.). In this case, researchers are forced to present percentages together with the probable error (P±ΔP) that is similar to the notation of C14 radiocarbon dating.

Thus, researchers' opinions based on quantitative data and accompanied by percentages with the probable error and the confidence intervals will become more reliable.

In order to calculate the probable error ±ΔP we suggest the following formula:

$$\Delta P = t\sqrt{\frac{P(1-P)}{N}}$$

where .

For a significance level $\alpha = 0,05$, i.e. with $95\hat{I}$ certainty for the width of the confidence interval, the following formula applies:

$$\Delta P = 1.96\sqrt{\frac{P(1-P)}{N}}$$

.

Generally speaking, t value equals the Student's distribution quintile. With quantity $N \to \infty$ according to the Central Limit Theorem value $t \to 1.96$. The $t = 1.96$ coefficient corresponds to the so-called large sample $N > 30$. In this case, Student's t limit distribution tends to the normal distribution or Gauss' distribution.

P – notation of the empirical percentage

Δ**P** – delta P or the probable error for the empirical percentage (P)

NO – quantity of material according to which the percentages are calculated

1 – 100%

1.96 – the coefficient that coincides with the 95% level of authenticity, i.e. the probability of an event to take place is of 95% (in statistics, this percentages is a very high level), while it is possible, in 5% of the cases, that the event does not take place.

If the level of probability equals 50%, then one can state, related to the event taking place, that it can take place or not, in equal measure.

The suggested formula can be created as a small program implement through "Microsoft Excel".

The use of this formula for calculating the probable error and the confidence intervals helps researchers obtain correct data and will prevent them from reaching erroneous conclusions.

Ion Pâslaru
"Callatis" Archaeological Museum
Mangalia, ROU
pslr2007@mail.ru; pslr2007@gmail.com

Vitaly Pozhidaev
East Ukrainian National University
Lugansk, UKR
witpozh@mail333.com

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