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Social and demographic implications of the variability of anthropomorphic figurines and knapped stone tools on the Late Neolithic site of Vinča-Belo brdo

Doctoral dissertation

Belgrade, 2022.

Univerzitet u Beogradu

Filozofski fakultet

Odeljenje za arheologiju

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Socijalne i demografske implikacije varijabilnosti antropomorfnih figurina i alatki od okresanog kamena na kasnoneolitskom lokalitetu Vinča-Belo brdo

Doktorska disertacija

Beograd, 2022.

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Social and demographic implications of the variability of anthropomorphic figurines and knapped stone tools on the Late Neolithic site of Vinča-Belo brdo

Abstract: The site of Vinča-Belo brdo has a rich stratigraphy with layers from different periods, but the long and continuous Late Neolithic occupation of the site and its rich material evidence have attracted particular attention of archaeologists from its discovery. The site has been studied for more than a century by many researchers who generated knowledge about different aspects of this settlement, while it also had a central place in general discussions about the Late Neolithic of the Central Balkans (~5300~4500 cal BC). During the long research history of the site, a wide variety of theoretical and methodological tools has been applied to the material culture, but the research within the cultural-historical framework has been particularly influential as it had laid some foundations of knowledge about the period, which influence the current research. However, knowledge production within the culture-historical framework relied on theoretical and methodological concepts which are now largely abandoned. Concerning the long-term socio-cultural dynamics, the subjective and unsystematic typologies, conducted on a selection of finds, were often interpreted in terms of simplistic explanations related mainly to concepts such as ethnicity, migrations, and social norms. The goal of this research is to re-evaluate certain cultural-historical interpretations of long-term cultural dynamics and offer a new perspective on this issue using novel tools and concepts. The long-term cultural dynamics were observed by a detailed analysis of anthropomorphic figurines and lithics, and interpreted in the light of cultural transmission theory. The three main research aims of this study were to – assess the character of cultural changes, explore the relationship between demography and cultural diversity, and reconstruct the models of cultural transmission. The results indicated that, contrary to frequently stated assumptions, there are no sudden cultural changes on the site, and that all cultural dynamics can be explained by the continuous, uninterrupted transmission of cultural knowledge about artifact production. Cultural changes continually appear throughout the sequence, indicating that the periodizations based on the Belo brdo sequence are arbitrary units for dividing the temporal variability of material culture. In such a scenario of continuous social reproduction, the social learning strategies were the main drivers in producing the observed stabilities and changes in the material culture, while the influence of demography on cultural dynamics is less clearly evident, although it might explain some of the observed patterns. The reconstructed models of cultural transmission (conformist, neutral, anti-conformist) indicate that the knowledge about the production of these artifact classes was partly collective, shared on the level of community, and partly individual, where a person could acquire it from any member of the community or innovate, but more research is needed to further narrow down the range of possible socio-cultural scenarios. The implications of certain conclusions go beyond this study, as they show how new tools and concepts can question some foundations of knowledge about the past and change our view about the possible scenarios of the past.

Keywords: long-term cultural dynamics, Vinča-Belo brdo, cultural transmission, diachronic changes, lithics, anthropomorphic figurines, character of cultural changes, demography, social learning strategies

Scientific field: Archaeology

Scientific subfield: Neolithic archaeology

UDC number:

903:314]"634"(497.11 Vinča)(043.3)

73:903]"634"(497.11 Vinča)(043.3)

903:679.8/.9"634"(497.11 Vinča)(043.3)

Socijalne i demografske implikacije varijabilnosti antropomorfnih figurina i alatki od okresanog kamena na kasnoneolitskom lokalitetu Vinča-Belo brdo

Apstrakt: Lokalitet Vinča-Belo brdo poseduje bogatu stratigrafiju sa slojevima iz različitih perioda, ali su dugotrajno i kontinuirano naseljavanje lokaliteta tokom kasnog neolita i mnoštvo materijalnih ostataka privukli posebnu pažnju arheologa još od njegovog otkrića. Lokalitet je proučavan više od jednog veka od strane mnogih istraživača koji su pružili saznanja o različitim aspektima ovog naselja, koje je takođe imalo centralno mesto u opštim raspravama o kasnom neolitu centralnog Balkana (~5300~4500 cal BC). Tokom ove duge istorije istraživanja lokaliteta, mnoštvo teorijskih i metodoloških pristupa primenjeno je na materijalnu kulturu, ali su istraživanja u okviru kulturno-istorijske arheologije bila naročito uticajna jer su postavila određene temelje saznanja o ovom periodu, koja u velikoj meri utiču na aktuelna istraživanja. Međutim, proizvodnja znanja u okviru kulturno-istorijske arheologije oslanjala se na određene teorijske i metodološke koncepte koji su danas u velikoj meri napušteni. Kada je u pitanju socio-kulturna dinamika, subjektivne i nesistematske tipološke analize, sprovedene samo na pojedinim nalazima, interpretirane su u vidu pojednostavljenih objašnjenja vezanih pre svega za koncepte poput etniciteta, migracija i društvenih normi. Cilj ovog istraživanja je preispitivanje određenih kulturno-istorijskih interpretacija dugoročne kulturne dinamike na Belom brdu i pružanje nove perspektive ovom pitanju upotrebom savremenih pristupa i koncepata. Kulturna dinamika posmatrana je na osnovu detaljne analize okresanih kamenih alatki i antropomorfnih figurina, a interpretirana u okviru teorije kulturne transmisije. Tri osnovna cilja ove studije bila su – proučavanje karaktera kulturnih promena na lokalitetu, istraživanje odnosa između demografije i kulturnog diverziteta, kao i rekonstruisanje modela društvenog učenja. Rezultati su pokazali da, surotno uvreženom mišljenju, nema naglih kulturnih promena na lokalitetu, i da se kulturna dinamika tokom čitavog perioda može objasniti kontinuiranim, neprekinutim prenošenjem znanja o izradi artefakata. Kulturne promene se kontinuirano javljaju duž čitave sekvence, ukazujući na to da su periodizacije zasnovane na sekvenci Belog brda arbitrarne jedinice za podelu vremenske varijabilnosti materijalne kulture. U ovakvom scenariju kontuinuirane društvene reprodukcije, strategije društvenog učenja bile su glavni činioci u stvaranju uočenih stabilnosti i promena u materijalnoj kulturi, dok je uticaj demografskih faktora na kulturnu dinamiku manje očigledan, mada bi mogao objasniti određene obrasce koji su uočeni. Rekonstruisani modeli (konformistički, neutralni, anti-konfromistički) društvenog učenja ukazuju na to da je znanje o proizvodnji ovih klasa artefakata bilo delom kolektivno, deljeno na nivou zajednice, a delom individualno, gde je individua mogla da usvoji kulturno znanje od bilo kog člana zajednice ili da napravi inovaciju, ali su potrebna dalja istraživanja da bi se dodatno suzio spektar mogućih socio-kulturnih scenarija. Implikacije određenih zaključaka prevazilaze okvire ove studije, jer pokazuju kako savremeni pristupi i koncepti mogu dovesti u pitanje određene temelje saznanja o prošlosti i promeniti našu sliku o mogućim scenarijima prošlosti.

Ključne reči: kulturna dinamika, Vinča-Belo brdo, društveno učenje, okresani kamen, dijahrone promene, antropomorfne figurine, karakter kulturnih promena, demografija, strategije društvenog učenja

Naučna oblast: Arheologija

Uža naučna oblast: Arheologija neolita

UDK broj:

903:314]”634”(497.11 Vinča)(043.3)

73:903]”634”(497.11 Vinča)(043.3)

903:679.8/.9”634”(497.11 Vinča)(043.3)

Acknowledgments

This research would not have been possible without the unselfish assistance of many people, and I truly thank them for all the help during these several years. Firstly, I would like to thank my supervisor, Professor Dr. Marko Porčić, who contributed enormously to this work and my development as a researcher during the last several years. From Marko, I learned a great deal about archaeological theory and method, scientific method and quantitative analyses, thinking and writing more clearly about the research, and many other things. Besides being very committed and professional about the work, Marko was always supportive and full of understanding for all my doubts, professional as well as private problems.

Great cordiality was shown by the people who are in different ways related to the site Vinča-Belo brdo. I am very thankful to Dr. Dubravka Nikolić, Dr. Marko Janković, and Dr. Milica Mitrović for giving me permission to analyze the lithics from Vašić's excavations. Professor Dr. Aleksandar Palavestra and Dr. Marko Janković gave me access to the part of the documentation from Vašić's excavations. Professor Dr. Nenad Tasić offered very generous support on several occasions, by giving me access to the materials from the new excavations and the necessary documentation, sharing with me (beautiful) photographs of figurines from the Archaeological Collection of the University of Belgrade, as well as providing me with useful literature. I am very grateful to Kristina Penezić for providing me with various information regarding the documentation, archaeological context, images, and access to the lithics from the new excavations of Belo brdo. I owe my gratitude to Dr. Vera Bogosavljević-Petrović, who generously allowed me to analyze stone tools from the new excavations of Belo brdo, and I learned a lot from our discussions related to the knapped stone tools and other topics.

Professor Dr. Sofija Stefanović invested a great deal of effort to employ me (and other colleagues) on the research projects of the Laboratory of Archaeology and to involve us in many activities of the Laboratory, and I truly thank her for that. She was also always keen to share all her knowledge about research, project proposals, public speaking, and other aspects of research. Besides Dr. Sofija Stefanović, the entire team of Laboratory of Archaeology, especially Dr. Sonja Vuković and Dr. Vesna Dimitrijević, gave a full support for all my research activities during my Ph.D., whether in advice, equipment, travel expenses, literature, and everything else. During the last several years, the Laboratory of Archaeology was an excellent working and social environment, and I thank you all. I would like to thank Aleksandra, Mina, Mirko, Sonja, Dimitrije, Teodora M., Teodora R., Marija K., Kika, Jelena M. Jelena B., Maja, Ana, and all others for being a great company over the years.

I am grateful to Professor Dr. Ben Marwick from Washington University for giving me important advice concerning different aspects of the thesis and for accepting to be a member of the thesis committee. Jugoslav Pendić has given me unselfish assistance and advice in creating photo documentation of the knapped stone tools. Dr. Sofija Dragosavac has always been a nice company for discussions about lithics and other topics, while I thank Ana Tripković for fruitful discussions about the anthropomorphic figurines.

I am very thankful to all my dearest friends for being there for being a lovely company and sharing both good and bad moments, especially to Natalija, Vlada, Jovana, Prokići (Ivana, Petar, Lenka, and Dunja), Vuk, Milica, Miloš, Celine, Danijel, Irina, Ivana D., Milan and Daca, Milutin, and my dear orienteers. My cousins (I prefer to call them brothers and sisters as we say in Serbian) Dijana, Saša, Sneža, Stefan, Laza, Nikola, Tamara, aunt Vesna, my sister-in-law Jelena, you are always a wonderful company and a great support. Unfortunatelly, some very dear people were not able to see me going through this point of my life – dear father, aunt, uncles, and Šomi – I truly thank you for everything.

My mother and brother, no words can describe how grateful I am to have you by my side. Last but not the least, the last several years were much nicer and easier with my dear nephews Gaga, Vedrana, and Nevena, who brought a lot of joy to my life.

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1. Introduction

Archaeology can be defined as 'the study of the past through its material remains' (Johnson 2020: 2). Stone tools of Mesolithic communities in Europe differ in some aspects from the Neolithic stone tools, while ceramic vessels of the so-called Vinča culture can be distinguished from the so-called Linear Pottery culture ceramics. These differences are not only evident on these large scales of time and space – material remains differ on much smaller spatio-temporal scales – within a region, site, phase, context, etc. Ceramic vessels from a single site and occupational phase can differ in terms of composition, size, shape, color, ornamentation, or other attributes. One of the main tasks of archaeologists is to search for such patterns of material culture variability, i.e. "various types of relevant similarities and differences" (Hodder, Hutson 2003: 173).

But the question is how to relate the observed patterns of variability of material remains with the past events. Why does the frequency of different types of ceramic vessels change with time, or why is there a high similarity of artifacts in a certain region? Diachronic changes in the frequencies of ceramic types can be explained by various factors, such as technological or demographic, while the homogeneity of material culture can be a consequence of contacts between communities, their common ancestry, or cultural convergence (Crema et al. 2014; Shennan et al. 2015). Archaeologists use different strands of evidence (e.g. chronology, the spatial relationship between the objects, environmental data) and different theoretical and methodological approaches to evaluate such assumptions. Importantly, both descriptions and explanations of the observed patterns of variability can differ greatly depending on our theoretical stance. Although they are not always explicitly elaborated, our ideas about culture, society, and other phenomena influence our explanations about the past anthropological reality (e.g. Johnson 2020).

Concerning the Late Neolithic of the Central Balkans (~5300~4500 cal BC) (Borić, 2009, 2015; Tasić et al., 2015a, 2015b, 2016; Whittle et al., 2016), the variability of material culture was described and explained largely in the manner of traditional culture-historical archaeology (see Garašanin 1979; Трифуновић 1968). Based on subjective insights into the similarity of material culture from different sites in this region, the so-called Vinča culture was defined, covering roughly the entire Late Neolithic of the Central Balkans (Garašanin 1979). It was defined as a cultural entity more or less distinct from the other older, younger, and contemporaneous archaeological cultures in the area in terms of characteristic material culture (e.g. houses, pots, figurines), economy, settlement features, etc. Besides similarities of material culture on sites of the Vinča group, spatial and temporal variation was also noted and used to define regional variants (e.g. Гарашанин 1968; Garašanin 1979) and phases (see Whittle et al. 2016 for an overview). General conclusions were also made about the economy, settlement organization, and other aspects of the Late Neolithic communities in the region (e.g. Garašanin 1979; Глишић 1968).

Due to its continuous occupation throughout the whole Late Neolithic and the abundance of finds, the site of Vinča-Belo brdo has been particularly important for defining the main characteristics of the so-called Vinča culture, establishing the regional relative chronologies, and assessing the social dynamics during this period. Many insights were made by observing the material from the Vinča-Belo brdo sequence, while other sites in the region often served only to make parallels or "fill the gaps" in the knowledge about the Late Neolithic of the Central Balkans. The major patterns of material culture variability from the sequence of Belo brdo were described and served as a model for the Late Neolithic of the area, such as the conservatism or changes within the Vinča group (e.g. Garašanin 1979).

Certain concepts, ideas, and interpretations of culture-historical approach are still largely used today, and influence the current research. However, many assumptions of the culture-historical framework have been questioned and criticized during the '60s and '70s (e.g. Johnson 2020; Olsen 2002; Палавестра 2011). Concerning the study of the variability of material culture in a culture-historical manner, there are two main issues, which also characterized the study of Belo brdo and other Late Neolithic sites in the Central Balkans: unsystematic *description* of variability in material culture, and a limited set of mechanisms that could *explain* cultural dynamics. When exploring the patterns of variability, numerous archaeological finds were compared by subjective assessments of individual researchers. These subjective insights served to describe some major trends of the variability of material culture, but their reliability for assessing the relevant similarities and differences can be questioned. They were based only on a selection of finds, as indicated by W. Schier (1996; 2000) and M. Lazić (Лазић 2008; 2015), while the informal, unsystematic typologies are problematic as they were subjective and prone to inter-researcher variability (e.g. Ruck et al. 2020), descriptive, and very general. Concerning the explanations, although some proponents of culture-historical approach acknowledged the possible influence of environment on past communities (e.g. Benac et al. 1979: 16), and of rules of marital residence (Глишић 1968), trade (Глишић 1968), internal evolution (Garašanin 1979), and individual (Глишић 1968; Јовановић 1968) factors on the material culture, cultural stability and change were most commonly explained by referring to a small number of internal and external factors, such as social norms, ethnicity, migrations, and diffusion. The subsequent research has shown that material culture can be affected by a wide range of factors other than the ones commonly discussed by culture-historians, including copying error (Eerkens, Lipo 2005), material constraints, technology, social learning (e.g. Eerkens, Lipo 2007), skill level (Herzlinger et al. 2017), etc.

During the last several decades, novel theoretical and methodological concepts were used for investigating different aspects of life on Vinča-Belo brdo – dietary habits (e.g. Filipović, Tasić 2013), herding strategies (Gillis et al. 2021), environment (Filipović, Tasić 2012; Filipović et al. 2018), social organization (e.g. Трипковић 2013), lithic organization (Bogosavljević Petrović 2015; 2018; Bogosavljević Petrović et al. 2017), standardization of pottery production (Vuković 2011), chronology (Tasić et al. 2015a; Tasić et al. 2015b; Tasić et al. 2016), etc. However, very few of them aimed to describe and explain the artifact variability throughout the sequence (Bogosavljević Petrovic 2015; Radovanović et a. 1984; Schier 1996; 2000). The study of W. Schier is a notable example of a study using a formal methodology in describing the diachronic changes in ceramic production. He analyzed changes in pottery shape and decoration, systematically recording and quantifying different attributes (e.g. shape, motives, handle types), as well as using statistical analyses to explore the patterns of variation. Analyzing around 3400 finds from Belo brdo, from the beginning of the Neolithic sequence to a relative depth of 4.0 m, Schier made a detailed account of changes in pottery, inferring that the shape changes faster than decoration. By applying the frequency seriation, Schier has shown that the Vasić's mechanical layers[1] exhibit the correct chronological ordering, and concluded that the "chronological resolution of Vasić's 10 cm levels is far better than generally assumed" (Schier 1996: 144). He also proposed a new periodization based on larger changes in the features of ceramics. Despite the great importance of this study for investigating the changes in material culture during the Late Neolithic, no insights were made about social dynamics on Belo brdo, nor were some of the legacies of the culture-historical approach questioned. Concerning the knapped stone tools, Radovanović et al. (1984) formally described certain diachronic changes in different aspects of knapped stone tools (raw materials, technology, recycling, use) from Belo brdo. Their detailed account

[1] Vasić excavated the site of Vinča-Belo brdo in roughly 10 cm thick mechanical layers. For every find, the relative depth was recorded in relation to the „absolute zero". Vasić's excavation methodology and reliability of the relative depths will be discussed in Chapter 5 (Materials).

of the variability of stone tools has allowed them and other researchers (Bogosavljević Petrović 2015; Kaczanowska, Kozlowski 1990) to recognize certain patterns – e.g. stability of technology, larger changes in raw materials, gradual in certain aspects, increased specialization – and provide certain explanations, mainly related to raw material availability and functional matters. However, the social mechanisms that maintained stability or produced gradual or sudden changes were not much discussed. Furthermore, these studies did not re-examine certain concepts (e.g. phases) and interpretations of social dynamics of culture-historical school.

Thus, despite the enrichment in knowledge about the Late Neolithic of Vinča-Belo brdo and other sites, certain ideas and interpretations made within the culture-historical archaeology remain largely unquestioned and influence the current research of this period in the Central Balkans. For these reasons, the primary goal of this research is to re-examine the legacy of the culture-historical approach, i.e. certain concepts, descriptions, and explanations made within this theoretical framework. Besides the availability of novel tools and concepts for exploring the past, improved state of research and new insights about the Late Neolithic in the area allow for independent evaluation of old (and new) hypotheses. Some of the questions that inspired this research are the following: Do the transitions between chronological phases reflect "important changes" (e.g. Garašanin 1979), or do they present only suitable, arbitrary analytical units for studying the spatial and temporal variation in material culture? Can we explain cultural stability and change by referring primarily to ethnicity, social norms, migrations, and diffusion, or are there some factors that could have affected the production of material culture? What kind of social dynamics could have caused gradual or sudden changes? As periodizations and interpretations were largely based on pottery, would we reach the same conclusions about past social dynamics if we observe the variability of other forms of material culture? Also, can new theoretical and methodological tools and concepts change our image about the social dynamics in the Late Neolithic of the Central Balkans?

With such questions in mind, this research aims to offer new descriptions and explanations of two artifact classes from the Late Neolithic layers of Belo brdo (~5300~4500 BC) – knapped stone tools (lithics) and anthropomorphic figurines – using novel methods for formally describing the material culture, and a cultural transmission theory as a suitable, empirically supported theoretical framework for understanding the observed long-term cultural dynamics. Systematic recording and quantification of diachronic changes in knapped stone tools and anthropomorphic figurines were used to formally describe patterns of variability. Regarding the explanations, based on the clearly defined theoretical concepts and a quantitative methodology developed within the cultural transmission theory, a new perspective on social dynamics within the Vinča-Belo brdo is offered. The goal of this research is to explore the influence of various factors (e.g. social and individual learning, population size) on cultural change during the Late Neolithic on Vinča-Belo brdo site, with particular focus on the reconstruction of cultural transmission models. Within the cultural transmission theory, it is possible to model and explore how individual-level actions affect the population-level processes that we observe in the archaeological record, which makes it suitable for exploring the internal socio-cultural dynamics within the Belo brdo community.

Anthropomorphic figurines and knapped stone tools are, along with pottery, the most abundant artifact classes on Belo brdo and other Late Neolithic sites in the region. As the previous research has shown the general stability in lithic production (e.g. Bogosavljević Petrović 2015) and numerous changes in the variability of anthropomorphic figurines (e.g. Letica 1964; Срејовић 1968), it will be interesting to see if the transmission of knowledge about these two elements differed within the community. Besides using the material collected on excavations led by M. Vasić from 1929-1934 for studying diachronic changes in these two artifact classes, this research includes the lithics from 2004-2014 rescue excavations of Belo Brdo, in order to contribute to the question of the usefulness of old evidence from Vasić's excavations (e.g. Јовановић 1960; Marić 2011; Palavestra 2020; Schier 1996; 2000), and reveal the benefits of applying more sophisticated excavation and documentation procedures, especially regarding the context of finds. Concerning the figurines, this is the first formal and systematic description of diachronic changes in multiple features of these objects from the Late Neolithic layers of Vinča-Belo brdo site.

The eponymous site of Vinča-Belo brdo, located near Belgrade, is suitable for the study of long-term socio-cultural dynamics due to several reasons. The continuity of human presence on this location during the Late Neolithic (around 800 years) offers a window into social dynamics during the entire period, while another convenience is a good state of research – a large number of recovered artifacts and considerable knowledge about this Late Neolithic community (see Tasić 2011b for an overview). A good chronological resolution of its stratigraphy (Tasić et al. 2015a; Tasić et al. 2015b; Tasić et al. 2016; Whittle et al. 2016) is particularly important, as it allows the exploration of past dynamics based on temporal intervals of known duration. Together, large artifact samples and high chronological resolution allow for the usage of quantitative analyses and models, which will be used for making inferences on the social dynamics on this site. As mentioned, another reason for the importance of study of the Vinča-Belo brdo material is its central place in the knowledge production about the Late Neolithic in the region (e.g. Tasić et al. 2015a: 6).

By re-examining certain descriptions, explanations and analytical concepts made within the culture-historical framework – using new tools, concepts, and partly new data – certain foundations of knowledge about the Late Neolithic of Central Balkans will be re-evaluated in this work.

1.1 Broader socio-cultural context of the study

The eponymous site of Vinča-Belo brdo has given name to the entire archaeological culture of the Late Neolithic of the Central Balkans, the so-called Vinča culture (~5300~4500 cal BC) (Borić, 2009, 2015; Tasić et al., 2015a, 2015b, 2016; Whittle et al., 2016). This archaeological culture encompassed a large territory, spreading across several modern-day countries: Serbia and Kosovo, parts of Macedonia and Bosnia and Herzegovina, southern Hungary, eastern Croatia, and western Romania and Bulgaria (Whittle et al. 2016). The settlements of the Vinča culture were founded on river terraces or near other water sources, although there is a shift to less approachable locations after the Gradac phase (Garašanin 1979; Ристић-Опачић 2005). The Vinča culture has some distinct features compared to the preceding Starčevo culture, such as the settlement organization (larger, with above-ground houses), more continuous occupation of settlements, the technology of ceramic production (e.g. Vuković 2015), etc. Although mtDNA analyses on a small sample of individuals from the territory of Romania have suggested that demic diffusion might be a likely scenario of the transition between these two periods (Hervella et al. 2015), the issue is still debated (see Chapman 2020; Porčić 2020; Vuković 2015; 2017; 2021 for recent discussions).

The previous studies have indicated the existence of small autonomous communities in this period, whose population usually numbered several hundred people (Porčić 2011; Porčić 2012b; Porčić 2019a), with a general trend of population increase at the beginning of the Late Neolithic and decrease in the final phase (Porčić et al. 2016; Porčić 2021; Ристић-Опачић 2005; Vander Linden, Silva 2021, Figure 5). The predominantly sedentary settlements consisted of a certain number of households which were the basic units of social organization, as evidenced by houses that could accommodate a nuclear or extended family, or groups that were related economically or in some other way (e.g. Глишић 1968; Трипковић 2013). The above-ground, rectangular houses were built using a wattle and daub technique and commonly arranged in rows. The houses consisted of several rooms and usually had ovens and storage spaces, while some of them also had an upper story (e.g. Borić 2008; Трипковић 2013). In the early phase of the Late Neolithic, the settlements consisted of large, tightly connected, and cooperative households of the "commune" type, while the later phases of the Late Neolithic are characterized by smaller, more autonomous households (e.g. Трипковић 2013). There are no clear indications of marked social inequalities within the communities during this period (McPherron, Srejović 1988; Porčić 2012b; 2019). Despite the general similarity of the material culture of Vinča culture sites, the spatial (e.g. Amicone et al. 2020; Garašanin 1979; Трипковић 2013) and temporal (see Whittle et al. 2016 for an overview) variation was also noted.

The economy of the Vinča communities was primarily based on agriculture and animal husbandry (Глишић 1968; Garašanin 1979), but also a varying degree of fishing and hunting of wild animals, so there were variations in subsistence strategies among the settlements (Chapman 1981; 2020; Orton 2012; Orton et al. 2016). Archaeobotanical analyses have indicated the presence of various crops and wild plant species on Vinča sites, such as wheat, barley, flax, pea, and other taxa (de Vareilles et al. 2022). The most common animal domesticates were pigs, caprines, and cattle which shows an increase in relative frequency with time (Orton 2012; Orton et al. 2016). Inhabitants of Vinča settlements were engaged in different craft activities, such as the production of figurines and (primarily black-burnished) pottery, manufacturing of stone and bone tools, pearls, and other artifacts (e.g. Chapman 1981; Garašanin 1979), while an important innovation is the appearance of copper metallurgy (e.g. Radivojević et al. 2010). Some authors have noted an intensification of production and consumption during the Late Neolithic (Kaiser, Voytek 1983; Tringham, Krstić 1990; Chapman 2020). Interactions between communities are evidenced by the exchange of different goods, such as copper (e.g. Antonović 2002; Radivojević, Grujić 2018), Spondylus and Glycymeris shells (e.g. Dimitrijević, Tripković 2002; Tripković 2006; Windler 2013), and obsidian (e.g. Tripković 2004; Tripković, Milić 2008; Milić 2016; 2021), inspiring certain researchers to coin the term "Vinča network" (e.g. Whittle et al. 2016). The majority of settlements were abandoned around 4500 cal BC, but this phenomenon has not yet been fully explained (see Borić 2015; Tasić et al. 2015a).

2. Previous descriptions and explanations of diachronic changes in lithics and anthropomorphic figurines from belo brdo

This section will present previous studies that focused on long-term changes of knapped stone tools and anthropomorphic figurines throughout the sequence of Belo brdo. The majority of researchers, more or less explicitly, suggested certain social dynamics based on the patterns of variability within these two artifact classes.

2.1. Knapped stone tools

M. Vasić, the first excavator of Vinča-Belo brdo, only sporadically mentions the stone tools in his monograph about the site (Васић 1932; 1936a; 1936b; 1936c). Due to his erroneous interpretation of Vinča as first a Bronze, and later an Iron Age settlement, numerous stone tools on the site were seen as anachronisms (Васић 1932: 52). Besides the misinterpretation of the chronology of Belo brdo, Vasić made a range of flawed conclusions about the site (see Borić 2016; Palavestra 2012; 2013; 2020; Palavestra, Babić 2016). Although his interpretations have changed during his career, in his monograph he described Vinča-Belo brdo as Ionian colony from the 6th century BC, founded primarily for extraction of cinnabar in the vicinity of the site. All the material was interpreted by making analogies with Aegean Iron Age sites, leading to bizarre conclusions about various aspects of the site – economy, religion, cultural connections, burial practices, etc. Concerning the knapped stone tools, flint and obsidian knives (blades), sidescrapers, and possible arrowheads are mentioned in the text, together with assumptions of their possible use (for tribulum, shaving, tattooing). However, there are no insights into diachronic changes of these objects, possibly as Vasić considered that Vinča-Belo brdo is "more or less a single-layer, culturally compact, static, and indivisible" site (Palavestra 2020: 231). Vasić has considered the possibility that obsidian on Belo brdo comes from the area of Bükk Mountains (Васић 1932: 52) and therefore is a possible indication of trade, which was confirmed by recent research (Tripković, Milić 2008).

Even though Vasić was not particularly interested in knapped stone artifacts, the collection of lithics that was excavated from 1929 to 1934, stored in the Archaeological Collection of the University of Belgrade, was the basis of all previous studies done so far on diachronic changes in the lithic organization. Srejović and Jovanović (1957) were the first to study this collection of knapped stone tools from all layers of Vinča, divided into flint (n = 1748) and obsidian (n = 1398) finds and analyzed separately. Before presenting the results of their analysis, they noted that there are "hardly any two pieces that would be equal to each other" (Srejović, Jovanović 1957: 257), indicating that it was difficult to make a typology of so variable objects.

Concerning the obsidian finds, Srejović and Jovanović noted that they are scarce in the deepest levels of the site (between 10 and 9 m of relative depth), most abundant between 8.6 and 8 m, while their frequency is gradually declining after 8 m before completely disappearing after 3.8 m of depth. According to the authors, the amount of obsidian indicates the intensity of connections with the neighboring areas in the north where the obsidian originates from, as latter confirmed by trace element analysis (Tripković, Milić 2008). They inferred that connections were weak and probably indirect in the deepest layers, becoming very intense between 8.6 and 8 m, while they stop after 3.8 m. The amount of obsidian was also seen as an indication of the importance of the settlement (Kaczanowska, Kozlowski 1990), or for suggesting that Belo brdo was possibly a trading center (Bogosavljević, Petrović 2015: 55). In the case of flint, the oscillations in the number of finds are somewhat different – sporadic finds in the lowest layers; a higher number between 9 and 8 m; flourishing after declining of obsidian between 7 and 6 m; abrupt reduction in their number after 4 m; complete disappearance after around 2.0 m.

Using a typological analysis, Srejović and Jovanović distinguished the main types of flint tools – blades with straight or curved profiles, fan-shaped and trapezoidal endscrapers, borers, possible arrowheads – and obsidian tools - blades with straight or curved profiles, fan-shaped and trapezoidal endscrapers, pointed scrapers (?). General characteristics of these types were described (cross-section type, distal end type, maximal length, presence and invasiveness of retouch), as well as their presence and abundance at different relative depths. They concluded that there are no notable changes within the types, but that there are some diachronic changes in the relative frequencies of different types, which was also noted by later researchers (Kaczanowska, Kozlowski 1990; Radovanović et al. 1984). According to them, lithic production is undeveloped in the deepest layers, increases between 9 and 8 m, thrives between 8 and 4 m (especially between 8 and 6 m), and decreases as all other stone tool types after 4.0 m. This "qualitative and quantitative" decline, which they found somewhat evident after 6 m, Srejović and Jovanović (1957: 264) ascribe to "certain radical changes in the relations of production".

Based mainly on their results, Garašanin (1979) has made only some very general observations about the diachronic changes in stone tool production within the group, observed according to his periodization (Vinča-Tordoš I, Vinča-Tordoš II, Gradac phase, Vinča-Pločnik I, Vinča-Pločnik II). According to Garašanin, the Vinča Tordoš II phase can be seen as a heyday in knapped stone tool production, a view held by other researchers (e.g. Bogosavljević Petrović 2015). He also indicated that after the Vinča-Tordoš II phase, there is a decline in the production of stone tools, culminating with the Vinča-Pločnik II phase, when the obsidian and other elements (e.g. certain types of bone and polished stone tools, different pottery types) also disappear.

In 1984, a team of researchers published analyses of knapped stone tools from Vasić's excavations between 1929 and 1934, observing different aspects – raw material variability, technology, typology, and use (Radovanović et al. 1984). They divided the sequence by, as they explicitly noted, arbitrary phases in order to make insights into the changes regarding the knapped stone tools. Each group (M. Pavlikowski, M. Kaczanowska, J.K. Kozlowski – raw materials; I. Radovanović – technology and typology; B. Voytek – usewear) used their stratigraphic system for tracking the diachronic changes, but they made a synthesis while describing the general evolution of lithics on Belo brdo. Subsequent researchers (Bogosavljević Petrović 2015; 2018; Kaczanowska, Kozlowski 1990) were largely relying on their results when making insights about diachronic changes in the lithic organization at Vinča-Belo brdo and other sites.

Like Srejović and Jovanović (1957), they classified the knapped stone tools in two groups: obsidian (n = 1488) and flint (n = 1745). It was inferred that the percentage of obsidian is 20.3% in the oldest layers (10.0-9.1 m), increases to 69.5% between 9 and 7 m, and then suddenly decreases to 5.8% and 4.1% in the subsequent 7.0-6.6 and 5.0-4.1 m levels, respectively, before disappearing at 3.8 m. The percentage of obsidian in the 6.0-5.0 layers was not calculated because of the small number of finds. Although obsidian finds were not the subject of a detailed technological and typological study, some general insights were made. They determined that all 22 obsidian cores are microcores (10-20 mm in length) with pyramidal or chisel-edged morphology. Based on the low number of cores (1.51%) in relation to flakes (20.01%) and blades (78.47%)[2], and the fact that the cores are smaller than the

[2] Percentages were calculated from the unnamed table in the upper part of page 19 of their work.

majority of blade blanks, the authors suggested that obsidian was either worked somewhere outside the excavated area, or the blade blanks from this raw material were brought to the site from outside.

Based on the first macroscopic and geochemical analyses of flint and other siliceous raw materials from Belo brdo, it was inferred that a wide variety of raw materials was exploited – 30 varieties and subvarieties. At the relative depth of 8.0 m, the spectrum of siliceous raw materials becomes more variable. The next important change they noted is at 7.0-6.5 m when there is a notable reduction in the amount of obsidian and shifts in the frequencies of flint types. Lastly, at around 5.0 (after hiatus between 5.7 and 5.2 m), new types of flint appear. By relating these patterns to periodizations by Milojčić and Garašanin, Radovanović et al. (1984: 15) concluded that „Changes in the system of raw materials supply mirror, in this way, the turning-points in the conventional periodization of the Vinča culture.“.

For the flint collection of Belo brdo, the structure of the collection is as follows – blades account for 60.97% of finds, followed by flakes (31.29%) and cores (7.7%). Radovanović et al. (1984) noted that when the obsidian, which was mainly used for blade production, becomes less frequent, the number of flint blades increases significantly. However, the ratio between flakes and blades stays roughly the same throughout the sequence when both obsidian and flint are observed together. When observing solely the flint collection, a somewhat lower number of blades in Vinča-Pločnik I is possibly due to the lack of good quality raw materials, according to the authors. At the relative depth of 5.0 m, the percentage of cores and blades increases, while the percentage of retouched pieces decreases. Authors interpret this as a consequence of a more local (within settlement) production of blades on prepared cores that were brought to the site, and the decrease in the number of retouched pieces that were transported to the site.

Flint cores (n = 135) are dominated by single-platform cores (56.6%), followed by irregular (23%) and cortical (11.2%) cores, while the double-platform (4.2%) and changed orientation (4.9%) cores are rare. These patterns of removals, as well as the other core attributes that were analyzed (dimensions, fragmentation, core type, platform angle), indicated no diachronic changes throughout the sequence.

Concerning the flint blanks, the only change they observed is related to dimensions, i.e. there is a gradual increase in length and narrowness of blanks from older to younger levels. The same pattern is observed on retouched tools, among which the most frequent types are scrapers, retouched blades, and truncations, while other types (perforators, burins, becs) are rare. The authors noted that wider blanks were chosen for a retouch. The frequencies of different tool types and subtypes change within the sequence – e.g. the percentage of scrapers decreases, while the percentage of retouched blades increases in their arbitrary groups, possibly related to use – but there are no changes in their presence/absence. There is a marked change in the morphology of endscrapers, which became more elongated after 7.0 m. There are also certain changes regarding retouch features, for example in the proximal part, where after the domination of abrupt and raised modes of retouch, it becomes more diverse in terms of direction, mode and width.

The results of the traceological analysis indicated that a high percentage of the studied pieces were used (65.2%), indicating either no waste of raw material or a bias in the collection of lithics during the excavations. The tools were used mainly for cutting and scraping (and rarely boring) a wide range of materials, from soft (e.g. meat) to hard materials (e.g. bone, antler), and even stone. Concerning the cutting activities, there is an increase in the use of knapped stone tools for cutting wood and vegetables (sickles), while the use on soft materials (such as meat) decreases. A similar trend was observed on a small sample of materials from the excavations done in 1978-1979. The scraping was done on a range of materials, but there is no clear pattern of change as in the case of cutting activities.

Using a formal and comprehensive methodology, these researchers have inferred that there are larger changes in the structure of raw materials (presence and relative frequency of obsidian and different types of flint), while the other aspects of knapped stone tools (core management, blank production, typology, retouch features, use) show a gradual change or stability. However, for the latest phase of the Late Neolithic (Vinča D), Radovanović et al. (1984) noted a decline in the lithic industry to "such an extent that it almost disappears" (Radovanović et al. 1984: 62). Regarding the explanations of these diachronic patterns, the authors noted that the technology of Vinča-Tordoš II phase is "inherited from previous phase" (Radovanović et al. 1984: 61) as they did not notice important changes between the phases, indicating explanation of this stability in terms of cultural transmission in this case. Concerning the changes, in certain cases they offered explanations for the changes in raw materials (their availability), the structure of collections (on-site vs. off-site knapping), and use (increase in the number of agricultural tools, production of wooden hafts).

Kaczanowska and Kozlowski (1990) made an overview of the lithic organization of the Vinča group, dividing it into three groups based on the regional variability: central, western, and eastern. Vinča-Belo brdo was classified as one of the sites of the central group, together with the sites of Gomolava and Divostin. Although their synthesis referred to the Vinča group in general, insights that were made based on Belo brdo material or that apply to this site will be presented here. Concerning the lithic raw materials, Kaczanowska and Kozlowski suggested that the import of siliceous raw materials was most intense between 7.0 and 6.0 m of the Belo brdo sequence. Some raw materials were imported from great distances, according to the authors – radiolarites from the south-west, flint from the east (probably pre-Balkan platform) and from Poland, and obsidian from the Carpathians. As mentioned, they saw the amount of obsidian as a reflection of the importance of sites and their contacts, noting that Belo brdo has a much higher percentage of obsidian than Selevac.

Kaczanowska and Kozlowski (1990: 37) suggested that "Vinča culture is a blade industry". Blades were produced mainly from single-platformed cores, followed by changed orientation and irregular cores. Additionally, they note that micro-cores appear in the early phases of the Vinča group, but are more common in later periods. At Belo brdo, Kaczanowska and Kozlowski observed a trend of increase in the number of blades and decrease in the number of flakes through the sequence. They proposed two explanations for this pattern – the whole blades were more frequently brought to the settlement in the later phases (cf. Bogosavljević Petrović 2015; Radovanović et al. 1984); blade technology in younger periods is more efficient, so there is a lower amount of by-products of laminar production.

The authors indicate that the blade length does not change during the Late Neolithic, but that it becomes more standardized with time, as well as interior platform angle. As Radovanović et al. (1984), they indicated that the blades became narrower through time, apart from a group of "very fine blades" that become bigger in the latest Vinča phase (pp. 41). Similarly to Radovanović et al. (1984), they concluded that the technology of production of blanks stays the same, while retouched tools have shown certain changes, reflected in the differing percentages of various tool types in different the phases.

According to Kaczanowska and Kozlowski, a high percentage of used pieces on Vinča-Belo brdo (and other Vinča group sites) can be explained by the fact that the suitable blanks were brought to the site to be used. They noted an increase in the percentage of tools used in woodworking and cutting of vegetable materials. However, they did not explain these assessments in terms of changes in activities and/or economy, as they indicate a complex relationship between the economic activities performed and the frequencies/percentages of inferred uses.

Regarding the lithic production, Kaczanowska and Kozlowski saw increased specialization – evidenced by a higher percentage of ready blanks that were brought to the settlements from outside workshops – and standardization of blades through time. They cite T. Kaiser and B. Voytek (1983) in explaining these tendencies: "increasingly specific routines of production" and "sedentism, population growth and new social relations". Based on the lithic evidence of the Vinča group, they do not see evidence of population change with the beginning of Vinča-Pločnik I phase (i.e. transition to Eneolithic within the Vinča culture in their terminology), but rather consider that "any changes in archaeological record should be accounted for as the effect of technological change" (Kaczanowska, Kozlowski 1990: 46). In their opinion, only the increase in the percentage of microliths might indicate the external influences from the east, or it can be explained by functional needs – using microliths as parts of hunting weapons.

Another overview of the Vinča group lithic organization was made by V. Bogosavljević Petrović (2015; see also Bogosavljević Petrović 2018). She summarized the previous studies and provided new insights using novel approaches – a formal petrological characterization of a large sample of knappable raw materials, the chaine operatoire approach for reconstructing the technology, contextual analysis of finds, and experimental archaeology for insights into production and use of knapped stone tools. Based on the changes in the presence and frequency of obsidian and different types of chert, described by Radovanović et al. (1984), Bogosavljević Petrović points to "drastic changes" (Bogosavljević Petrović 2015: 412) in the spectrum of raw materials, i.e. "sudden changes" with Vinča-Tordoš IIb and „radical changes of the raw material basis on Belo brdo" (Bogosavljević Petrović 2015: 51) with Gradac phase, when obsidian disappears and new types of flint appear. According to her, the obsidian and flint were acquired from „other centers of exchange" during the „unfavorable situations", i.e. after the raw material turnovers (Bogosavljević Petrović 2015: 201).

Based on the structure of collections, similarly to Radovanović et al. (1984) and contrary to Kaczanowska and Kozlowski (1990), Bogosavljević Petrović (2015: 86, 201, 208) assumes that the production becomes more local in the later phases. More specifically, she suggests that it was only partly local (around 1/3 produced on-site) on sites like Belo brdo and Gomolava in the earliest phase (Vinča-Tordoš I), while during the Vinča-Tordoš II and later periods blades were more often produced within the settlement. According to the author, blades on Belo brdo (and Gomolava) were partly imported from extra-local, still unidentified workshops outside the settlement (Bogosavljević Petrović 2015: 202).

Bogosavljević Petrović argues that there is a decline in lithic production during the Gradac phase (Bogosavljević Petrović 2015: 438). She notes that this „ceasure" in lithic production on Belo brdo possibly happened as the inhabitants of Belo brdo needed some time to acquire raw materials from other sources after losing the access to obsidian (Bogosavljević Petrović 2015: 479). More generally, Bogosavljević Petrović suggests that this „transitional period" represents the „turning point" of the whole Vinča group (Bogosavljević Petrović 2015: 206). The hiatus in the presence of lithics after the Gradac phase, between 5.7 and 5.2 m, was interpreted as a possible indication that the excavated area was not inhabited for some time (Bogosavljević Petrović 2015: 109-110).

Concerning the technological organization, Bogosavljević Petrović (2015: 481) argues that the basic goal of production stays the same throughout the whole period – to obtain blades, mainly from the single-platform cores (Bogosavljević Petrovic 2015: 211-212) – while the changes are gradual (slow) rather than abrupt (Bogosavljević-Petrović 2018). According to the author (Bogosavljević Petrović 2015: 353), all three main knapping techniques of laminar production were applied for obtaining blades on Belo brdo during the Vinča D phase – direct percussion (mostly using soft organic percussors), indirect percussion, and pressure debitage. It is important to note that she also suggests a possible use of copper hammers in the Vinča D phase, based on the analysis of the material from new excavations (Bogosavljević Petrović 2015: 491). Concerning the diachronic changes in the choice of the knapping techniques, in her dissertation, she claims both that there are no notable chronological patterns in the choice of techniques (Bogosavljević Petrović 2015: 448), and that direct percussion becomes more common and pressure technique less common in the later phases of Late Neolithic (Bogosavljević Petrović 2015: 365), while in the more recent article it is stated that the pressure technique becomes more common in the later phases (Bogosavljević Petrović 2018). During the Late Neolithic, some novel elements appear, such as the tools on massive flakes that will be typical in the Eneolithic (Bogosavljević Petrović 2015: 219).

The production is most intensive during the Vinča B and Vinča C phases – there is an increased diversification of raw materials (Bogosavljević Petrović 2015: 519) and more frequent retouch (Bogosavljević Petrović 2015: 453) – while it is similar in the oldest and the youngest phase of the site when Vasić's collection is observed (Bogosavljevic Petrovic 2015: 212). However, based on the data from 1998-2007 excavations, Bogosavljević Petrović (2015: 363) argues that, contrary to the common opinion about a decline in Vinča D, there is an increased activity and production in this phase is more intensive than in the earliest Late Neolithic phase of the site. There is also increased industrialization (Bogosavljević Petrović 2015: 504) and recycling of knapped stone tools (Bogosavljević Petrović 2015: 203, 234) in later phases.

According to this author, lithic technology is quite stable and changes in the lithic organization are gradual, leading to the conclusion that the „positive experiences" related to technology were passed on throughout the whole Late Neolithic, regardless of the raw material (Bogosavljević Petrović 2015: 486). She describes lithic technology as the „Integration of successive technological improvements in the traditional system of stone production and adaptation during eight centuries" (Bogosavljević Petrović 2018: 29). Bogosavljević Petrović (2018: 8) also claims that the lithic organization of the whole Vinča group shows "strong components of standardization".

More recently, analyses of lithic materials from the new excavations (1998-ongoing) of Vinča-Belo brdo were published (e.g. Bogosavljević Petrović et al. 2015; Bogosavljević Petrović 2021; Богосављевић Петровић, Марковић 2011). However, they were not related to the diachronic changes, so they will not be presented here. Nevertheless, they offered some valuable insights into contextual and other information about the lithic material from Belo brdo, and will be mentioned in other chapters of this thesis. It should be also noted that S. Perišić (1984), in her synthesis about lithic finds stored in the Belgrade City Museum, mentions 27 lithics pieces from Vinča-Belo that were collected as surface finds by amateur enthusiasts. However, the lack of context and the way the finds are jointly analyzed with those from other sites and periods, makes this study uninformative for the study of long-term patterns in lithic production.

Table 1.1 summarizes the inferred diachronic patterns in lithic organization on Vinča-Belo brdo, and their possible explanations. The stability in lithic technology was related to cultural transmission only in some cases (Bogosavljević Petrović 2015; Radovanović et al. 1984), possibly as the authors considered it as an obvious explanation in this case. Bogosavljević Petrović (2015) and Radovanović et al. (1984) point to important changes in raw material structure – changes in the presence and frequency of raw material types (especially at 8.0, 7.0-6.5, and 5.0 m). Radovanović et al. (1984) stated that these changes in raw materials happened during the „turning points" of the whole Vinča group (e.g. Radovanović et al. 1984), i.e. they match with the boundaries of the commonly used periodizations of the whole Vinča group. This implies that they relate these changes to some broader regional-scale dynamics. Srejović and Jovanović (1957) assumed that oscilations in the amount of obsidian were related to the intensity of regional connections. The gradual changes in certain aspects of lithic production (structure of colletions, tool frequencies, blade morphology, retouch, use) were ascribed to more specific explanations. Changes in the percentages of cores and blades were the basis for proposing more local (Bogosavljević Petrović 2015; Radovanović et al. 1984), or less local and more efficient production in the later phases (Kaczanowska, Kozlowski 1990), while the change in the percentages of inferred uses of tools were seen as indications of changes in the economic activities on the site (Radovanović et al. 1984). Finally, it was suggested that the stone tool production culminates in Vinča-Tordoš II (Vinča B) (Bogosavljević Petrović 2015; Garašanin 1979) and declines in Vinča-Pločnik II (Vinča D) phase (Bogosavljević Petrović 2015; Radovanović et al. 1984; Srejović, Jovanović 1957). Srejović and Jovanović explain the latter in terms of „changes in the relations of production".

Table 2.1. Diachronic patterns of variability in lithics from Belo brdo and the proposed explanations.

OBSERVED PATTERN	EXPLANATION(S)
Important **changes in the raw material structure** (Bogosavljević Petrović 2015; Radovanović et al. 1984)	**Raw material availability** (Radovanović et al. 1984); **turning-points of the Vinča group** (Bogosavljević Petrović 2015; Radovanović et al. 1984)
Fluctuations in the amount **of obsidian** (Bogosavljević Petrović 2015; Radovanović et al. 1984; Srejović, Jovanović 1957)	Changes in the **intensity of connections** with the neighbouring groups (Srejović, Jovanović 1957); changes in the **regional importance** of the site (Bogosavljević Petrović 2015: Kaczanowka, Kozlowski 1990)
General **stability** in lithic technology (core maintencance; blank production) (Bogosavljević Petrović 2015; 2018; Radovanović et al. 1984)	**Cultural transmission** (Bogosavljević Petrović 2015; Radovanović et al. 1984)
Gradual changes in lithic organization (structure of collections, tool frequencies, blade morphology, retouch, use) (Bogosavljević Petrović 2015; 2018; Kaczanowska, Kozlowski 1990; Radovanović et al. 1984)	Structure of collections – **on-site vs. off-site knapping, more efficient technology** (Bogosavljević Petrović 2015; Kaczanowska, Kozlowski 1990; Radovanović et al. 1984); use of tools – **changes in activities**
Increased standardization of blades (Bogosavljević Petrović 2015; Kaczanowska, Kozlowski 1990)	Intensification of production (Kaiser, Voytek 1983)?
Heyday in lithic production in **Vinča-Tordoš II** (Bogosavljević Petrović 2015; Garašanin 1979)	?
Decline in production during the **Gradac phase** (Bogosavljević Petrović 2015)	Loss of access to obsidian (Bogosavljević Petrović 2015)
Decline after 4.0 m (Bogosavljević Petrović 2015; Radovanović et al. 1984; Srejović, Jovanović 1957)	Radical **changes in the relations of production** (Srejović, Jovanović 1957)

2.2. Anthropomorphic figurines

M. Vasić was much more interested in anthropomorphic figurines from Vinča-Belo brdo (**Figure 2.1**) than in stone tools, dedicating one whole volume to this artifact class (Васић 1936b) while describing and discussing them in other volumes of his monograph as well (Васић 1932; 1936a; 1936c). In volume III of his monograph, Vasić has described 641 figurines that were collected during the 1929-1934 excavations, making certain insights into their variability. Some of his descriptions of figurines will be summarized here, but it should be stressed that his misinterpretations (see Borić 2016; Palavestra 2012; 2013; 2020; Palavestra, Babić 2016) of the site have influenced both descriptions and explanations of these objects. He inferred that the majority of figurines represent humans, primarily in sitting (on ground or throne) or standing position, or less frequently kneeling and possibly lying down (Васић 1936b: XV). Figurines are always represented frontally (Васић 1936b: XXVII) with different arm positions, while their body proportions are not realistic (Васић 1936b: XXVII). Standing figurines can be either self-standing or not (Васић 1936b: XXVII). Vasić suggested that there are both male and female figurines (and noted that it is often difficult to distinguish them), while the latter are sometimes carrying a child (*kourotrophoi*) (Васић 1936b: XV). He also noticed that buttocks on figurines are often pronounced (steatopygia) (Васић 1936b: XXVII). Other descriptions of figurines (e.g. helmet, armor, gloves) were largely inspired by his misinterpretations of Belo brdo chronology and other aspects.

Figure 2.1. A selection of figurines from Vinča-Belo brdo (from Игњатовић 2008).

In the volume dedicated to figurines, Vasić noted seven groups of figurines – standing figures (most frequent); sitting figures; female Kourotrophos figures; standing male figures; figures of various forms and meanings; animal figures; talismans and votive figurines sensu stricto – and described them by group, according to relative depths. However, due to his specific theoretical stance (see above), Vasić has paid little attention to describing the changes in figurine appearance throughout the sequence or reasons for such changes. There are some exceptions – e.g. change from "Cycladic" face type to pentagonal face (Васић 1932: 44); the presence of mouth from 7.5 to 5.6 m (Васић 1936b: XXX); the cylindrical lower part, slowly replaced by figurines with separated legs; from around 4.7 m figurines with flattened body appear and become more frequent with time (Васић 1936b: XV); the earliest representation of eyelashes at 5.2 m (Васић 1936b: 58). Vasić also made certain insights about the figurines from the youngest layers of the site, indicating that there is a "degeneration" of standing figurines after 4.0 m (after 5.4 m for sitting figurines), when they become less elaborate (with some exceptions which he considers intrusions), a process that is somewhat paralleled in ceramic production

(Васић 1936b: 82). It was noted that the figurines after 4.0 m often have flattened bodies contrary to the cylindrical body in the older layers, no neck or low level of details when there is a neck, face only with a flattened nose (the so-called „bird face“), and various engraved ornaments with unclear meaning (Васић 1936b: 82-84). Vasić suggested that this degeneration is a consequence of „unknown changes in the settlement“ (Васић 1936b: 82). Besides these few insights, his descriptions and typologies mainly served for making erroneous assumptions (Borić 2016; Palavestra 2012; 2013; 2020; Palavestra, Babić 2016) – cross-cultural analogies, recognizing imports, establishing relative chronologies, and for proposing somewhat bizarre interpretations of these objects (e.g. workers with safety masks against cinnabar evaporation, gods or demons, ushabti, board game figures).

In 1964 publication, Z. Letica described the major features of figurine variability, as well as the diachronic changes in their appearance (Letica 1964). She suggested a following periodization of the Vinča culture: Early Phase (9.2 – 6.5/6.0 m) and Late Phase (6.5/6.0 – 2.2 m). Letica noted that thousands of anthropomorphic figurines found on Belo brdo are almost exclusively made of clay, with the exception of three stone figurines. Probably due to their high variability, as well as the presence of both crude and well modeled specimens, she claimed that “the figurines are the products of many hands, not of a single workshop” (Letica 1964: 27). It was noted that the texture of the figurines is generally fine-grained. Their color is reddish-brown or grey to black, while more elaborated figurines have a polished grey coating or matt white coating. Certain figurines are painted with a red color. Red-painted and figurines with matt white coating are more frequent in the younger levels of the site. Letica suggested that the figurines were hand-modeled by three techniques – modeling from a single piece of clay (e.g. cylindrical figurines); separately modeling of left and right half, which are then joined together (characteristic for lower layers); relief technique where a figurine is made separately and then attached to a surface (e.g. vessel, plaque). As Vasić, Letica noted that all the figurines are represented frontally. Figurine height is between 5 and 15 cm, although the author notes that there are with several larger and one monumental specimen, but she did not provide the height values for them.

According to Letica, there are three main types of figurines: single free-standing figurines (most common); figurines of a mother with a child (*kourotrophos*); figurines in the form of vases. The last type is a specific form of vessel, and will not be further discussed here. Based on certain features, she recognizes male (have genitals or caps), female (most numerous; have breasts), and asexual figurines (although probably female according to Letica), as well as possible hermaphrodites. Like Vasić, Letica suggested that figurines often have pronounced buttocks. The figurine body position is either standing or sitting, although the latter type is rarer and appears later in the sequence. Standing figurines have arm stumps that are spread towards sides, or arm and leg position which indicates a movement (typically in younger layers). Similarly to Vasić, she argued that lower and upper body proportions are not realistic. Concerning the general morphology, it was noted that figurines can have either completely cylindrical or flat body, or can have flat upper body and cylindrical lower body (the so-called mixed-type).

Letica notes two types of figurines in the earliest levels (9.2 – 8.0 m), both with the arm stumps and without modeled legs – elongated figurines with pronounced buttocks, and flat figurines without buttocks. At 8 m of relative depth figurines with modeled legs (and sometimes knees) appear. The mixed-type figurines appear at 7 m, and become more frequent in subsequent layers, when the flat figurines slowly disappear. After 6.0 m the mixed-type body is the most frequent, while some other novelties appear which are typical for the whole Late Phase. New types of sitting figurines appear (on a throne or pedestal), as well as figurines with a child (*kourotrophoi*), and those with cylindrical shape, long-arm stumps and pronounced breasts. From the depth of 5.0 m the body becomes less proportional – the upper body is more elongated, while the lower body gets shorter. Hips are more pronounced and sometimes perforated, and arms are more commonly placed on the abdomen, while the figurines that are sitting on a pedestal become rare. After 4.0 m the mixed-type figurines without pronounced buttocks become more two-dimensional, and there is a reappearance of flat figurines. As in the preceding layers, the hips are pronounced, while the figurines with a child and those sitting on a throne "begin to degenerate" (Letica 1964: 29).

The diachronic changes in face characteristics were separately described. In the earliest levels, the faces have a triangular shape with a modeled nose, the back of the head is protruding, while the incised eyes are of angular shape. Between 8.0 and 7.0 m the triangular face shape does not change, but begins to resemble a mask, while the back of the head becomes more elongated and is perforated. In the subsequent levels (7.0 – 6.0 m), the face shape becomes polygonal (with accentuated cheeks) and resembles a mask, while the mouth is pit-shaped. The top of the head is flattened, the back of the head is not protruding anymore, and the representation of hair by incision appears instead of the back of the head perforations. The eyes are still incised, as in the previous levels, but are also modeled in some cases. Between 6.0 and 5.0 m the face shape remains polygonal, the back of the head is no longer protruding, while the eyes can be modeled or incised. In the following levels (5.0 – 4.0 m) the top of the head becomes lower than the forehead, and is often perforated. The eyes are incised and shaped as a semi-circle or ellipse. Additionally, the figurines with a "bird face" appear. Between 4.0 and 3.0 m of relative, the bird face figurines become dominant, while the previous face shapes are present only in a "derivative form" (Letica 1984: 31). The figurines with pentagonal faces have a modeled nose and circular incised eyes. For figurines found after 3.0 m, Letica suggested that "only in the narrower sense can their stylistic characteristics be connected with the plastic art of Vinča" (Letica 1964: 31).

Letica noted that the figurines in the earliest levels usually have no clothing, although incised belts with buttons sometimes appear (possible aprons). Belts represented by incised lines, accompanied by fringes or bands that hang from them, appear after 6.0 mm, and these are likely also some kind of aprons according to the author. At 5.0 m a novelty is a presence of oblique incised lines on the lower body, interpreted as probable "wrapped leggings" (Letica 1984: 31). At this depth, possible "gloves" also appear. Triangles around the neck occur in the Early Phase, but are more common in the Late Phase.

According to Letica (1964: 32), the figurines in the Early Phase are "treated organically". The figurine producers aimed to produce realistic representations, but were not skilled enough to do so. The realistic style peaks at around 6.5 m, in the final levels of the Early Phase. The first part of the Late Phase (6.5 – 3.9 m) is characterized by "ornamental-abstract style", i.e. abstract rather than realistic representations, and with clothing that has a more decorative purpose. After 3.9 m "the artistic quality of the Vinča figurines has quite degenerated; neither realistic nor ornamental elements appear." (Letica 1964: 32). The figurines of this phase are commonly flat and "the artisan is content only to indicate the outlines" (Letica 1964: 32).

Letica also indicated that the Vinča group figurines have a local development, but were influenced by both Starčevo group and "cultural stimuli and, possibly, migrations from Anatolia… although this influence can be more easily traced in pottery" (Letica 1964: 32). Regarding their meaning, she claimed that it might have differed in space and time. Rather than being representations of Mother Godesses, she suggested that they might represent some kind of symbol of association between "the fertility of the earth and woman's role as a general provider" (Letica 1964: 32). Due to lack of details, she also proposed that the figurine meaning could have been adapted to the requirements of the situation, for different rituals and magic purposes.

D. Srejović (Срејовић 1968: 191-195; see also Srejović 1981; 1992) has noted some general tendencies in the iconography of Vinča group figurines. The figurines from Vinča-Belo brdo were described together with those from other sites in the Danube valley. Thus, there is a difficulty in distinguishing the changes observed based on the material from Belo brdo, which was a central site for describing the variability of the whole group, from those observed on other sites. He considered that the early Late Neolithic figurine production was largely influenced by the preceding local traditions. Thus, the main characteristics stay the same – standing human figure, frontally represented, with no clear representation of sex – but the style is different, as there are sharp contours rather than columnar, unsegmented figurines in earlier periods, and anatomical details are more common – abdomen, breasts, buttocks, arms, and legs. Also, there is a high diversity of figurines of the Vinča group: clothed or naked human figure; standing, sitting, or kneeling body position; figurines of woman with a child; figurines with a mask; hermaphrodites; twins; two-headed figurines; hunchbacks; musicians. Like Letica (1964), Srejović claims that there is a general tendency from naturalistic to progressively more realistic forms of figurines. Between 8.5 and 7.9 m figurines become increasingly realistic in relation to previous levels, where the body is much more geometrically organized, while naturalistic tradition is present only in certain details (e.g. face, engraved details). Between 7.8 and 6.6 m of relative depth, he sees the first notable changes – there is a „strive for the most faithful reproduction of natural forms" (Срејовић 1968: 194), with softer contours, more dynamic and livelier forms. There is also a wide variety of forms, new anatomical details (pupils, mouth, ears, groins) and clothing appears. Also, new body positions or movements appear. Besides these new types, the types typical for deeper layers are still present, possibly as a reaction to new forms according to Srejović. Between 7.6 and 7.1 m, there are figurines with arms facing forwards or upwards, whereas sitting figurines have arms on the abdomen. Between 6.5 and 5.9 m the forms become completely free and clear, there are new body positions and movements, and many details (elbow, fingers, foot), leading Srejović (Срејовић 1968: 194, 205) to characterize this period as the „greatest achievement" and „flourishing" of Vinča group figurine production. Although noting that it seems that these elaborate forms (e.g. „Vidovdanka") with pentagonal faces are completely different from the previous ones, such as the figurines with „Cycladic face", Srejović claims that there are transitional forms between the two. As the eyes (in the shape of the arched segment) and nose become larger, the face proportions are modified to accommodate these changes – it gets more elongated, the forehead gets shorter, and the eyes and nose are moved upwards. The body lines (e.g. buttocks, hips) are more curved than in the earlier periods.

The figurines in Vinča-Pločnik phases (or Eneolithic phase of Vinča group, in Srejović's terminology) are characterized by a higher regional variability compared to the previous phases (Срејовић 1968: 206). There is a high diversity of forms – sitting figurines, female carrying a child, as well as two-headed, fantastic creatures with animal bodies and a human head, which indicate „significant ideological changes and a new religious practice" (Срејовић 1968: 206). According to Srejović, the influences of Early Eneolithic cultures from the Eastern Balkan region are evident in figurine production. From 5.9-4.9 m, figurines characterized by a fully developed ornamental style appear. As in the Morava valley, there are figurines with bird faces in this period. Another novelty is the appliance of colors (pigments) to figurines, in order to give depth and three-dimensionality to figurines. Besides these novel forms, there is a small number of figurines that follow the traditions from the previous layers. As Letica, Srejović notes that there is a new style of figurines after 3.9 m, the so-called „linear-abstract" style, evidenced by simply modeled flattened figurines, where only the nose is represented (produced by simply pinching the clay). Srejović argues that these figurines do not follow a tradition of the previous periods, but are imitations of figurines made from other materials (stone, bone, copper plates) of Gumelnița and Sălcuţa-Krivodol cultures (Срејовић 1968: 210-211). According to this author, after 4.2 m of relative depth „Vinča plastic loses all its old characteristics and manneristically accepts the foreign forms" (Срејовић 1968: 211), while the low number of figurines also indicates a cultural crisis.

Srejović (e.g. Срејовић 1985; 1994) usually made some kind of association between Vinča group figurines and rituals, magic, and religion. Based on the diversity of figurines, he considered that they could have been used in various rituals related to birth and death, renewal of life, disease, sowing and reaping, rain, seasons, etc. Within the Vinča group, the only exception are the settlements where the copper was processed which had their own deities and heroes. In a more recent publication (Srejović 1992), this author notes that the figurines were not found in ritual contexts as it would be expected if they were deities (as some researchers suggested), but in places where certain household activities were performed (see also Chapman 1981; Greenfield 1991). Additionally, he noted that „the differences in their appearance are motivated by artistic rather than religious desires". Their frequent association with objects of everyday use, and the fact that they were often broken and discarded, lead him to suggest that they were discarded after their use in rituals. Despite proposing more profane role of figurines in this intepretation, related to rituals rather than worshiping deities, Srejović associates them with certain „supernatural forces".

In his overview of the Vinča group, M. Garašanin (1979) has made some very general insights about the changes in figurine appearance. Like Srejović, he described the variability of the whole group, but with a special reference to Belo brdo as a central site for making inferences. He suggested that the figurines of Vinča group are quite variable (body position, arm and leg position, details, clothes, faces), especially compared to previous Starčevo figurines, indicating "much greater freedom of creation" that is also evident in ceramic vessels (Garašanin 1979: 195). According to Garašanin, figurines in the earliest Late Neolithic phase (Vinča-Tordoš I) have either flattened or cylindrical form. In the deepest layers of the site the standing position is the norm, while after the relative depth of 9.0 m figurines in the sitting position appear. "Cycladic" faces of triangular shape are characteristic for Vinča-Tordoš I phase, depicted with nose and engraved eyes that are either angular or in the shape of horizontal lines. There are figurines with conical head top, which resembles a cap. The presence of steatopygia, pronounced buttocks, is represented in the earliest and the last phases of Belo brdo (Garašanin 1979: 168).

In Vinča Tordoš II, new features appear in figurine iconography (Garašanin 1979: 173). Heads have a more protruding nape that was often vertically perforated, while cheeks are more pronounced, leading to pentagonal faces in younger layers. Eyes are commonly plastically modeled in the shape of "elongated segment". A new type of figurines also appears – those with elaborated details, including pronounced hips and modeled legs. Figurines with a cap are still present, although these figurines are rare on the whole site.

Gradac phase brings some new elements in figurine appearance, which will be characteristic for the Vinča-Pločnik phases (Garašanin 1979: 174-175). In this period, the figurines with flattened upper body and cylindrical lower body (e.g. "Vidovdanka") appear, the so-called mixed-type figurines. They have a polygonal face (resembling a mask), plastically modeled eyes, and mouth is frequently represented. There are also stumpy figurines of mixed-type, with skirts depicted with fringes and engraved hair. Between 7.0 and 6.0 m of relative depth, novel figurine types are present – sitting on a pedestal or throne, and figurines of a mother with a child.

The figurines with the flattened upper and cylindrical lower body are still present in Vinča-Pločnik I. There are some changes in proportions, where the torso becomes larger in relation to the lower body. The face is polygonal, with a pronounced nose and forehead, while the nape is perforated. The eyes are modeled by engraving in the shape of a segment. Arms are spread towards the sides or placed on the abdomen. The head, torso, and arms are ornamented with engraved parallel lines, while they are triangle-shaped around the neck. The motives on the lower body are more variable – engraved meander-shaped and spiral motives, or "nets". Described figurines are particularly common in levels between 5.0 and 4.0 m of relative depth. Figurines with a cap disappear, while the ones with a child become more common. This phase is also characterized by the appearance of figurines with bird faces, which will be characteristic for Vinča-Pločnik II (Garašanin 1979: 177-178; see also Tasić 2011a).

Similarly to Vasić, Garašanin acknowledges that there is an "increasing degeneration of statuettes" (Garašanin 1979: 19580) in Vinča-Pločnik II and indicates the "clear signs of … fatigue" (Garašanin 1979: 195) while noting there are still more elaborated figurines as in Vinča-Pločnik I. Previously described types are still present – those with steatopygia, mixed type, sitting on the throne – but they are simplified. Figurines with bird faces become more common, often having no eyes and nose in the shape of a beak. Garašanin also noted a degenerated type of sitting figurines – with horizontally placed legs and bird faces (Garašanin 1979: 180).

Similarly to Letica and Srejović, Garašanin suggested that the figurines were probably used in different rituals, but primarily in those related to fertility and maintenance of life. As figurines were often found broken and discarded, it seems likely that they were thrown away after fulfilling their purpose in rituals.

In 2008, N.N. Tasić (Тасић 2008) also made some general insights into variation of figurines from Belo brdo. He indicated that the figurines are chronologically sensitive and suitable for establishing relative chronologies (with other Vinča sites on the Central Balkans), suggesting that some temporal patterns can be observed. Tasić suggested that it is important to take into account four elements in order to understand development of figurines from Vinča-Belo brdo: style (body proportions, decoration, and details), typology, archaeological context, spatial and temporal distribution. He indicates that the Vinča group figurines were found in various contexts – in and around houses, in leveling horizons, building foundation trenches, different pits, and other places. However, they were not found in funerary contexts. Based on the context, he suggests that there was probably no "formal space for their use and disposal", admitting that this insights does not bring us much closer to understanding of their purpose.

Tasić notes that there are "strict rules" in face depiction. The earliest figurines have triangular faces, which will become pentagonal in later phases, while both face types contain few details and resemble a mask. Pentagonal face shape dominates until the "intermediate stage of development" Vinča figurines, while the later figurines have head shapes that are less realistic and that have pentagonal faces often with almond-shaped eyes and long noses. Masks are commonly depicted on Vinča-Belo brdo figurines, while their possible purpose might have been to hide the identity of the bearer. The mouth representations are rare, possibly due to impersonality that was needed for certain rituals. Incised eyes of angular shape are characteristic for early levels, while "after several generations they get the recognizable Vinča [i.e. segment] shape" (Тасић 2008: 145). During the final Late Neolithic, eyes are not represented on the figurines. According to Tasić, this might be due to the small size or "complete impersonality" of these representations. Tasić indicated that nose is represented in all, even the most schematic figurines from Belo brdo. Noting a high diversity in nose representations, he claims that the nuances in modeling of this facial characteristic could have been used for representing character and personality on the figurines. Regarding the perforations found on heads, arms, and sometimes hips of figurines, Tasić suggests that they could have served for hanging or decorating figurines, or some other purpose (see also Tasić 2011a).

Tasić inferred that Vinča figurines often have some elements of clothing and other body decorations. According to him, each skirt is unique – there are no figurines with the same pattern of decoration. Tasić indicates as a possibility that these patterns of clothing decoration symbolized groups, not individuals. He also mentions V-shaped incisions around the necks of figurines, and different hairstyles. Another form of figurine decoration is a red (from mercury sulfide or iron oxide) or white paint on some of them.

Figurines of the initial Late Neolithic are columnar and unsegmented, with the markers of sex and “eyes as a reflection of a character” (Тасић 2008: 144), bearing some similarities to the preceding Starčevo figurines. Modeling of certain body features, such as arms, legs, and pronounced hips in some cases, appears quite early in the Late Neolithic.

According to Tasić, figurine production thrives in later phases of the site, peaking around 4800 BC. In terms of Vasić’s relative depth, classic phase of Vinča-Belo brdo figurine production is spanning from 7.5 and 5.5 m of its stratigraphy. During this period, he distinguishes two types of figurines – those with many details (skirt/dress, hairstyle, eyes); and those with no incised details, where the focus was on three-dimensionality of figurine form (found between 7 and 5 m). In this period, author notes the existence of some personal characteristics based on the minor variations in face features, which is absent in other periods when the impersonality is the norm.

Regarding the latest Late Neolithic levels of Vinča-Belo brdo, Tasić indicates that „The end of a great epoch of Vinča anthropomorphic plastic is looming“ after 3.5 m of relative depth (Тасић 2008: 151). The only common elements with the previous levels are the cross-shaped form (i.e. standing with spread arms) and certain incised details. Compared to realistic representations of the earlier levels, figurines become stylized with rare details. Their heads are crudely modeled in triangular (instead of pentagonal) shape, while their nose resembles a beak. As the figurine generally lack other details, Tasić argues that clothing decoration probably indicates „individual characteristics or group affiliation“ (Тасић 2008: 151). Due to more careless manufacture of the figurines, the author suggested they might have lost their significance within the community.

Standing figurines with spread arms are present in all Vinča layers and are the most common type, according to Tasić. Other forms are those with arms placed under breasts or on abdomen, mother with a child, “Siamese twins”, and sitting figures. Sitting figurines are more common from the “middle stage of development” of Vinča culture. Besides the sitting body position that differentiates them from standing figurines, they resemble them in other features and are found in similar archaeological contexts.

Tasić and colleagues (Tasić et al. 2015b) made only certain remarks about figurines in the article about the absolute chronology of Belo brdo. They noted that „Early figurines ... become progressively more elaborate“ and that „after 6 m, this profusion of form and decoration ends“. According to the authors, linear ornaments are found in older levels, and meanders in tthe younger. The bi-colored figurines disappear after 6.0 m.

Lazić noted that the early researchers (e.g. Letica 1964, Срејовић 1968, Garašanin 1979) have not assessed the variability of individual figurines, but they rather observed only the representative finds (Лазић 2008; 2015), leaving many of them aside. In his 2008 article, he suggested that many insights can be made by analyzing the whole collection, i.e. more than 1100 figurines from the 1929-1934 excavations of Vasić, stored in the Archaeological Collection of the University of Belgrade. Lazić described certain types of figurines that he detected during his analysis, and observed their distribution within the sequence of the site.

Lazić noted that the standing figurines with spread arms are found from the earliest to the youngest levels of the settlement. While some of their features (e.g. face features, clothing) change throughout the sequence, as described by Srejović, their general form remains the same during the whole Late

Neolithic. This has lead him to suggest that they „keep their meaning and significance“ during this time, while „the changes in the manner of modeling and decorating take place according to the moment in which they occurred“ (Лазић 2008: 38). He notes that there are two main types of arms on these figurines – arm stumps with streched or straigh-cut end; and short, cone-shaped arms. Both types are present in all the levels of the site, so he suggested that the differences might have been utilitarian or related to different indentities that were represented on each of them, concluding that in any case these two types had different meanings. No correlation between the sex and these two types of arms was observed.

According to Lazić, standing figurines can be further divided into different variants, some found throghout the sequence and others only in certain layers of the site (7.0-6.0 m), while most of them disappear after 4.0 m. He notes the existence of figurines with arms facing upwards. Their arms are short and cone-shaped, while they typically have oval or flat body, and most of them have breasts. Another figurine type that Lazić recognized based on arm position are the ones with arms bent in elbows and placed on hips, breasts, or genitals. They appear between 7 and 6 m or relative depth, and can be divided based on body position – standing and sitting or kneeling. The standing variant has arms placed on hips, while the sitting are more diverse, as arms can be placed on hips, breasts, or genitals.

Concerning the head of the figurines, Lazić suggests that there are two types based on the modeling of the transition between the forehead and the top of the head. Some figurines have a clear line (ridge) between these two parts of the head, while others have a smooth transition. Both types are present throughout the sequence, although the latter is most common between 9 and 5 m. Lazić dinstinguishes another type of figurines based on the head features – those with a „hood“, i.e. a representation of hair or a cap. They are found between around 9 and 4 m of Belo brdo sequence, coexisting with the figurines with „commonly“ modeled heads. According to Lazić, there are certain diachronic changes in the nose form. It is nipple-shaped in the earliest levels, slightly curved and elongated in younger levels, while it changes to elongated and cone-shaped in the youngest levels on figurines with a bird face. Another type of nose that he notes, which is elongated and beak-shaped, is restricted only between 8 and 7 m of the sequence.

Lazić concludes that some types and subtypes, such as standing figurines with spread arms and the ones with "round head-top", are found in all (former) or almost all (latter) levels of the site. Others are found in more restricted intervals, such as those sitting on a throne, knelling, or the one with the "hood". Contrary to Letica (1964), he considers that the artisans had enough skill to produce realistic representations, so they intentionally represented disproportional or deformed figures. According to Lazić, the co-existence of different ways to represent the same features (e.g. heads or arms) are also intentional, and „carry clear messages for those for whom they were intended“ (Лазић 2008: 42). This "diverse and rich iconographic repertoire" is "similar to that in more complex religious and mythological systems" (Лазић 2008: 41). The types he proposes thus represent specific characters with particular features (arm and body position, arm type, certain head features) that do not change, implying that their meaning stays the same through the whole period. On the other hand, decorative elements are susceptible to modifications, as they follow the aesthetic and stylistic changes.

Inspired by the works of Srejović (see above) who suggested that figurines were short-lived, and found in profane contexts, discarded and intentionally damaged, Lazić suggests that they do not represent gods or idols. For him, more probable explanation is that they represented demons, which "Belo brdo inhabitants feared and ritually destroyed" (Лазић 2008: 42). However, Lazić then refuses this assumption as the figurine body and arm position – spread arms and the head facing the sky, sitting with arms that are bent and placed on the body – is more indicative of a praying activity or a representation of a humble believer. Their function was probably the "substitution of their owner in an attempt to achieve a constant communication between a man and a god" (Лазић 2008: 43). The owner of the figurine and his family were connected with divine forces for a certain period of time, after which the figurine is destroyed and a new one produced. In this interpretation, the masks served to "prevent the face of the profane and the ordinary from appearing before the face of the exalted and omnipotent" (Лазић 2008: 42-43). Lazić indicates a correlation between the variability in figurine appearance and the social status of their producers: "As always, individuals or groups of high social and economic rank could afford high-quality terracottas, while the poorer ones used the ones of a more simple craftsmanship, which they acquired either from the unskilled artisans or produced by themselves." (Лазић 2008: 43). Based on this statement, it can be concluded that Lazić also considered that there were some kind of specialists for figurine production.

This author published another study in 2015, where he evaluated his assumption that the figurines represent individuals (Лазић 2015). Due to a high variability of figurines, he claimed that it is difficult to make a detailed typology based on all the elements of these objects. In this research, he made a simple typology based on the body position (standing and sitting), and arm shape and position (straight-cut arm stumps spread towards sides, with cone-shaped arms spread towards sides; arms placed on the abdomen). By combining the modalities of body position and arm shape and position, he created six types of figurines. Among 379 figurines that he analyzed, the standing figurines with either cone-shaped (64%) or straight-cut (31%) arms spread towards sides are the most common, while the standing figurines with arms placed on the body and the sitting figurines account only for 3% and 4%, respectively. Standing figurines with spread arms are present in all phases of the Late Neolithic, while standing figurines with the arms placed on the body and sitting figurines appear during Vinča B. Besides these six types of figurines, Lazić also noted that there are some other figurine types, such as hermaphrodites, kneeling figurines, and those carrying a child, but they are very rare. According to this author, different body positions and arm shapes and positions probably served to demonstrate certain differences and carried some universal messages. He noted that earlier researchers indicated different meaning for figurines sitting on a throne or a chair, either related to hierarchy of Neolithic pantheon or with their specific social status.

Lazić suggests that sexual characteristics are among the primary features to be observed if we want to reveal who the figurines represent. It was hypothesized that if the figurines represent individuals, the number of female and male figurines should be roughly equal. Figurines with breasts or vagina were regarded as female, while those with penis or without breasts were considered to be male. Using such approach, he calculated that of the total of 476 figurines where it was possible to observe these attributes, 65% are male and 35% female. Although these results had not supported his initial assumption of a roughly equal number of male and female figurines, Lazić suggests that the sex ratio on figurines and other forms of material culture depends on multiple factors, especially those related to social roles and gender constructs. Morover, he noticed that the sex ratio was unequal only for standing figurines with cone-shaped arms spread towards sides, whereas it is more equivalent for other figurine types. Thus, Lazić concluded that the figurines are representations of individuals or „real people". On the other hand, based on the impersonality of their faces, he suggested that what connected them is a state where all people are equal – death. Figurines represented real people, and were ritually broken in rituals related to the cult of the dead. However, he pointed out that this interpretation cannot be applied to all the figurines, as some of them represented certain events or scenes (e.g. hunting, reaping), or ancestors, heroes, mythological characters, etc.

Besides being the first study to quantify clearly defined figurine attributes and types, Lazić was the first to display the frequency of figurines by relative depths and phases of Belo brdo. From Figure 1

(Графикон 1) of Lazić's article, it is evident that the number of figurines in the earliest levels of Belo brdo is low, increases in Vinča B and especially Vinča C, and then sharply decreases around the beginning of Vinča D. A pattern of decline in the number of figurines in the latest Late Neolithic phase was noted on other sites of the Central Balkans (Borić 2015), possibly as their role in rituals that regulated the social relations within communities disappeared with the social disintegration in this period (for social disintegration see Tringham 1992).

The question of sex representation on Late Neolithic figurines of the Central Balkans was recently re-examined by J. Vuković (2021). By conducting a preliminary analysis of figurines from five Late Neolihic sites of the Central Balkans (Divostin, Grivac, Pavlovac-Čukar, Selevac, Vinča-Belo brdo), she demonstrated that the identification of figurine sex is more complex than assumed by some of the previous researchers (e.g. Лазић 2015), and that the traditionally assumed predominance of woman figurines is not supported, as asexual figurines represent the majority on certain sites (Selevac, Grivac). Observation of only several attributes, such as penis, vagina, and breasts, does not seem as a reliable method for distinguishing the sex on figurine. For example, there are figurines with no breasts but with pronounced hips („hourglass shape", Hudson, Aoyama 2004) or a belly indicative of a pregnant woman. Moreover, breasts seem more indicative of the figurine age, as they are commonly represented on figurines with sagging bellies more characteristic of older females. Vuković suggests that quantitative studies of the frequencies of different sexes should be undertaken, whilst noting that some of the used criteria for sex identification are unreliable.

All the previously presented descriptions and explanations of Vinča-Belo brdo figurines were based on the material from the excavations of M. Vasić. In 2011, N.N. Tasić published an article where he described figurines found on excavations that started in 1998. All the figurines are from Vinča D phase, and several types have been defined. The majority of figurines are found in leveling horizons or trenches, and there is no clear pattern of their association with certain contexts. Tasić noted that „no two of these could have been remotely associated with the same maker" (Tasić 2011b: 5). This author argues that there are some depictions of individuality even though the figurines of this phase are quite abstract.

The summary of diachronic patterns in figurine production and the corresponding narratives is presented in **Table 1.2**. Certain figurine features, such as particular body and arm position (standing with arms spread towards sides; Lazić 2008; 2015; Тасић 2008), as well as certain face characteristics, remained unchanged during the whole Late Neolithic at Vinča-Belo brdo. Lazić argues that this is related to the meaning of the figurines, which stays the same during the whole Late Neolithic. Srejović (Срејовић 1968) also noted certain continuities in the production of figurines of the preceding generations, which he saw as reactions against the new forms (conservatism). Srejović ascribed the changes to the shifts in stylistic and aesthetic values of inhabitants (and also Лазић 2008), but also to possible influences of external stimuli at around 6.5-6.0 m where he saw evidence for the changes in religious practices and influences of the Eneolithic cultures. Similarly, Letica suggested the possible influences of external factors on figurine production. Another important change was seen at 4.0 m (start of Vinča-Pločnik II, Vinča D), when there is a new style of figurines or their degeneration, as proposed by some (Garašanin 1979; Васић 1932b; Срејовић 1968; Тасић 2008), interpreted as evidence for adoption of foreign forms, sign of fatigue (Garašanin 1979) or uknown changes in the community (Васић 1932b). These changes coincide with the evident reduction in the number of figurines at this point (Лазић 2015), which Borić (2015) explains by suggesting that figurines lose their cohesive role in rituals with the social disintegration.

Table 2.2. Diachronic patterns of variability in figurines from Belo brdo and the proposed explanations.

OBSERVED PATTERN	EXPLANATION(S)
Continuity of certain types and attributes (standing position, spread arms, certain face features) (Лазић 2008; 2015)	**Unchanged meaning** of figurines (Лазић 2008)
Following **traditions of the previous layers** (Срејовић 1968)	**Reaction against the new forms/conservatism** (Срејовић 1968)
General **stylistic changes** from naturalistic to realistic, and finally abstract style (Letica 1964; Срејовић 1968)	"**cultural stimuli and, possibly, migrations** from Anatolia" (Letica 1964: 32);
Changes with Vinča-Pločnik **- New elements around 6.0 m/Gradac phase (6.5), which will be typical for Vinča C and D (Vinča Pločnik phases)**	„significant **ideological changes and a new religious practice**" (Срејовић 1968: 206); **external influences** (Letica 1964; Срејовић 1968);
Fluctuations in the **number of figurines** – low number in Vinča A; increase in Vinča B and C; decrease in Vinča D phase (Borić 2015; Лазић 2015)	Decrease in Vinča D – **social disintegration** (Borić 2015)
Flourishing between 8.5 and 5.9 m (Срејовић 1968); **thriving** (Тасић 2008)	?
Changes in the iconography of figurines around 4.0 m (Garašanin 1979; Васић 1932b; Срејовић 1968; Тасић 2008)	**Adoption of foreign forms** (Срејовић 1968); **signs of fatigue** (Garašanin 1979); **uknown changes in the community** (Васић 1936b: 82)

3. Research aims

By assessing the transmission of knowledge about production of anthropomorphic figurines and knapped stone tools, the goal of this research is to re-examine old and offer new explanations of socio-cultural dynamics on the Late Neolithic site of Vinča-Belo brdo (~5300~4500 BC). This will be achieved by formally describing the variability of these two artifact classes and providing possible explanations of the inferred patterns by integrating clearly defined theoretical concepts and quantitative methodology developed within the cultural transmission theory. Concerning the descriptions, there are new tools and concepts for analyzing the material culture that are more appropriate for assessing relevant similarities and differences and inferring patterns of cultural evolution. Regarding the narratives, earlier researchers were explaining cultural dynamics mainly by referring to simplistic social scenarios (e.g. social norms, diffusion), but the goal of this research is to offer a new perspective by exploring the influence of various aspects (e.g. models of social learning, demography) on cultural evolution during the Late Neolithic on Vinča-Belo brdo site. The cultural transmission theory represents a suitable framework for formally modeling and exploring the relationship between individual behaviors and the large-scale cultural dynamics, such as appearance or disappearance of certain cultural variants, cultural continuity or discontinuity, gradual or sudden cultural changes, etc. In this work, the cultural dynamics will be observed by tracing the transmission of knowledge about lithics and anthropomorphic figurines, while a particular focus will be on inferring the character of cultural changes (e.g. sudden vs. gradual) at Belo brdo, examining the relationship between demography and cultural diversity, and reconstructing the cultural transmission models and possible socio-cultural factors that influenced them.

Another aim of this research is to discuss the inferred results about the cultural evolution of lithics and anthropomorphic figurines in the light of other data about the site and the whole Late Neolithic of this area. In this way, some foundations of knowledge about the Late Neolithic communities of the Central Balkans will be critically evaluated.

The research aims in this study will be reached through the formal evaluation of two research hypotheses, and answering three research questions. The general research hypothesis is that ascertained social (Borić 2015; Chapman 1981; McPherron, Srejović 1988; Tringham 1992; Tringham, Krstić 1990; Трипковић 2013) and demographic (Porčić et al. 2016) changes will be reflected in the formal variability of knapped stone tools and anthropomorphic figurines. Within this general hypothesis, two specific research hypotheses will be tested:

Hypothesis 1: Sudden changes in the material culture have taken place at the beginning of Gradac phase.

This hypothesis was proposed by M. Garašanin (Garašanin 1951; 1979) based on the examination of the variability of material culture from Vinča-Belo brdo and other sites. Garašanin divided the temporal sequence of the Vinča culture into five phases: Vinča Tordoš I, Vinča Tordoš II, Gradac phase, Vinča Pločnik I, Vinča Pločnik II. The transition to the Gradac phase starts at 6.5 m of Vinča-Belo brdo stratigraphy, and it is dated to around 5000 to 4900 years BC (Tasić et al. 2015b). According to Garašanin, N. Vulić and M. Grbić have already “correctly observed” the “caesura in the evolution of the Vinča group” at around 6.5/6.0 m of Belo brdo stratigraphy (Garašanin 1979: 150). Garašanin himself noted “considerable changes” (Garašanin 1979: 203) or “significant turning point” (Garašanin 1979: 151) in many aspects of material culture on Belo brdo and other sites in the region, characterized by the appearance and disappearance of many cultural elements (e.g. types, ornaments) at this depth (Garašanin 1979: 151). Among them, particularly notable are changes in the variability of ceramics

(Garašanin 1979: 174) and figurines (Garašanin 1979: 174-175), as well the appearance of copper pearls at 6.6 m (Garašanin 1979: 162; cf. Borić 2009). Besides these changes in material culture, there are also changes in the settlement patterns – in contrast to multi-layered settlements on the river terraces and low hills that were founded in the earlier Vinča phases, the settlements founded after the beginning of the Gradac phase were mostly single-layered, and situated on more dominant, difficultly approachable hills that are easier to defend (Garašanin 1979: 153-154; see also Ристић-Опачић 2005). Finally, there are many burned houses at ~6.5 m of relative depth, but this "does not necessarily mean the catastrophe of the whole settlement" (Garašanin 1979: 174). Garašanin suggested that similar evidence, i.e. important changes in the material culture and the "particularly intense demolitions", are visible in the corresponding layers of Gradac (Garašanin 1979: 174-175) and Supska (Garašanin 1979: 168).

Other researchers have also indicated some notable changes around the beginning of the Gradac phase, either on Belo brdo itself or more generally for the whole Vinča group. B. Stalio (Сталио 1968: 85) noted the changes in the construction of houses and the use of hearths between 6.2 and 5.6 m, describing them as a "return to more primitive work". N.Tasić (Тасић 1968: 270) has suggested that the changes with the Gradac phase are evident in different artifact classes, i.e. ceramics, jewelry, tools, and weapons. In the production of figurines, the new "Eneolithic" style appears at 6.0/5.9 m (Срејовић 1968: 214). The changes are also evident in lithic organization, where the raw material structure shows large oscillations in the frequencies of obsidian and different chert types at 7.0-6.5 m (Radovanović et al. 1984), while the production is "drastically reduced" during the Gradac phase (Bogosavljević Petrović 2015: 438). Concerning the ceramic production, Schier (1996: 146) notes that the "most dramatic change in vessel shape and decoration can be observed between [his] phases 5c and 6 (levels 6.4 – 6.1 m)", although he later suggested that these seemingly sudden changes in the pottery production can be the consequence of stratigraphic disturbances (destruction and leveling horizon, pits) (Schier 2000). Tasić et al. (2015a: 16-17) similarly argued that there are „abrupt changes" in ceramic production at 6.0 m, as well as in figurines, altars, and bone tools, indicating that „there is the potential for much more significant change" (2015a: 55) at this depth compared to other cultural changes on the site.

There are different narratives behind the notion of "significant changes" with the Gradac phase. According to Garašanin, cultural dynamics at this depth "are related to changes in socio-economic relations, not so much within the Vinča group itself, but in the neighboring areas where the development of the use of metals leads to the transition to the Eneolithic." (Garašanin 1979: 154). In other words, there is an "uninterrupted internal evolution" of the Vinča culture (Garašanin 1979: 203), while the changes are "repercussions" of more fundamental social and economic changes in Thrace and the entire eastern Balkans. In this scenario, the external factors in the form of cultural diffusion have affected the cultural evolution during the Gradac phase. Similarly, Tasić has argued that the Vinča culture was affected by cultural diffusion from Anatolia, while the intensity of influences and resulting changes depended on the „proximity to the wave core" (Тасић 1968: 285). Rather than explaining it in terms of movement of ideas, Ristić-Opačić has suggested that the transition to Gradac phase can be related to migration, i.e. "… the penetration of new cultures to the central Balkans" (Ристић-Опачић 2005: 96). Based on the material from Vinča sites on the territory of Romania, G. Lazarovici has also suggested that the abrupt changes during this period are evidence of the population movements, naming this hypothetical event as "Vinča C shock" (Lazarovici 1987, cited in Tasić et al. 2015a).

Certain explanations of the observed changes are somewhat enigmatic in terms of the underlying social dynamics, such as a description of the transition to the Gradac phase as a "turning point" (Bogosavljević Petrović 2015: 206; Radovanović et al. 1984: 15, but for all the transitions) of the whole Vinča group, or a statement that "events, or a series of smaller events in general activities on Belo brdo are reflected in a drastically reduced volume of [lithic] production" (Bogosavljević Petrović 2015: 438). The viewpoint of Srejović is also somewhat confusing, as he argued both that „in the narrow belt of the Serbian Podunavlje [Vinča] culture gradually loses its individual features (in Vinča around 6.0 m) and starts to adapt to new stylistic concepts" (Срејовић 1968: 205) of the arriving Eneolithic cultures, and that there is a "sudden break with the local tradition" of figurine production (Срејовић 1968: 214).

Finally, some authors are more inclined towards explaining the transition to the Gradac phase in terms of internal processes. B. Stalio argued that the changes in house construction and the use of hearths in levels between 6.2 and 5.6 m are related to "economic weakening" (Сталио 1968: 85). Many researchers did not consider the changes with Gradac phase as significant, but rather as a part of continuous, gradual changes within this community (Chapman 1981; Глишић 1968; Грбић 1968; Јовановић 1968; Milojčić 1949b, cited in Tasić et al. 2015b). According to these authors, „there were no deeper social and economic changes" during this period (Грбић 1968: 72), i.e. "those changes did not occur abruptly, suddenly and without the possibility of anticipation through previous developments" (Глишић 1968: 30), but rather as a part of a "long-term, peaceful development" (Јовановић 1968: 139-140). In this view, there are no large or abrupt changes on boundaries between the phases, so they could be considered only as analytical units for analyzing the temporal variability of material culture.

From this overview of the previous narratives regarding the cultural dynamics with the Gradac phase, it can be seen the majority of researchers did not question the continuity on Belo brdo and of the entire Vinča group, as many cultural elements show uninterrupted evolution (e.g. Bogosavljević Petrović 2015; Chapman 1981; Kaczanowska, Kozlowski 1990; Radovanović et al. 1984). However, there is a disagreement about the character of diachronic cultural changes with the Gradac phase. Are these changes a part of the continuous, gradual changes within the community, or they are abrupt and discontinuous, indicating some other social scenarios (e.g. external stimuli, social disintegration)? In this work, the character of cultural changes on the site of Vinča-Belo brdo will be assessed. If the hypothesis of sudden, significant changes with the Gradac phase is correct, notable (e.g. sudden appearance of many new variants) and/or synchronous changes in the material culture are expected at the beginning of the Gradac phase. The assumption is that larger, discontinuous cultural changes or simultaneous changes in different cultural aspects would indicate some notable social dynamics caused by internal or external factors (e.g. migration; see Zvelebil 2001). While many researchers have already made subjective insights into the character of cultural changes with the Gradac phase, the goal of this research is to to visualize and quantify the cultural changes at this depth and assess their magnitude in comparison to the other changes throughout the sequence.

Within this research hypothesis, the character of other cultural changes along the Belo brdo sequence will be assessed. Larger changes in material culture were indicated for the boundaries of all commonly utilized periodizations (e.g. Radovanović et al. 1984; Tasić et al. 2015a) – with Vinča B (~8.0 m) (e.g. Spataro 2018), Vinča C/Gradac phase (6.5-6.0 m), and Vinča D (~4.0 m). Besides the suggested abrupt changes with Gradac phase, many researchers have indicated that there are changes in the social circumstances (e.g. Srejović 1994; Tringham 1992; Трипковић 2013; Whittle et al. 2016) in the final Late Neolithic, evidenced by a decline of production of knapped stone tools (e.g. Garašanin 1979: 178), figurines (Borić 2015), and other forms of material culture, as well as more frequent house burnings (Whittle et al. 2016), increased autonomy of individual households (Srejović 1994; Трипковић 2013), etc. By examining the changes in different aspects of material culture at various moments, the adequacy of phases as interpretational or analytical units will be re-evaluated.

Hypothesis 2: During the sequence of Vinča-Belo brdo site, diversity of material culture increases, peaking during the Vinča C phase, and then decreases, following the established population dynamics.

This hypothesized trend of material culture diversity is expected to follow the changes in population size during the Late Neolithic of the Central Balkans (Porčić et al. 2016). It is expected that cultural diversity will increase, and then decrease, mirroring the population dynamics that were reconstructed using the Summed Calibrated Radiocarbon Probability Distributions Method (SCPD) (Porčić et al. 2016[3]), as well as by counting the number of settlements in each Late Neolithic phase (Ристић-Опачић 2005; cf. Roberts et al. 2021: 42). In Figure 3 of the article of Porčić and colleagues (2016), it can be seen that the population size gradually increases from the earliest Late Neolithic (~5300 cal BC), reaching maximum in the Vinča C phase (more precisely around 4800 cal BC), and then decreases until the end of the Late Neolithic (~4500 cal BC). A positive correlation between cultural diversity (and complexity) and population size is indicated by some theoretical (e.g. Henrich 2004; Kobayashi, Aoki 2012; Neiman 1995; Okumura, Araujo 2014; Rorabaugh 2014), experimental (e.g. Derex et al. 2014), and empirical research (e.g. Collard et al. 2013a; Henrich 2004; Kline, Boyd 2010; Lycett, von Cramon-Taubadel 2008). Higher cultural diversity is generally expected in larger populations, as more individuals can store and transmit them further (e.g. Shennan 2001), while population decrease can lead to loss of certain cultural elements (Heinrich 2004). However, there are some exceptions to this pattern (e.g. Caldwell, Millen 2010), as other factors, such as the population structure (e.g. Lipo et al. 2021), models of cultural transmission (e.g. Rorabaugh 2014), environmental factors (e.g. Fogarty, Creanza 2017) and adaptations to them (e.g. Collard et al. 2013b), and complexity of cultural variants (e.g. Fogarty et al. 2015), should be taken into account. Thus, the relationship between the two should not be oversimplified. Nevertheless, demography can be an important factor in understanding the cultural dynamics, so its potential effects on the variability of material culture on Belo brdo will be explored.

Some researchers have already noted the "flourishing" of production in Vinča B and C (e.g. Срејовић 1968) when there is a population boom, and „decline" (e.g. Garašanin 1979: 205) in Vinča D during the population bust, indicating the possible correlation between population dynamics and cultural diversity. However, this study aims to formally, quantitatively examine the relationship between the two.

Research question 1: Which models of cultural transmission stand behind the transmission of knowledge and ideas about making anthropomorphic figurines and knapped stone tools?

Based on the variability of formal attributes in lithics and anthropomorphic figurines, the goal is to determine which models of social learning could have predominated in the transmission of knowledge about these two artifact classes through generations. Models of social learning have an important role in explaining cultural dynamics, such as cultural stability and change (e.g. Crema et al. 2016; Minar, Crown 2001). The neutral model applies to stylistic elements that individuals choose for a variety of reasons, i.e. randomly on the population level, while the biased models of transmission (e.g. the frequency-dependent biases; see Chapter 4 for more information on models of social learning) are related to elements that had a certain function for most individuals within a population, such as survival (Dunnell 1978), expression of individual or collective identities, etc. Thus, various artifact classes can have divergent evolutionary trajectories related to different models of transmission (e.g. Shennan et al. 2015). A functional role is expected for lithics, while there are multiple narratives about possible role of figurines (see Bailey 2017 for an overview), and this research will use a more formal approach to assess their role and meaning within the Belo brdo society.

[3] The most recent results of SCPD analysis (Porčić 2020) show a trend that slightly differs from the one described here. The population size increases during the initial Late Neolithic phase, reaches a peak quite rapidly (~5200 BC) and remains constant before decreasing around 4500 BC.

Rather than providing simplistic explanations of stability and change, such as social norms or migrations, the focus of this research will be on reconstructing the internal mechanisms of change on Belo brdo. Using the cultural transmission theory as an interpretative framework, it will be examined what historical scenarios have most likely produced the variability of two artifact classes on Belo brdo. More specifically, the aim will be to infer what kind(s) of knowledge-sharing within the community could have maintained stability (Bogosavljević Petrović 2015; Radovanović et al. 1984) in the case of stone tools (it does not have to be high-fidelity copying; e.g. Richerson, Boyd 2005: 86) and obvious changes in the case of figurines (e.g. Letica 1964; Срејовић 1968; Тасић 2008). The goal is to narrow down the range of possible historical scenarios that could have produced the observed empirical patterns – for example, passing of knowledge within households (a sort of vertical transmission), or homogenous population-level culture due to conformism, prestige bias, or specialization. Other strands of evidence (such as contextual information) will be taken into account to further evaluate which are the (un)likely scenarios that produced the material culture. By reconstructing the models of cultural transmission, i.e. the scenarios of information-flowing within this community, insights about social dynamics and social organization of this community will be made and discussed in the light of previous research on this topic (Borić 2015; Chapman 1981; McPherron, Srejović 1988; Tringham 1992; Tringham, Krstić 1990; Трипковић 2013) to make more general conclusions about the Late Neolithic in the area.

It will be also explored if there are changes in the models of cultural transmission during the sequence (sensu Crema et al. 2014; 2016). The expectation is that there will be changes in the strategies of knowledge-sharing in the case of changes in social organization, such as those suggested for transition to the Gradac phase and Vinča D. For example, if the suggested scenarios of social disintegration (Tringham 1992) is correct and reflected in the production of lithics and anthropomorphic figurines, we should expect a shift towards scenarios related to anti-conformism.

Research question 2: Are the changes in different cultural elements synchronous?

If there are larger diachronic changes in the variability of lithics and anthropomorphic figurines, it would be significant to explore if they are synchronous or not. The evolutionary trajectories of lithics and anthropomorphic figurines will be compared with meticulously described changes in the variability of ceramic vessels (Schier 1996; 2000). As already stated, the simultaneous changes in artifact attributes or types could indicate changes in the social relations, i.e. they would represent a more sound foundation for conclusions about the reality of changes in certain aspects of socio-cultural structure in the past. Within this research question, the adequacy of proposed periodizations will be addressed and evaluated if they represent appropriate analytical and interpretational units.

Research question 3: Does the choice of analytical units influence the results, and thus the interpretation of the past?

In this study, three analytical approaches will be used for describing the variability of lithics and anthropomorphic figurines: attribute analysis, paradigmatic classification (formal typology), and geometric morphometrics. As the collected data will differ depending on the used approach, it will be examined if the interpretations based on these different data will differ too. For example, more detailed tracking of morphological changes using the geometric morphometrics could lead to detection of some changes which could not be identified using the attribute analysis, or the changes could encompass only certain characteristics of artifacts, which would be appropriately described using the attribute analysis, but not using the typological analysis.

4. Theoretical framework

The theoretical basis of this research is the theory of cultural transmission, developed within the framework of evolutionary archeology (Eerkens, Lipo 2007; Lycett 2015; O'Brien, Lyman 2000; Shennan 2002; 2009; 2011). The first part of this chapter will summarize the main concepts of the CT theory, while the second will discuss the influence that it had on archaeological theory and methods. The final part of this chapter will deal with the specific theoretical assumptions that are necessary to tackle the research aims in this work.

4.1. Cultural transmission theory

During the 1980s, the basic concepts of dual inheritance (or gene-culture coevolution) theory were developed by M. Feldman and L. Cavalli-Sforza (1981) and R. Boyd and P.J. Richerson (1985). According to this theory, human behavior is influenced by genes, culture, and environment (e.g. Richerson, Boyd 2005: 19-20; Boyd, Richerson 1985: 3). The behavior of other living beings can be largely explained by interactions of genes and environment, but within the dual-inheritance theory, the importance of culture in understanding human behavior and diversity was particularly highlighted (e.g. Heinrich 2015; Richerson, Boyd 2005). The proponents of this theory suggested that, by studying the biological and cultural inheritance, as well as the interactions between the two (e.g. genetic tendencies towards particular cultural information; cultural factors associated with the evolution of lactose tolerance), many aspects of human behavior and culture can be explained.

However, it was not solely the focus on these two forms of inheritance that set the dual inheritance theory apart from the other theoretical stances. It was the explicit modeling of cultural dynamics within a certain population (cultural transmission theory or cultural evolutionary theory), which aimed to examine how individual-level actions affect the population-level cultural dynamics, and vice versa. The previous anthropological theories have seen culture as an abstract phenomenon that was affected by certain factors (e.g. environment, external stimuli, social tensions), but they had difficulties in relating the individual behavior and population-level cultural dynamics. Rather than seeing individuals as passive observers of large-scale cultural processes, within the CT theory individuals were modeled as active agents capable of making decisions that influence the population-level cultural dynamics. Thereafter, it was possible to investigate the effects of individual actions on the existence of cumulative culture (e.g. Lewis, Laland 2012) and creating spatial and temporal patterns of cultural variability (e.g. Axelrod 1997; Boyd, Richerson 1985), explore the relationship between demography and cultural complexity (e.g. Derex et al. 2013; Henrich 2004; Powell et al. 2009; Shennan 2001), etc. The explicit modeling of the behavior of individuals relies on a simple definition of culture:

"Culture is information capable of affecting individuals' behavior that they acquire from other members of their species through teaching, imitation, and other forms of social transmission." (Richerson and Boyd 2005: 5)

This definition of culture is similar to the one by E. Tylor (1871; cited in O'Brien, Lyman 2000: 386): "Culture… is that complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities acquired by man as a member of society". It focuses on the heritability of cultural information through social learning, where social learning or cultural transmission can be defined as the transmission of cultural elements (e.g. language, customs, knowledge) through observation, imitation, teaching, or other social learning mechanisms. Transmission of knowledge about agricultural activities, like sowing, is an example of social learning, which can be transmitted from parents to offspring, between peers, or in some other way.

With the focus on social learning, culture is conceptualized as a system of inheritance of cultural information (knowledge, ideas, beliefs, etc.), analogue but also different from genetic inheritance. Cultural elements, like biological, are inherited and modified through generations. Therefore, it was assumed that certain evolutionary principles, related to the concept of descent with modification, can be applied to cultural elements, although with certain adjustments. For example, while our genes are inherited by our parents, culture can be inherited by other individuals (e.g. peers, relatives). Although cultural and biological evolution differ in certain ways due to a different nature of entities that are being transmitted and factors that influence them, a general similarity has served for creating a theoretical framework and methodological tools for understanding and investigating culture as a phenomenon.

R. Dawkins popularized the idea that certain cultural elements are transmitted in similar ways as genes in biological evolution: "Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation." (Dawkins 1976: 206). Dawkins assumed that the Darwinian principle of descent with modification can be applied to any system that involves replicators – elements that are differentially passed on through generations. His examples include different aspects of animal (bird song) and especially human culture – e.g. fashion, technology, tunes, ideas, beliefs, customs, and art.

The assumption that particular cultural elements are transmitted in somewhat similar ways to genes was formalized by Feldman and L. Cavalli-Sforza (1981) and Boyd and Richerson (1985), who developed clear concepts of the theory and the first mathematical models of cultural transmission. By borrowing and adapting ideas from population genetics, they have built the formal models of cultural dynamics – i.e. explored the relationship between individual-level behavior and the population-level cultural dynamics. One of the basic assumptions of these researchers was to observe culture as a population phenomenon. Culture is based on the actions of individuals, but it is most meaningful to observe it on a population level, especially when observed in broad spatial and temporal contexts. Moreover, the culture of individuals is dependent on the culture of the whole population. For cultural elements that can be regarded as having discrete modalities (e.g. children names, ornament types), the population-culture can be conceptualized as a structure of frequencies of cultural variants, while the cultural change can be seen as a change in the frequency structure of variants in a population. In the case of continuous traits (e.g. measurements), the population-level culture can be conceptualized as a distribution of values for that variable.

When the culture is conceptualized in such a manner, it can be tracked how different individual actions affect the population-level cultural dynamics (structure or distribution of cultural elements). As mentioned, cultural dynamics (or evolution) can be explained in simple terms by descent or inheritance of cultural information, and modification or the appearance of new cultural elements. In other words, culture is transmitted and modified by individual actions. Descent or inheritance refers to the transmission of cultural elements between individuals through social learning – e.g. from parents to children (vertical transmission), teachers to pupils (oblique transmission), or between peers (horizontal transmission). The 'modification' denotes the appearance of new cultural modalities, which are created both consciously (innovation) and unconsciously (copying error). These two mechanisms largely influence the patterns of cultural dynamics and will be described in more detail in the text below. But before describing them, some attention should be dedicated to the question of units of cultural transmission, i.e. what is exactly being transmitted between individuals.

What are the units of cultural transmission?

While genes are firmly established as units of biological transmission, it can be more difficult to define the units of cultural transmission (cultural variants, elements, memes). As stated by Eerkens and Lipo (2005: 318): "units of transmission are ideational and not directly observable", implying that we can only observe the indirect manifestations of cultural information (ideas in someone's brain) through words, behavior, artifacts, etc. Moreover, even the same cultural elements (e.g. the idea of heaven) can be perceived differently by different individuals (e.g. Atran 2001). Thus, we can only guess how are cultural information (e.g. ideas, knowledge, or social norms) processed by our "cognitive filters" (Gil-White 2005: 329) and stored in our brains. By observing the indirect manifestations of cultural ideas, it is evident they are not always faithfully replicated as well-defined clusters of information (like genes). While cultural information such as culinary receipts or baby names can be quite faithfully transmitted within populations, many cultural phenomena (e.g. political ideologies) are subject to different transformations during the process (e.g. Atran 2001), and are far from faithful, identical copies. An illustrative example is the Chinese whispers (Broken Telephone) game, where the copying errors quickly accumulate, transforming the original cultural variant. Cultural elements can be copied partially, unfaithfully, or together with other cultural information. As stated by Dawkins (1976: 209): "It looks as though meme transmission is subject to continuous mutation and also to blending". Thus, the units of cultural transmission can be much more fluid and loose units than genes.

Nevertheless, easily definable, discrete units of cultural transmission are not necessary for the existence of cultural evolution (e.g.; Richerson, Boyd 2005: 6), as evidenced by theoretical models (e.g. Gil-White 2005; Henrich, Boyd 2002), as well as the fact that cultural transmission of many cultural elements has been successfully modeled (e.g. baby names, artifacts, cars) (see Lycett 2015; Mesoudi 2011). A suitable definition was given by Eerkens and Lipo (2005: 318): "cultural units represent any measurable units that we can delineate within the suite of cultural variation that displays heritable continuity, measured as a greater than random degree of coherence of information traced through time and across space.". This implies that the units of cultural transmission should be discussed for each particular case and defined based on the empirical observation.

How are the information transmitted? Between whom? Why?

Unlike biological transmission, where genetic traits are passed at one moment in time, social learning is continuously happening during our lifetimes, as we continuously share cultural information in our daily interactions. It should be noted that learning should not be understood in its modern sense, but mode widely, in terms of acquiring any cultural information through communication, imitation, observation, etc. Lycett (2015) defines four basic mechanisms of transmission of information between individuals, i.e. social learning: stimulus enhancement (individual learning stimulated by another individual only by learning context), emulation (copying the result of another individual, e.g. a vessel), imitation (copying the actions of another individual), and teaching (active involvement of knowledgeable individual during the learning process). While in biological evolution the genes are inherited from parents (with some exceptions), in cultural transmission person can inherit cultural elements from any individual, including biological parents, cousins, friends, teachers, prestige individuals, etc. Cultural information can be transmitted by a different number of individuals – they can be acquired by one or more individuals, and transmitted to one or more individuals. Depending on the relationship between the individual that passes the knowledge and the person that acquires it, three transmission pathways were defined: vertical transmission (social learning from parents), oblique transmission (from non-related individuals of previous generations), and horizontal transmission (social learning from peers) (Cavalli-Sforza, Feldman 1981).

But why do individuals decide to acquire cultural information from others? For example, what are the reasons to rely on social learning when manufacturing a hunting tool, instead of inventing it from scratch? The downside of relying only on individual (trial and error) learning is that it can be susceptible to errors (e.g. creating arrowheads that do not perform well), or costly in terms of time, resources, or energy (Richerson, Boyd 1985: 99-147). Mathematical models have shown that reliance on social learning, accompanied with individual learning, is an efficient way to reach adaptive solutions, particularly when there are oscillations in climatic conditions (Richerson, Boyd 1985: 99-147). The reliance on social and individual learning (the so-called guided variation) is often a suitable way for acquiring the necessary knowledge for certain tasks, such as creating an efficient hunting tool.

But disregarding the reasons for the appearance of social learning, it is a common human behavior – when producing tools, choosing an outfit, acquiring religious beliefs, etc. Although individuals commonly acquire cultural information from their parents (vertical transmission), they can also acquire them from any individual from the population (oblique and horizontal transmission). Observing on a population level, the choices of individuals can be either biased towards particular elements (e.g. more attractive, more common) or not. In the unbiased or neutral model of cultural transmission, every individual has their reason for acquiring a certain cultural element, but on a population level, these choices are not biased towards particular elements. The probability of an element being transmitted is equal to its frequency in the population. However, due to stochasticity (randomness), i.e. multiple factors that influence the real-life scenarios, the frequency of some cultural elements will increase or decrease, changing the population-level structure of frequencies. When observed over larger time scales, such unpredictable, random fluctuations in the frequency of elements (drift in biological terminology) will lead to a distinct pattern of change – the popularity principle (e.g. O'Brien, Lyman 2002).

Alternatively, individuals in a population can prefer certain cultural elements over others (biased transmission). Among many reasons to be biased towards acquiring particular cultural elements (e.g. Boyd, Richerson 1985: 68-76), a distinction between content and context biases can be made (Heinrich, McElreath 2003). If the properties of the cultural element itself make it more prone to be distributed within a population – e.g. more appealing, memorable, or useful in a certain context – there is a content bias towards that element. When the choice is not dependent on the cultural element itself, but rather on the social factors – e.g. who is the individual who carries it or how common it is – there are different context biases. If individuals acquire cultural elements by their frequency in the population, there is a frequency-dependent bias. In conformist transmission, individuals are more likely to copy the cultural element than it would be expected by its frequency, while with the anti-conformist (or pro-novelty) transmission the opposite is true – individuals tend to copy the rare cultural elements. Finally, the individuals might choose the cultural elements by evaluating a cultural model that displays them (model-based biases). Prestige bias indicates a scenario where individuals tend to copy from those who are considered prestigious for some reason (e.g. their social status, skill). Individuals might also be biased towards particular models for other reasons, such as age, sex, or ethnicity (e.g. Chudek et al. 2015; Rendel et al. 2011). These models of cultural transmission were largely inspired by empirical studies of anthropologists and psychologists (Boyd, Richerson 1985: 2).

Depending on these models and pathways of transmission, there is a cultural selection of memes in a population, as only some of them will be passed further whereas others will not. However, as in the case of biological evolution, natural selection can also affect the differential transmission of elements, as death can prevent an individual to transmit their cultural information to others.

The appearance of new cultural elements

New cultural modalities can be created either consciously or unconsciously, either during the transmission process or during the "execution" of the cultural element (Eerkens, Lipo 2005). Novelties appear by imperfect copying (copying errors), intentional innovations (e.g. discoveries, recombinations of elements, interpretations), or translations of cultural elements into different media (see Eerkens, Lipo 2005 for more details and somewhat different classification of innovation mechanisms). Within a particular population (e.g. a village community), new elements can also appear due to a movement of people (migration) or the spread of ideas (diffusion).

Simulating the cultural dynamics

As mentioned, the CT models serve to relate individual-level actions and population-level cultural dynamics. Different models can be seen as different anthropological scenarios (simulations of hypothetical "realities"), where the consequences of different interactions between individuals are observed – who copies a cultural variant from whom, how often, how precisely, whether they modify the copied behavior or not, etc. Individuals are considered as active agents capable of behaving in different ways – for example, acquiring cultural information from other individuals, or modifying it either consciously or unconsciously. For many reasons, only certain cultural elements from a population will be selected and transmitted further, indicating some sort of selection of cultural information. Others will disappear – for example, they can be forgotten, too complex to learn or memorize, or their carrier might die before transmitting them to other individuals. However, new cultural elements will appear by innovation and copying errors. Depending on the interaction of these factors – i.e. which cultural information are transmitted and between whom, how faithfully, how often are new ones created – as well as the influence of other factors (such as demography and climate), the structure of cultural elements on the population level (e.g. community, regional population) will change in different ways, as shown by theoretical mathematical models and simulations of social dynamics (e.g. Axelrod 1997; Boyd, Richerson 1985; Cavalli-Sforza, Feldman 1981).

Let us present an example. In a village without access to the internet or any other modern technology, everyone decorates their ceramic vessels with an ornament. We observe how individuals choose ornaments for their vessels in five generations, and how their choices affect the structure of ornaments on a population level. In the first generation, there are three distinct ornaments that we can denote with A, B, and C, which have equal frequencies on a population level (**Figure 3.1a, Figure 3.1b**). In subsequent generations (2-5), one possibility is that the ideas about ornamentation of ceramic vessels are transmitted within the families, i.e. children inherit them from their parents. For the sake of simplicity, let us assume that all families have an equal number of children. After several generations, the majority of individuals will maintain the "tradition" of their family, but some new ornaments (type D) might appear due to the innovation or the (accumulation of) copying errors. On a population level, the structure of frequencies of different ornaments in the last generation will be quite similar to the one in the first generation (**Figure 3.1a**), except for the appearance of a novel ornament variant (type D). In this scenario, commonly named "vertical transmission", the initial variability (structure of ornament frequencies) will be maintained if the copying error and innovation rate are small, or increased if the novel elements frequently occur.

In another scenario, certain ornament type(s) can be more appealing than the ones that the individuals' parents have – e.g. it is more aesthetically pleasing, easier to produce, or the most prestige individuals in the village use it. If many individuals are biased towards the more appealing ornament, it can be inherited by almost all the individuals in the village in several generations. In this case, the majority of vessels will be decorated with the preferable ornament type, i.e. the structure of ornament frequencies will be highly homogenous on a population level (**Figure 3.1b**).

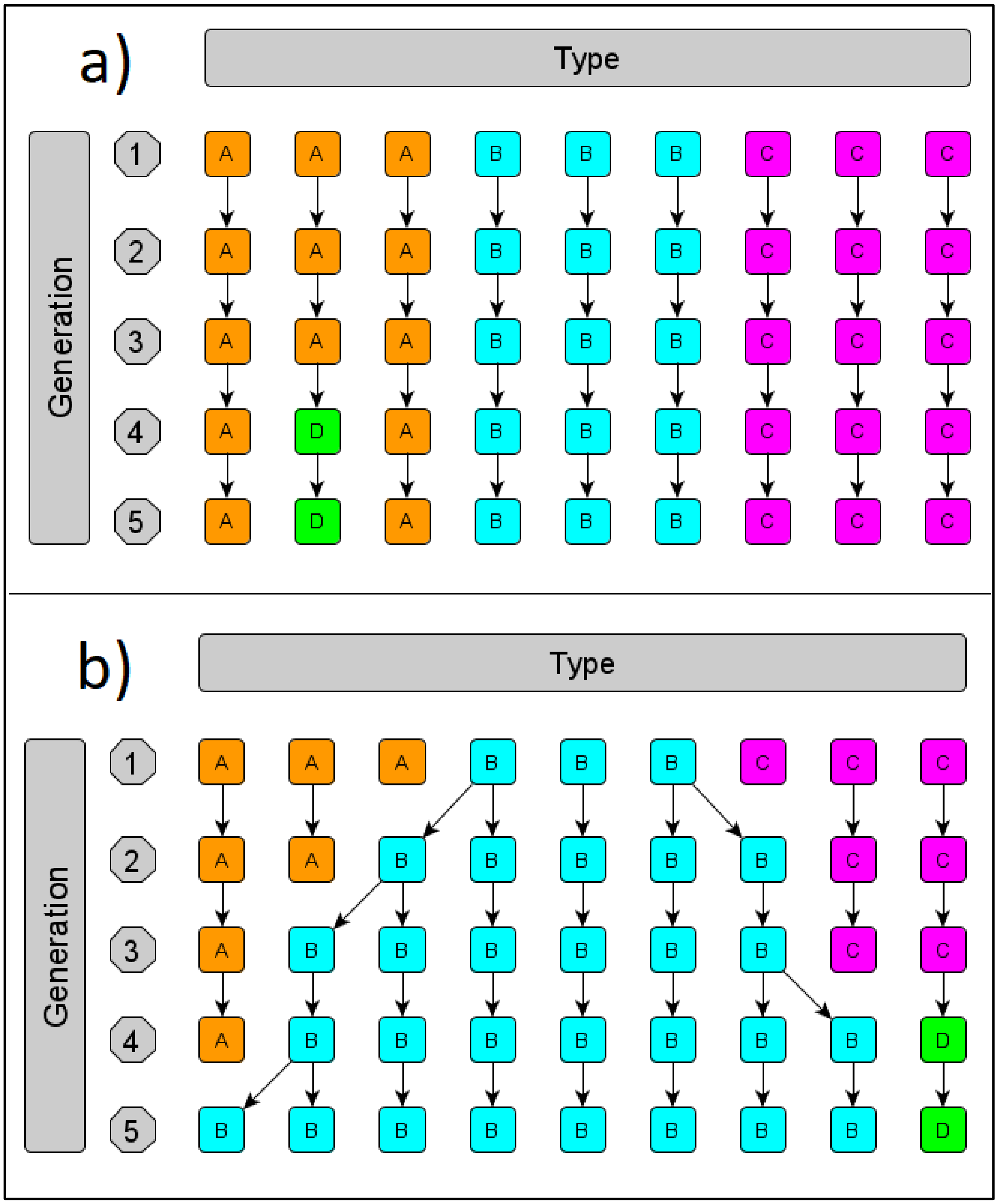


Figure 3.1. Two simple scenarios of cultural transmission of ornament types: a) vertical transmission (parent to offspring) with occasional innovation leads to maintenance or increase of variation; b) individuals are slightly biased towards type B ornament and occasionally acquire it by oblique transmission, resulting in a homogenous population-level culture after several generations.

This simple example illustrates how different individual-level actions (decision-making) can affect the population-level cultural dynamics. However, the CT models can be either simple or complex, and can incorporate many varying parameters: population size and dynamics, the use-life of an object, discrete generations vs. continuous inheritance, innovation rate, copying error, etc. The stochasticity (randomness) factor is also frequently modeled, to represent the influence of many (unknown) factors that affect real-world situations, making the models more realistic. By using formal, quantitative models and simulations, the CT theory offers means of evaluating the outcomes (population-level patterns) of multiple scenarios of cultural transmission. For example, to evaluate which historical scenarios best fit the patterns observed in the archaeological record (Aurignacian ornaments), Kovačević et al. (2015) performed 2,680,000 simulations of interactions of individuals, a task which would be impossible by common sense and without the use formal, quantitative methods and computers. Moreover, "even simple models can unfold into surprising and counterintuitive patterns" (Romanowska et al. 2019: 3). For instance, according to Mesoudi (2011: 141) "Cultural evolutionary models show that what might be very small selection biases in a single cultural generation can have dramatic effects when repeated over several cultural generations".

By explicitly modeling the cultural dynamics in time and space, the CT theory represents a suitable framework for understanding culture as a phenomenon and investigation of cultural dynamics in time and space. The insights from mathematical models and simulations were supported and extended by other lines of research, such as laboratory experiments of cultural transmission (see Heinrich 2015; Mesoudi 2011) and ethnographical studies (e.g. Aunger 2000; Hewlett, Cavalli-Sforza 1986; Hewlett et al. 2011; Ohmagari, Berkes 1997; Tehrani, Collard 2009). The CT theory has also been applied in empirical studies, for explaining the patterns of change of different cultural phenomena (see Henrich 2015; Mesoudi 2011; 2015; 2017; Richerson, Boyd 2005 for overviews), including language, animal cultures, archaeological artifacts, baby names, cars, etc.

4.2. CT theory in archaeology

As acknowledged by many proponents of the CT theory, the archaeological record represents a fertile ground for studying the long-term cultural dynamics and reconstructing different aspects of cultural transmission. In archaeology, the CT theory aims to investigate what scenarios of individual actions could have produced the patterns of variability of material culture that we see in the archaeological record. For example, what kind of behavior of individuals leads to stability of certain cultural elements (e.g. handaxes; Finkel, Barkai 2018) that stay relatively unchanged for thousands of years, or rapid changes in other cultural elements (e.g. clothing, art)? Although there is a long history of research of such questions in archaeology (e.g. Johnson 2020: 180-202; Palavestra, Porčić 2009), individuals were largely invisible in the evolutionary approaches preceding the CT theory. Large-scale cultural dynamics were generally related to large-scale processes (e.g. ethnicity, migrations, and adaptations) where individuals were largely seen as "passive dupes who blindly follow social rules" (Johnson 2020: 114). In this regard, the CT theory is more similar to more recent approaches that consider the archaeological record as a result of more complex interaction of individuals – e.g. those related to practice theory and agency (see Harris, Cippolla 2017 for an overview), communities of practice (e.g. Sassaman, Rudolphi 2001; Minar 2001), various approaches that deal with skill and learning process (e.g. Assaf 2021; Goldstein 2018; Minar, Crown 2001), assemblage theory (e.g. Borić 2016), etc. However, the epistemology of CT theory is quite dissimilar in comparison to these approaches.

Nevertheless, ideas that resemble certain aspects of the CT theory can be found among the previous approaches that investigated the large-scale cultural dynamics (e.g. O'Brien, Lyman 2000). The culture historians were particularly committed to investigating the cultural diversity in time and space, and some of them recognized that social learning plays an important part in explaining the patterns that were observed in the archaeological record (e.g. Kroeber 1916, cited in Eerkens, Lipo 2007). Moreover, certain tools that are still used for studying cultural evolution were developed, such as seriation (e.g. O'Brien, Lyman 2002; Porčić 2018), a relative dating technique based on the principle of popularity. However, there was no coherent theory that would relate the behavior of individuals and the population-level patterns, and the explanations of cultural dynamics were largely based on common sense (e.g. Dunnell 1978).

Although usually considered as one of the proponents of New Archaeology, the ideas of D. Clarke, elaborated in his book Analytical archaeology published in 1968, share many similarities with the contemporary CT theory (Lycett, Shennan 2018). According to Clarke, culture can be conceptualized as an information system that can be explained by a concept of descent with modification (Clarke 1968, cited in Lycett, Shennan 2018). He considered that cultural information (learned behavior, ideas) are transmitted between individuals or societies, where factors such as cultural selection, innovation, and imperfect copying influence the population-level patterns that we see in the archaeological record. There were no methodological tools at the time to study the models of cultural transmission, but Clarke predicted the importance that computer simulations will have in the future.

During the '70s and '80s, R. Dunnell published a series of texts where he argued for applying the Darwinian evolutionary principles to the cultural phenomena (Dunnell 1978; 1980; 1989). Dunnell argued against a view of cultural evolution as a progress and cross-cultural generalizations, and suggested that the Darwinian concepts should be adapted to the study of culture. For Dunnell, there is an important distinction between functional (adaptive) and stylistic elements, which exhibit different patterns of change. Functional elements are subject to natural selection as they affect individuals' fitness, which explains their fixation in the population. Stylistic elements, on the other hand, are not affected by selective pressures and vary randomly within a population (the effect of drift), producing specific patterns of change in the archaeological record. Within the CT theory, this model of cultural inheritance was termed unbiased or neutral transmission. Many of Dunnell's other ideas – e.g. the existence of a correlation between population size and cultural complexity, the materialistic nature of archaeological phenomena, and the importance of individual behavior in understanding the cultural evolution – were later discussed and became integral parts of the contemporary CT theory.

While these examples show the early existence of concepts that share similarities with the contemporary CT theory, methodological tools for applying such ideas to the archaeological record were not developed. It was Neiman (1995) who made a huge step forward in developing the methodology for inferring the aspects of cultural transmission from the archaeological record. Building on the definition of style by Dunnell (1978), Neiman modeled transmission of stylistic elements both in time and space and observed the resulting cultural diversity. He adapted the models from population genetics to simulate the (unbiased or neutral) transmission of stylistic elements, suggesting that the two main factors that affect the cultural diversity in the case of neutral transmission are population size and innovation rate. Neiman first simulated the transmission of stylistic traits within a single community, showing that in the case of neutral transmission (without innovation) there will be a fixation of one of the cultural variants in the population after a certain amount of time, due to chance or stochasticity (or drift in biological terminology). While the probability for a variant to be transmitted is equal to its relative frequency in the population (for neutral transmission), the proportion of some variants will increase (or decrease) slightly due to chance in finite populations. In the next generation, the probability of copying those variants will increase, and these effects get cumulative over time leading to the disappearance of most variants and the fixation of only one. Using simulations and solving mathematical models, Neiman has shown that the time needed for fixation in population to be reached depends on the population size – the effect of drift will eliminate the diversity faster in small than in large populations. Neiman subsequently introduced innovations (either internal or external) to his models of neutral transmission, inferring that such models produce patterns that were previously recognized as the popularity principle (e.g. O'Brien, Lyman 2002).

Neiman subsequently explored the spatial models of cultural transmission, suggesting that the rate of intergroup transmission is the main factor that influences the regional patterns of cultural diversity. Assuming that the on-site innovation rate is fairly constant, Neiman reasoned that the cultural diversity will be most affected by intergroup transmission (innovation from the neighboring communities). Thus, he deduced that the fluctuations in cultural diversity for individual sites or assemblages can indicate a changing rate of intergroup transmission. Neiman has also shown that a higher intergroup transmission rate will lead to more homogenous regional-level culture, while a lower rate of intergroup transmission (i.e. more isolated communities) will lead to higher heterogeneity among the assemblages.

Besides observing the resulting cultural patterns in these various scenarios using the simulations and mathematical models, Neiman has deduced the quantitative expectations of cultural diversity that can be expected under the neutral transmission model and explored the utility of two measures of cultural diversity (tE and tF). These theoretical insights have allowed him to make inferences about the cultural transmission parameters based on the empirical data from the archaeological record. In his case study, he explored different aspects of cultural transmission based on the spatial and temporal variability of Woodland period ceramics, more precisely a lip exterior ornamentation types. Neiman examined the diversity of 35 ceramic assemblages from five archaeological sites, divided into 7 temporal units, noting a temporal trend in cultural diversity – low in the early phase, increases in the middle phase, and then decreases in the latest Woodland phase. This was interpreted in terms of changes in the interconnectedness of Woodland communities – the rate of intergroup transmission rate is low during the early period, higher during the middle period when the interactions are more intensive, and reduces in the final period indicating more isolated communities in this phase. This conclusion was confirmed by measuring the regional cultural diversity using the squared Euclidean distance – cultural heterogeneity decreases during the middle period and increases in the final period.

Following Neiman's work, there has been an increasing interest in the applications of CT theory in archaeological research during the last two decades (Eerkens, Lipo 2007; Lycett 2015; O'Brien, Lyman 2000; Shennan 2002; 2009; 2011). The majority of researchers focused on developing methods for solving the "inverse problem" (Shennan 2011) – making inferences about different parameters of cultural transmission based on the empirical patterns in the archaeological record. Shennan and Wilkinson (2001) were among the first to follow Neiman's work, and approach the issue of inferring different transmission models based on the archaeological remains. They adopted two diversity measures that Neiman proposed (tE and tF) and suggested that the deviations of empirically observed diversity (tF) from the diversity that is theoretically expected in the case of neutral transmission (tE) can inform us what transmission models were responsible for producing cultural patterns in the archaeological record. If tF is lower than tE, i.e. the observed diversity is lower than diversity expected in the case of the neutral transmission, transmission models that maintain or increase homogeneity, such as conformist transmission, prestige bias, or specialization, are the likely scenarios. On the other hand, if tF is higher than tE, a social context where individuals tend to maintain diversity by adopting the novel or rare variants (anti-conformity or pro-novelty) is a probable explanation. The neutral transmission as a null hypothesis lies between these two extremes and represents the scenario where cultural elements are transmitted more or less randomly on the population level, which happens when there are no clear regularities in learning preferences, i.e. individuals copy traits due to many reasons. By applying such concepts to ornaments of the LBK pottery from assemblages in western Germany, Shennan and Wilkinson indicated that there was, along with drift or neutral transmission, a tendency of maintaining the diversity of pottery decoration, also called anti-conformist bias.

In many subsequent studies, the neutral model was used as a null hypothesis, where different statistical tools (see Kandler, Crema 2019 for an overview) were used to evaluate if certain empirical observations meet the expectations of the neutral model (e.g. Bentley et al. 2004), or there are deviations which indicate some sort of bias (e.g. Bentley, Shennan 2003; Kohler et al. 2004). Recently, approximate Bayesian computation (ABC) (Crema et al. 2014; 2016) has been proposed as an inferential framework that offers certain advantages over neutrality tests. The ABC allows researchers to simulate multiple historical scenarios and evaluate which of them best fit the data (and exclude the unlikely ones), as well as to incorporate many relevant parameters, such as use-life of tools, population size and dynamics, time-averaging (Madsen 2012; Porčić 2015; Premo 2014), etc. There is also a possibility to include both equilibrium and non-equilibrium models (e.g. Crema et al. 2014), and to evaluate the problem of equifinality (e.g. Crema et al. 2014; Kandler et al. 2017). Apart from modeling the cultural transmission of discrete cultural elements, the transmission of continuous traits was also examined using agent-based simulations, either for deriving theoretical expectations or explaining the empirically observed patterns (e.g. Eerkens, Lipo 2005; Premo 2021).

Although much research has been devoted to the "reverse problem" of assessing the parameters of cultural transmission from the archaeological record, the CT theory has been employed in various ways in studying cultural interactions in time and space (e.g. Bettinger, Eerkens 1999; Lipo et al. 1997; Prentiss 2019; Tostevin 2012), reconstructing cultural phylogenies using cladistics methods (e.g. Buchanan, Collard 2008; O'Brien et al. 2001; 2014; O'Brien, Lyman 2003), understanding social learning and the resulting variability in the controlled experiments (e.g. Mesoudi 2008; Mesoudi, O'Brien 2008), etc.

In various cultural transmission models, artifact types and their attributes are regarded as units of cultural transmission, i.e. manifestations of ideas that are transmitted between individuals. The need for defining the units of cultural transmission has initiated an important discussion about archaeological systematics (e.g. Lyman 2021; O'Brien, Lyman 2000; Riede et al. 2019). For example, O'Brien and Lyman (2000) suggest that artifact types, rather than being unchangeable categories (essentialism), continuously change in time and space (materialism). Dunnell's (1989: 38) statement for living beings is suitable for describing the materialistic nature of archaeological objects: "things above the scale of individual are transitory configurations of greater or lesser stability in continuously changing populations". Thus, no classification can appropriately describe the objects which are "… in constant state of becoming something else" (O'Brien, Lyman 2000: 28), so typologies should be only used as analytical units tailored according to our research questions. Similarly, phases, layers, archaeological cultures, and other archaeological units are our research constructs, and their utility for understanding the past should be critically evaluated.

4.3. Theoretical assumptions

In this research, inferences about social phenomena were made based on different theoretical assumptions that were developed within the CT theory, or were derived from its basic concepts. The first assumption is that the character of cultural change, which is reflected in the patterns of material culture variability, could indicate possible social changes within the community. Human culture is largely based on previously acquired cultural information, and it is hard to imagine that any single individual could independently invent even the simple forms of culture (Richerson, Boyd 2005: 50). Thus, cultural knowledge (for example about artifact production) is continuously transmitted through generations in the absence of important changes within the community, causing the culture of cultural descendants to be highly similar to that of their cultural parents. This implies that larger changes in the variability of material culture, such as synchronous changes in different classes of material culture, could indicate the changes in a social environment, which could be caused by either internal (social disintegration, demography) or external factors (e.g. environmental disasters, migrations). The cultural changes through generations are reflected in the change in distributions of certain cultural modalities (e.g. artifact type and attributes) through time, where the higher dissimilarity between temporal units could signify the larger changes within the studied community. In this research, the variability of knapped stone tools and anthropomorphic figurines will serve for examining the character of temporal cultural dynamics.

The second assumption is that the material culture of a certain population will change in different ways depending on the nature of the interaction between individuals, i.e. how culture is transmitted and modified by the actions of individuals. This assumption is supported by various simulations of social dynamics (e.g. Axelrood 1997; Boyd, Richerson 1985), as well as by empirical research (e.g. Hewlett, Cavalli-Sforza 1986). Depending on the mutual effect of different models of social learning, innovation, and other factors, the population-level culture will change in different ways. Some of the basic models of cultural transmission are neutral, conformist, and anti-conformist models, while the predominance of one of these is conditioned by various social aspects, such as the social organization or the role of a particular cultural element within the community. As mentioned, the neutral model indicates a social context where there is no clear preference for particular cultural variants within the population, while the other two models indicate the situation where there is a preference for common (conformist bias) or rare variants (anti-conformist bias). Although the social reality is generally far more complex than these simple theoretical models, the goal is to determine which of the transmission model(s) could have predominated within a population and which can be rejected as unlikely, narrowing down the spectrum of historical scenarios that could have created the empirical patterns that we observe in the archaeological record.

The final assumption concerns the relationship between the demography (population size and dynamics) and material culture diversity and complexity. In archaeology, Neiman (1995) was the first to formally explore the relationship between population size and cultural diversity for the neutral model of transmission. By adapting the mathematical models and simulations from population genetics to the study of culture, Neiman has shown that there is a positive correlation between population size and cultural diversity in the case of the neutral model – it is expected that a larger population will have a higher diversity of cultural variants, while in the case of smaller populations there is a higher probability of losing cultural variants due to death of an individual that carries it, imperfect copying, or other factors (e.g. Shennan 2000).

5. Materials

The materials that will be analyzed in this research come from the site of Vinča-Belo brdo, while the temporal scope of the research covers the entire Late Neolithic of the Central Balkans, i.e. the period between ~5300 and ~4500 cal BC (Borić, 2009, 2015; Tasić et al., 2015a, 2015b, 2016; Whittle et al., 2016). In this chapter, the general information about the site of Vinča-Belo brdo and the analyzed sample of lithics and anthropomorphic figurines will be presented.

5.1. Vinča-Belo brdo

The site is located on the right bank of the Danube river, approximately 14 km to the east of Belgrade and the confluence of the Danube and Sava rivers (**Figure 5.1**). The first excavations of Belo brdo started in 1908, under the supervision of Miloje Vasić, and continued with interruptions over the next two and a half decades (1908; 1911-1913; 1924; 1929-1934) (Васић 1932; 1936a; 1936b; 1936c). After a long break, the excavations continued in 1978 in the organization of the Serbian Academy of Sciences and Arts and lasted until 1986. The most recent excavations started in 1998 and are still ongoing, directed by N.N. Tasić and characterized by multidisciplinary approaches (Tasić 2005; 2011b). The rich stratigraphy of the site contains archaeological remains from the Neolithic to Medieval period, but the majority of deposits are from the Late Neolithic, and they had a huge impact on studying this period on both local and regional scale. The site was continuously inhabited during the whole Late Neolithic of the Central Balkans, for around 800 years (~5300~4500 BC) (Tasić et al. 2015a; 2015b; 2016).

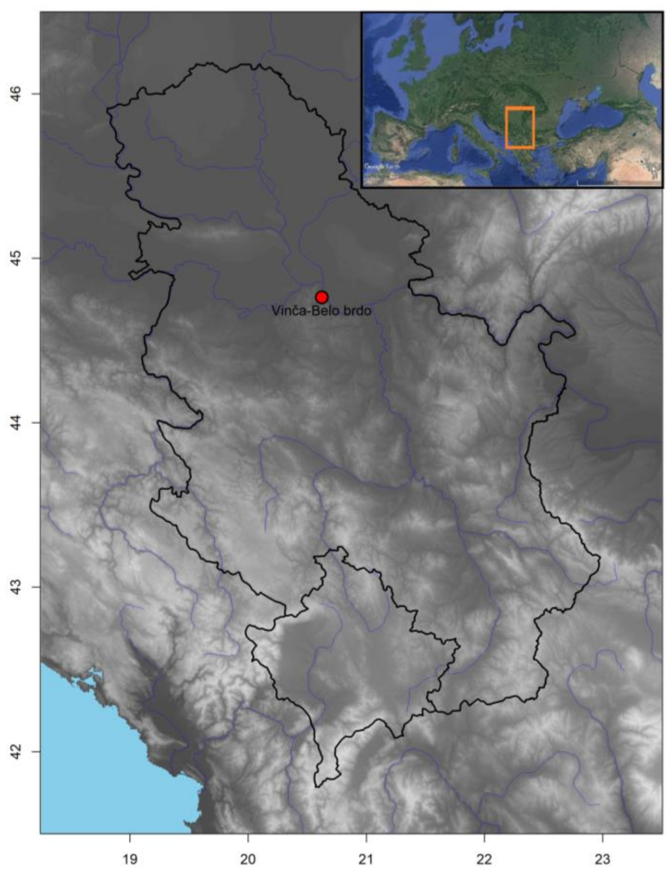


Figure 5.1. The location of Vinča-Belo brdo.

The site of Vinča-Belo brdo was probably among the largest settlements of the so-called Vinča cultural group (estimated to be around 10 ha, Tasić et al. 2015b), possibly having over 1000 inhabitants (Porčić 2019a). Characteristic above-ground houses of rectangular shape, built using the wattle-and-daub technique, were discovered in all Late Neolithic phases. Densely packed houses were arranged in rows with similar orientations (mostly SE-NW) (e.g. Тасић 2008). The interiors of the houses were divided into a differing number of rooms, while their inventory consisted of ovens, storage spaces, and various artifacts that indicated certain household activities (e.g. Трипковић 2013). Many activities were also performed outside the houses (Тасић 2008). The settlement was possibly surrounded by a ditch in different periods (e.g. Garašanin 1979: 154-155), probably built for defensive purposes or for restricting the movement of domestic animals. This indicates the existence of some communal undertakings (Трипковић 2013), while another example of some joint activities might have been the acquisition of clay from the surrounding area (Matsunaga 2009, cited in Tasić 2011b) – the clay that was used for the production of various objects (vessels, figurines, altars, etc.) shows a high uniformity indicative of a common origin.

The geochemical analyses have indicated favorable conditions in terms of temperature and precipitation from the initial settling of this location (Veselinović et al. 2021), with abundant natural resources in the surrounding area (Filipović et al. 2019). Remains of both domesticated and wild plants and animals revealed the dietary habits of the inhabitants (e.g. Dimitrijević 2006; Dimitrijević, Mitrović 2006; Filipović, Tasić 2012; Filipović et al. 2019). The economy was mainly based on domesticates – herding cattle, caprines, pigs, and cultivation of different crops (e.g. wheat, barley, peas, lentils) – but also on hunting wild mammals (e.g. red deer, roe deer, wild boar, hare), fishing, collecting mollusks, etc. The remains of wild species are typical for both dense and open forests, grasslands, and wetlands (Filipović et al. 2019). Different craft activities were practiced on the site – production of clay objects (vessels, figurines, altars, lids) (e.g. Schier 1996; 2000; Spataro 2018; Tasić 2011a; Vuković 2011; 2013), bone (e.g. Cristiani et al. 2016) and stone tools (e.g. Antonović 1992, cited in Filipović et al. 2019; Bogosavljević Petrović 2018; Богосављевић Петровић 2021; Radovanović et al. 1984), and other objects. Large quantities of obsidian and other trade goods (e.g. bracelets from Spondylus and Glycymeris shells) (Dimitrijević, Tripković 2002; Tripković 2006) on Belo brdo have instigated conclusions about cultural connections with other regions, and for claiming that Belo brdo was a trading or redistribution center (e.g. Bogosavljević Petrović 2015; Milić 2021).

The temporal sequence of the site was divided into different temporal units (phases) that often served as a yardstick for establishing regional chronologies (see Whittle et al. 2016 for an overview). The majority of researchers relied on material from Vasić's excavations of Belo brdo for creating these periodizations, using his relative depths as chronological markers for the site and its wider surrounding. Among many periodizations, the most commonly used ones are those proposed by M. Garašanin (1979) and V. Milojčić (1949). As mentioned, Garašanin divided the chronology of the Vinča culture into five main phases (and certain subphases, in brackets): Vinča Tordoš I (a, b), Vinča Tordoš II (a, b1, b2, b3), Gradac phase, Vinča Pločnik I, Vinča Pločnik II (a, b). According to this periodization, the beginning of Vinča Tordoš I starts at 9.1 m of Belo brdo stratigraphy, while the subsequent phases start at 8.5 m (Vinča Tordoš II), 6.55 m (Vinča Gradac), 6.0 m (Vinča Pločnik I), and the final Vinča pločnik II phase at 4.0 m and finishes at 1.3 m. Although usually regarded as similar, Milojčić's periodization consists of four phases: Vinča A, Vinča B (B1, B2), Vinča C (and transitional C-D subphase), and Vinča D. The boundaries of these phases are somewhat different – Vinča A starts at 9.3 m, B at 8.0 m, C at 6.0 m, and the final Vinča D phase starts at 4.0 m and ends at 2.5 m of relative depth.

5.2. Samples

The material that was analyzed in this research comes from two excavations campaigns: 1) lithics and anthropomorphic figurines collected during Vasić's 1929-1934 excavations, curated in the Archaeological Collection of the University of Belgrade; 2) lithics recovered during the rescue excavations of the site in 2004-2005 and between 2012 and 2014. While the Vasić's collection covers the entire temporal sequence of the site and allows the study of temporal trends of cultural dynamics, the lithic finds from the new excavations mainly come from the later phases of the site, so they will be used only for assessing the quality of Vasić's evidence. In the following text, a brief overview of these two excavation campaigns will be presented, as well as the main characteristics of the studied samples.

5.2.1. 1929-1934 excavations (M. Vasić)

Between 1929 and 1934 Vasić excavated new trenches P (on the property of Petar Simonović) and G (after the former property of Gospava Jovanović) (Palavestra 2020). The trench G probably covered an area of around 215 m^2, as it was 43 m long and 5 m wide (Žurnal[4] 9. 8. 1933, 3; cited in Palavestra 2020: 151). The area of trench P was possibly ca. 185 m^2, as I calculated from the excavation plan from the Archaeological Collection of the University of Belgrade, published as illustration 69 in Palavestra (2020: 164), although Jovanović (Јовановић 1960: 10) indicates that the dimensions of the trench are 24.4 x 6.2 m (~151.3 m^2). Despite the existence of the "main axis" during the 1929-1934 excavations, i.e. a linear reference point in relation to which Vasić (occasionally) positioned the excavated material, he did not take many notes about the spatial (horizontal) distribution of objects and finds (Palavestra 2020). This axis was laid out in approximately SE-NW direction and around 90 m long (Palavestra 2020: 151), i.e. roughly parallel to the longer sides of trenches P and G. Some very general and selective information can be drawn from his journals, publications, and excavation plans (see Palavestra 2020 for an overview) – such as the position of certain houses, ovens, pits, and finds (e.g. skull, Hyde vase, Myres pithos, etc.). Thus, the context of finds is largely missing for the collections of lithics and anthropomorphic figurines from these excavations.

The vertical disposition of finds was much more meticulously recorded by Vasić. The site was excavated in 10 cm spits/mechanical levels (the so-called *strip digging*, Palavestra 2020: 98), and a relative depth of objects and features was noted in journals, excavation plans, and on the artifacts themselves (see Palavestra 2020). A relative depth was measured as a vertical distance from the "zero", "an absolute reference point" (an elm on the top of the hill, Palavestra 2020) that he established in 1910 (Marić 2011: 274-275). This arbitrary reference point was a basis for all subsequent measurements of relative depth, although the area of Vasić's "zero" was possibly excavated and removed in later campaigns (Marić 2011). Another issue is that Vasić's "10 cm" mechanical levels were sometimes larger than this value, reaching up to 30 cm (Palavestra 2020), as evident from the excavation diaries. Finally, Vasić was trying to relate the relative depths of 1929-1934 material with those from previous campaigns, so he was adding certain values to the relative depths of the finds excavated from P and G trenches (0.5 m, 1.8 m).

Based on the evidence provided by Palavestra (2020), the validity of Vasić's relative depths seems questionable and his system of measuring vertical disposition is certainly confusing. However, there are two strands of evidence that indicate that the relative depths of Vasić are fairly robust and give a valid sequence of relative chronology:

[4] Excavation journal of M. Vasić.

1) As already mentioned in the introduction of this thesis (Section 1. Introducton), W. Schier (1996; 2020) conducted a detailed analysis of the variability of ceramic finds recovered between 1929 and 1934. By conducting a frequency seriation (a method of relative dating) based on the frequency of ceramic types in different levels of the site, Schier was able to reconstruct the correct chronological ordering of Vasić's 10 cm units (levels). The correct chronological ordering is expected if the layers are not mixed, disturbed, or inappropriately excavated, thus supporting the reasonable reliability of Vasić's evidence in the case of ceramics. As Schier (1996: 144) concluded: "chronological resolution of Vasić's 10 cm levels is far better than generally assumed".
2) In 2015, Tasić and colleagues published the results of a comprehensive analysis of the absolute chronology of Vinča-Belo brdo, based on the radiocarbon dating of samples from Vasić's excavations (Tasić et al. 2015b). In total, 85 radiocarbon determinations were made on 82 samples (some samples were dated multiple times), mainly bone and antler finds from various relative depths, but also 6 charcoal pieces, and 9 human remains (from Starčevo pits). A Bayesian framework was applied to establish a formal chronological model of the site, where prior knowledge about the stratigraphic position of samples (age-depth model) and possible reservoir effect were incorporated. Despite noting the presence of a certain number of outliers, Tasić et al. (2015b: 38) concluded that the "chronological resolution of Vasic's 10-cm spits is far clearer than previously thought, and that the contamination effects caused by unrecognised pits and reworked material are not serious enough to discredit the entire stratigraphic sequence and the analysis of cultural finds based upon it.".

These two examples do not indicate that the material from all of Vasić's excavation campaigns is comparable and reliable, but in the case of certain materials (pottery; bone and antler finds) stored in the Archeological Collection of the University of Belgrade, the relative depths are fairly reliable. Another confirmation of the validity of relative depths is given by the fact that the described cultural trajectories for pottery and figurines, i.e. temporal changes in these artifact classes, are paralleled on other sites (e.g. Garašanin 1979; Whittle et al. 2016). There are other studies that evaluate certain aspects of Vasić's system of relative depths (e.g. Јовановић 1960, Marić 2011), but this goes outside the scope of this study. It can be concluded that while the Vasić's evidence should be critically re-evaluated when possible (see below), the relative depths of the material from the Archaeological Collection are robust indicators of the chronological ordering of artifacts, but "it should be pointed out that the mentioned demarcations by meters must not be taken too sharply" (Garašanin 1979: 152).

Lithic sample (Vasić 1929-1934)

A total of 6279[5] knapped stone artifacts from 1929-1934 excavations (from the archaeological collection of the University of Belgrade) were analyzed, but that number was reduced to 5552 after excluding all artifacts without a relative depth. When nodules (n = 15) and tried nodules (n = 6) are excluded, this number falls to 5531[6]. It should be noted that this number includes some knapped pieces (primarily flakes) that were possibly part of the polished stone tool technology, but there are difficulties in distinguishing between the two industries on this level of analysis, as some raw materials are suitable both for knapped and polished stone tool production. However, for this sample, this issue mainly

[5] The total number of finds in this collection is 6430, as it also includes a certain number of polished stone tool production (e.g. rejuvenation flakes), as well as 50 pebbles/cobbles that might have been used as percussors (some of them have traces from percussive activities). However, these finds will not be discussed further.
[6] This number is much higher than the number reported by Radovanović et al. (1984) – a total of 3233 finds (1488 obsidian and 1745 chert finds). I guess that a part of the chert collection was not available to the authors at the time.

concerns 36 finds from the raw materials that I classified as miscellaneous sedimentary rocks (such as limestones), so their presence/absence should no systematically bias the results. The distribution of analyzed finds according to relative depths and Milojčić's phases is shown in **Figure 5.2,** showing no hiatus between 5.7 and 5.2 m, as previously observed (Radovanović et al. 1984). The number of lithic finds gradually increases from Vinča A to Vinča C, and then sharply decreases at around 4.0 m of relative depth (start of Vinča D).

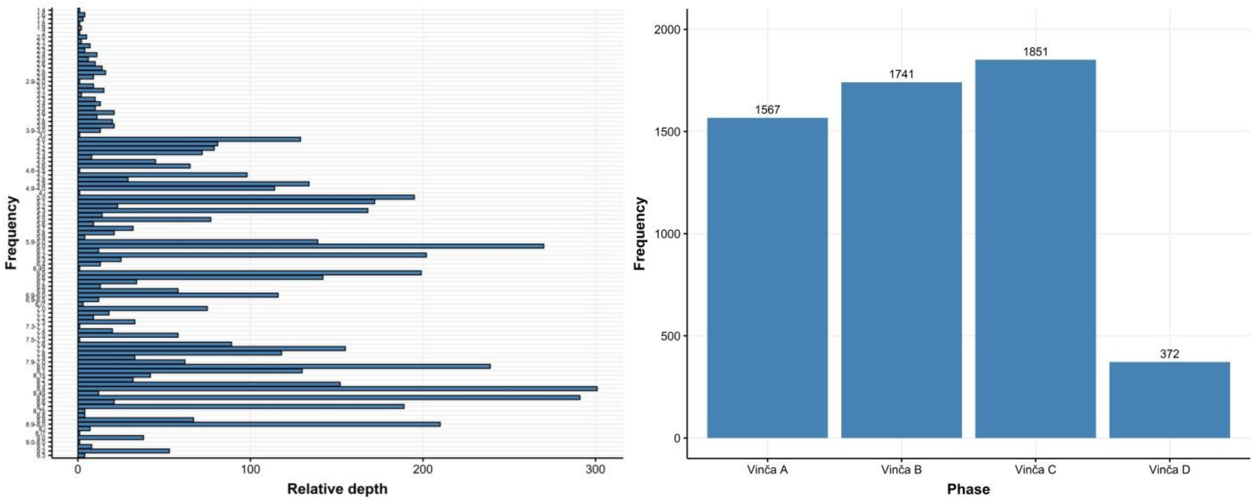


Figure 5.2. Distribution of lithic finds according to relative depths and Milojčić's phases (1929-1934 collection).

The macroscopic determination of lithic raw materials has shown that the most common raw material types are chert (4269) and obsidian (1213), with a much smaller number of finds classified into other groups of raw materials – miscellaneous sedimentary (36), quartz (7), or undeterminable (6) (**Figure 5.3**). Although a formal analysis should be undertaken by petrologists as archaeologists can make erroneous identifications of raw materials (Bogosavljević Petrović 2015), the macroscopic determination is suitable for a rough classification, especially for larger sample sizes and the study of lithic technology (Bustillo et al. 2009).

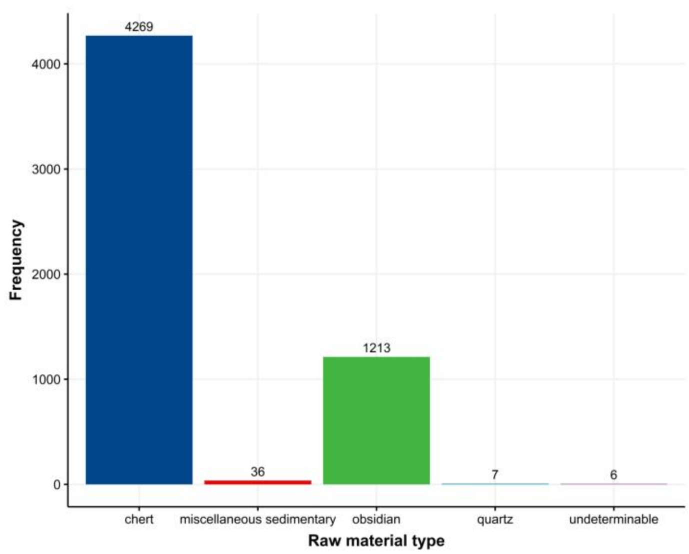


Figure 5.3. The frequency of different raw material types on Belo brdo (1929-1934 collection).

As raw material properties (e.g. rock type, quality) and abundance can affect the organization of technology (e.g. Andrefsky 1994; Brantingham et al. 2000; but see also Eren et al. 2014), the technological organization was analyzed and discussed separately for different raw material types. Since only the chert and obsidian collection yielded sufficient samples for tracking the temporal cultural changes, other raw material types were excluded from further analysis. The percentages of chert and obsidian in each of Milojčić's phases are shown in **Figure 5.4.** The proportion of obsidian decreases with time, as suggested by previous researchers (Srejović, Jovanović 1957; Radovanović et al. 1984). However, the percentage of obsidian by phases reported here is lower than indicated by Radovanović et al. (1984, up to 70%), probably as a more complete collection with a higher number of chert finds was analyzed in this study. However, even these lower percentages of obsidian are probably not realistic in the light of evidence from new excavations (see below).

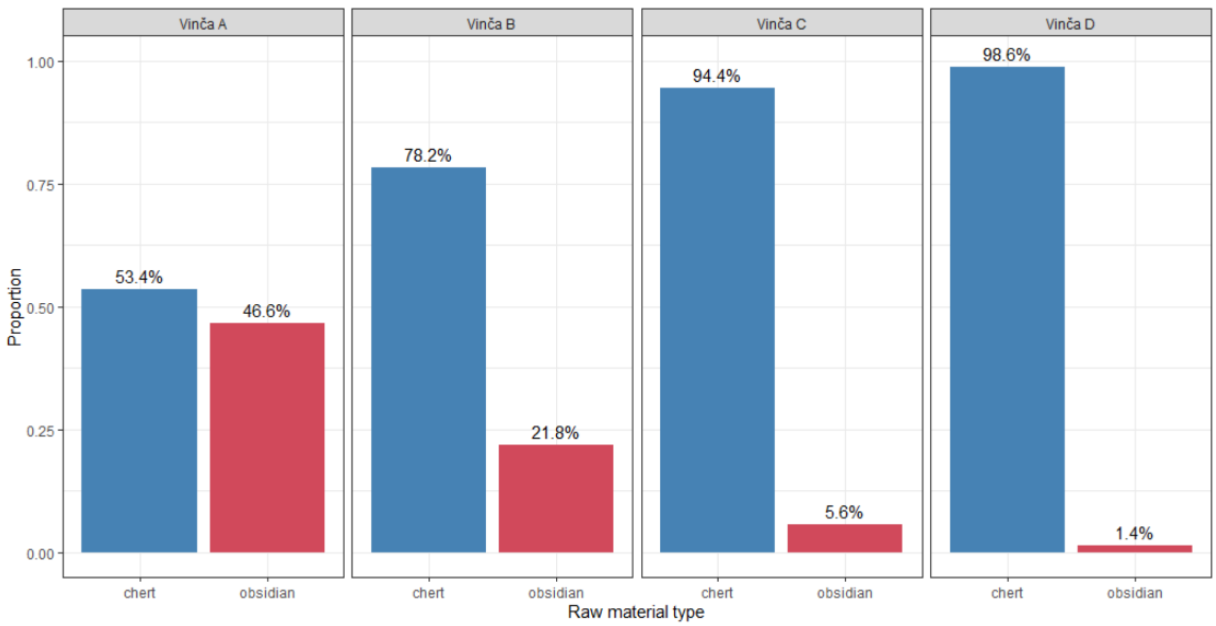


Figure 5.4. The percentages of flint and obsidian by Milojčić's phases.

Chert finds (Vasić 1929-1934)

Cherts from Belo brdo come in different varieties that were macroscopically classified as chert (low translucency and gloss), flint, jasper, chalcedony, and opal. These varieties differ in texture (from coarse to fine-grained), here used as a proxy for the quality of raw materials. While chert is usually either medium- or fine-grained (rarely coarse-grained), other varieties are most often fine-grained. Generally, good quality raw materials were used for lithic production on Belo brdo (coarse-grained – 0.2%; medium-grained – 9.4%; fine-grained 90.3%). Cherts are present in many different colors (e.g. white, beige, dark red), but most commonly in different shades of grey and brown. The frequency of chert finds gradually increases from Vinča A to Vinča C phases, and then sharply decreases in Vinča D (**Figure 5.5**).

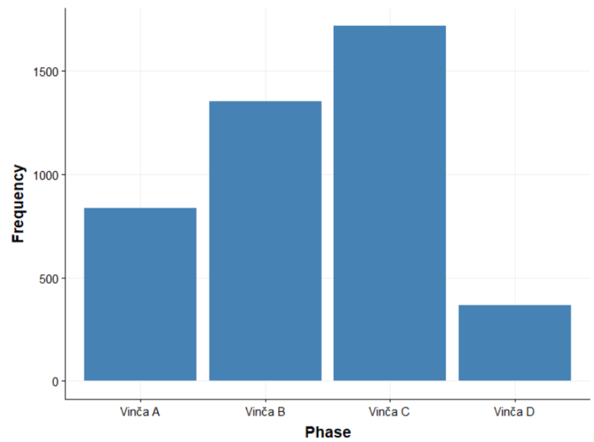


Figure 5.5. Frequencies of chert finds in Milojčić's phases.

The chert collection consists of 258 cores (6.0%), 3724 flakes (87.2%), and 287 pieces (6.7%) that were classified as waste or undeterminable. It was argued that the low percentage of cores indicates that some blades were brought from outside workshops or acquired by exchange (e.g. (Bogosavljević Petrović 2015: 319-320; Radovanović et al. 1984), but it may just point to a high degree of core exploitation (Sullivan, Rozen 1985) or bringing prepared cores to the settlement. Cores were shaped either from pebbles/cobbles or other types nodules (n = 31; 12.0%), or were made on flakes (n = 26; 10.0%), but for the majority of cores the initial properties were undeterminable (n = 201; 77.9%). The blade cores are predominant (n = 156; 60.2%), followed by flake cores (n = 99; 38.2%), while 4 cores might have been reduced by bipolar knapping on an anvil technique (1.5%). The majority of blade cores are unidirectional (**Figure 5.6**) with conical/pyramidal or tabular shape, so their debitage surface is typically either triangular/semi-oval or rectangular. The blade negatives on these cores are usually moderately regular (n = 145; 93%) and rarely irregular (n = 11; 7%). The mass of blade cores ranges from 2.2 to 118 g, with a mean of 24.4 g. The flake cores are most often multidirectional (**Figure 5.6**), while the most common shapes are irregular, polyhedral, and tabular. Their mass ranges between 4.4 and 145.2 g, with a mean of 38.9 g.

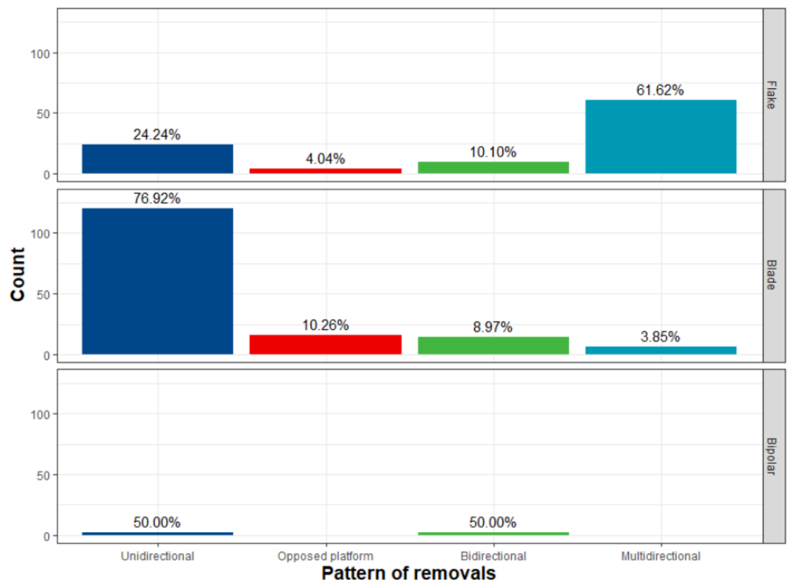


Figure 5.6. Frequencies and percentages of different patterns of removals for different core types (flake, blade, and bipolar cores).

The predominance of laminar technology is also indicated by a higher number of blades (n = 1998; 53.6%[7]) in relation to flakes (n = 1726; 46.3%). Moreover, the category of flakes includes 56 blade core rejuvenation flakes, removed to renew the striking or debitage surface of the blade cores, and probably other pieces that were part of the laminar technology (e.g. initial core preparation flakes. The material is highly fragmented, as 2126 out of 3724 (57.1%) of flakes and blades are intentionally or unintentionally fragmented.

From a total of 3724 complete and fragmented flakes and blades, 917 of them (24.6%) are retouched. Whole and fragmented flakes have a retouch on lateral sides (sidescrapers, double scrapers), a distal end (endscrapers), or on an undeterminable part in the case of fragmented flakes (scrapers). Out of 1998 blades, there are 37 crested blades that originate from the core preparation phase. The cortex, which usually covers a small part of the dorsal surface, is present on 13.8% of blades, indicating that there are blades from the initial stages of the reduction process, further supporting the local production of blades. The size of whole or almost whole (slightly damaged) unretouched blades ranges from 2.2 to 8.6 cm, with a mean of 4.3 cm (**Figure 5.7**), and a similar conclusion can be made by observing debitage surfaces of the cores (none is longer than 8.5 cm). As there is a continuous and unimodal distribution of values of maximal length, no distinction was made between blades, bladelets, and micro-blades[8]. A very high number of fragmented blades (1697 out of 1998; 85.0%) suggests that they were frequently intentionally broken (Radovanović et al. 1984: 28; see also Anderson-Whymark 2015; Slavinsky et al. 2019), primarily for producing sickles, as they frequently exhibit macroscopically visible sickle polish (22.9%[9]) and possible hafting residues. The pseudo-retouch, originating from use, post-depositional processes, or storage conditions, is common on blades (42%). Around a quarter of blades (n = 464; 23.2%) of blades is retouched, most of them non-invasively on lateral sides or the distal part (mean Clarkson's index of invasiveness is 0.1). Less frequently, blades were shaped into other types (e.g. borers, burins). The majority of blades are moderately regular (96.2%), or more rarely irregular (2.7%) or very regular (1.1%).

As mentioned, there is no contextual information for the material from Vasić's excavations. However, the evidence from the new excavations (1998-2007, Bogosavljević Petrović 2015; deep sounding 2005-2012, Tasić et al. 2016) revealed that chert finds were recovered from various contexts – houses, cultural layers, pits, fillings, etc. Thus, it might be argued that the knapping activities were practiced in different areas of the settlement, while the waste was occasionally cleared away into pits and other refusal areas. Bogosavljević Petrović (2015: 363-380) has shown that there are some zones of knapping activities (e.g. concentration of 143 finds) on the site, but there are no indices of specialized workshops (cf. Healan et al. 1983).

[7] The frequency (and percentage) of blades is probably higher than this number, as very small blade-like pieces that cannot be reliably attributed to blades were classified as flakes.

[8] The distinction between these three categories was made by J. Tixier when analyzing lithic finds from the Epipalaeolithic of the Maghreb region (Tixier 1963, cited in Inizian et al. 1999, 73). Despite the suggestion that such distinctions should be made on a case-by-case basis and only after statistical analyzes of the blade lengths, these categories are often uncritically applied to other contexts (Inizian et al. 1999, 73). Based on **Figure 5.7**, it seems that there is a single line of production of blades of similar sizes, so there is no reason to make arbitrary division(s) according to blade length.

[9] The presence of the sickle gloss was not observed from the beginning of the study, so it was not done on the entire sample of blades, but a large sample of 1793 blades.

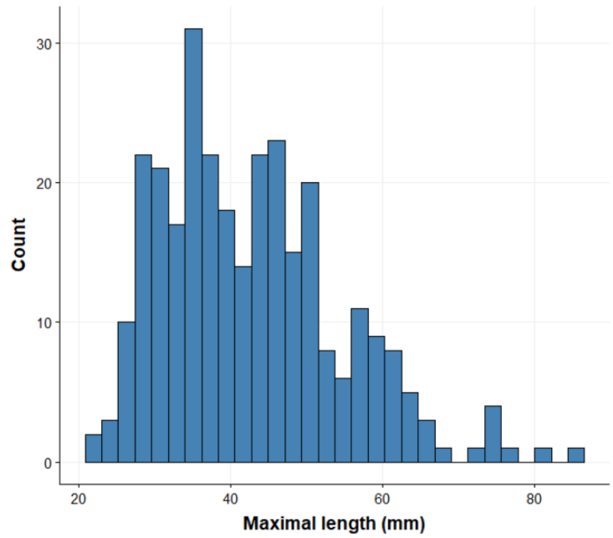


Figure 5.7. Distribution of maximal length of whole chert blades.

Obsidian finds (Vasić 1929-1934)

From a total of 1465 obsidian finds, 1213 of them have a relative depth. Obsidian finds are most frequent between 9.0 and 7.7 m, their number reduces after this depth, before disappearing at 3.8 m (**Figure 5.8**). As mentioned, archaeometric analyzes by Tripković and Milić (2008) have indicated that obsidian from Vinča-Belo brdo originates from Slovakia (the so-called Carpathian 1 source). The obsidian on Belo brdo is of either black or grey color (see Tripković, Milić 2008 for more detailed visual characterization of obsidian), mainly depending on the thickness of individual pieces of obsidian – thinner pieces tend to be grey, thicker are more frequently black, although there are some exceptions (**Figure 5.9**). All obsidian finds are fine-grained, as expected.

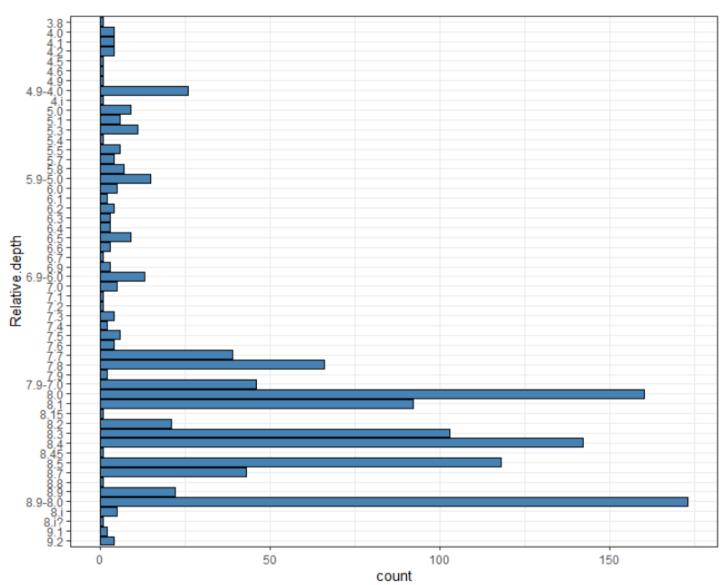


Figure 5.8. Distribution of obsidian finds from Vasić's 1929-1934 excavations according to relative depths.

Figure 5.9. Two obsidian finds with similar thickness, but different colors.

The obsidian collection consists of 13 cores (1.1%), 1183 flakes sensu lato (flakes and blades) (97.5%), and 17 finds classified as waste/undeterminable (1.4%). There are 10 blade cores (3 of them are on flakes) and 3 flake cores. Two of these flake cores have blade-like negatives with parallel lateral egdes, but these negatives do not satisfy the definition of blades to be at least two times long as they are wide, so these cores might represent blade cores in the final stage of exploitation – their largest dimensions are around 10 mm and they are very light (**Figure 5.10**). Three flake cores all have a different pattern of removals – unidirectional, bidirectional, and multidirectional –, while their shape is conical/pyramidal in two cases, and irregular in one case. Out of 9 blades cores (one core is fragmented), 7 cores have a unidirectional pattern of removals, while there are single occurrences of both opposed platform and multidirectional cores. The majority of blade cores are conical/pyramidal (n = 4), but they also have other shapes (tabular, bullet-shaped, plano-convex, polyhedral, irregular). Their debitage surface is either triangular (n = 3), rectangular (n = 4), semi-oval (n = 1), or irregular (n = 1). Blade cores are generally heavier than flake cores (**Figure 5.10**), but no test was done to evaluate if these differences are statistically significant due to the small sample size.

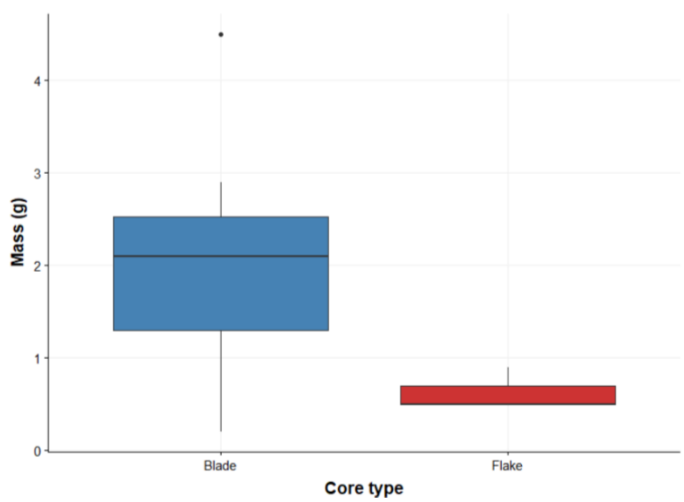


Figure 5.10. Box-plot diagram comparing the mass of flake and blade obsidian cores.

It has been suggested that obsidian blades were not knapped locally as there is a low percentage of obsidian cores (Radovanović et al. 1984). However, a high degree of exploitation of obsidian cores can explain this pattern[10] (Sullivan, Rozen 1985) – the mass of these cores ranges between 0.2 and 4.5 g,

[10] For example, Sheets and Muto (1972) have produced 83 blades from a single obsidian core.

while the mean mass is 1.7 g. They are significantly lighter than chert cores ($n = 272$, $W = 5$, $p < 0.01$) (**Figure 5.11**). A very low mass of obsidian cores indicates that this raw material was usually fully exploited, as expected for a material that might have had some special significance for Neolithic communities in the area (Трипковић 2001).

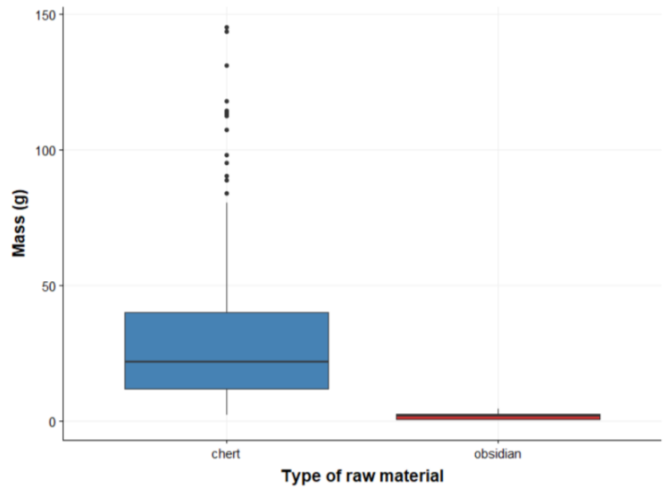


Figure 5.11. Box-plot diagram comparing the mass of chert and obsidian cores.

From the total of 1183 flakes, 264 (22.3%) are classified as flakes and 919 (77.6%) as blades[11]. A high percentage of flakes are fragmented (1039 out of 1183; 87.8%), which is understandable given the fact that obsidian is a highly brittle material and that the obsidian pieces (particularly blades) are very thin, as well as the fact that they were possibly intentionally fragmented by prehistoric knappers[12]. As in the case of chert finds, the pseudo-retouch is common on obsidian blades. There are almost no cortical pieces in the analyzed material, besides one blade with cortex, but there are two crested blades and 11 core rejuvenation flakes (striking surface and debitage surface rejuvenation), suggesting that prepared cores might have been imported to the site and knapped by Belo brdo inhabitants. The maximal length of whole obsidian blades is from 1.2 to 6.1 cm, with a mean of 2.6 cm (**Figure 5.12**), while the maximal dimensions of blade negatives are shorter (generally around 1 cm), indicating that the cores are from the latest stages of production. In comparison to chert blades, obsidian blades are generally shorter, narrower, and especially thinner (**Figure 5.13**).

[11] Again, this number of blades is conservative and probably higher, as small blade-like pieces without sufficient blade stigmata were categorized as flakes.

[12] Another factor that should be taken into account concerning the fragmentation is that Vasić was rewarding laborers that found obsidian during excavations, so they were intentionally fragmenting obsidian pieces to get higher wages (Garašanin, Garašanin 1953, 26, cited in Palavestra 2020: 79, footnote 70).

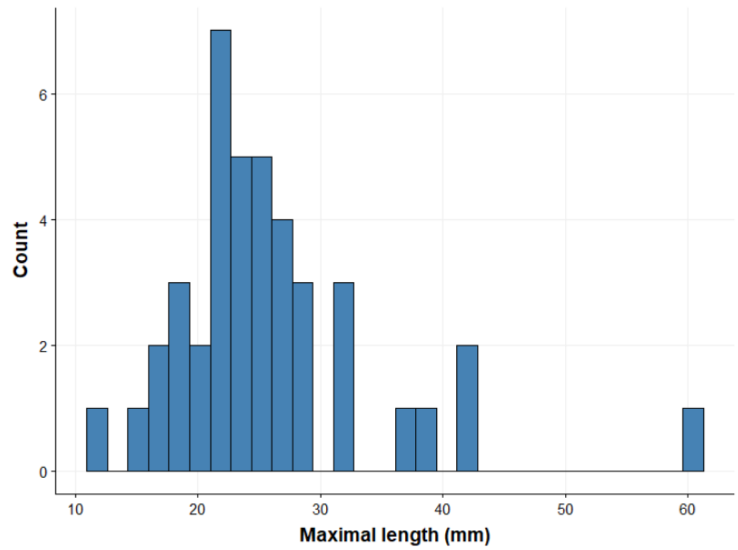


Figure 5.12. Histogram showing the distribution of maximal lengths of obsidian blades (n = 41).

From a total number of 1183 flakes and blades, 76 (6.4%) are retouched. Concerning the blades, 68 out of 922 are retouched (7.4%), with a mean of Clarkson's index of invasiveness of 0.09. Both whole and fragmented blades are retouched on either lateral sides or on proximal/distal surface (for medial parts this cannot be distinguished). Eight obsidian flakes are retouched into sidescrapers and endscrapers.

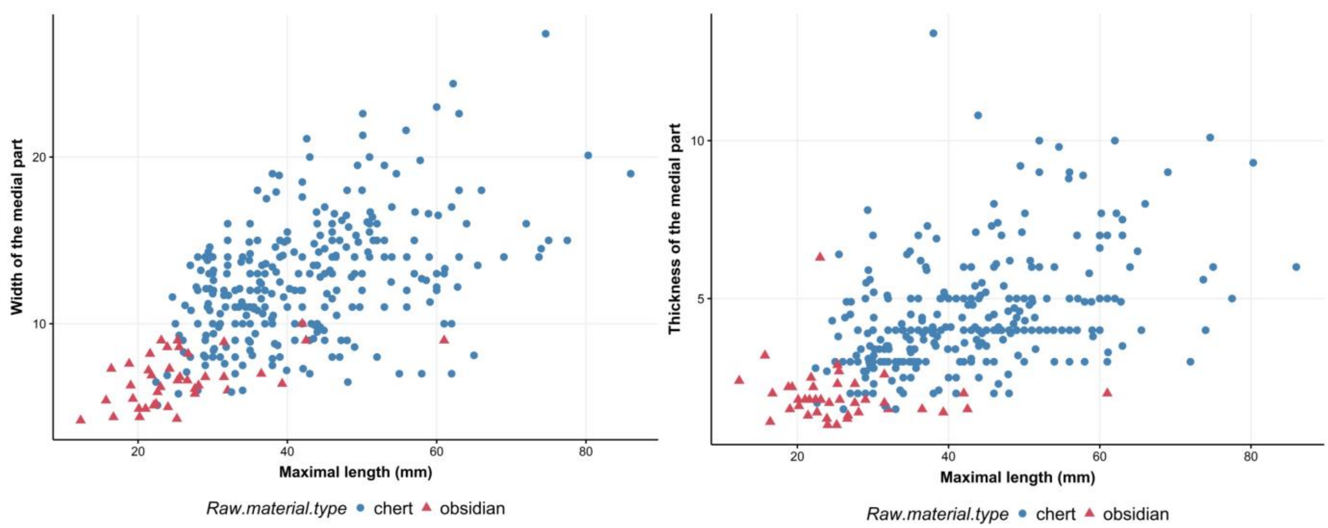


Figure 5.13. The scatter diagrams comparing dimensions (length, width, thickness) between whole chert and obsidian blades.

There is almost no contextual information for the obsidian finds from Belo brdo, except for 14 pieces from the new excavations that were all found in the cultural layer. The obsidian collection was only partly discussed in the context of the character of cultural changes on Belo brdo for several reasons. It does not cover the whole temporal sequence of Belo brdo, and the low frequency of finds in later phases is not sufficient for some statistical analyzes. Moreover, the disappearance of obsidian in the latest Late Neolithic levels is not supported by the new excavations (see below), indicating a possible collection, preservation, or storage bias for the obsidian collection.

Figurine sample (Vasić 1929-1934)

In this research, a total of 1000 figurines from the Archeological Collection (University of Belgrade) were analyzed from photographs, many of which were published in the Vasić's four-volume monograph (Васић 1932; 1936a; 1936b; 1936c). However, this number was reduced to 837 after excluding undeterminable parts and figurines from the preceding Starčevo period. Their frequency is low in the earliest levels, rises notably around 7.0 m of relative depth, and sharply decreases at ~3.8 m (**Figure 5.14**). There are 91 whole or almost whole (missing one arm) figurines, while the remaining 737 are fragmented in various ways (**Table 5.1**), although for 19 of them it was not possible to determine if they are fragmented or their lower part is intentionally missing (as they were analyzed from photographs).

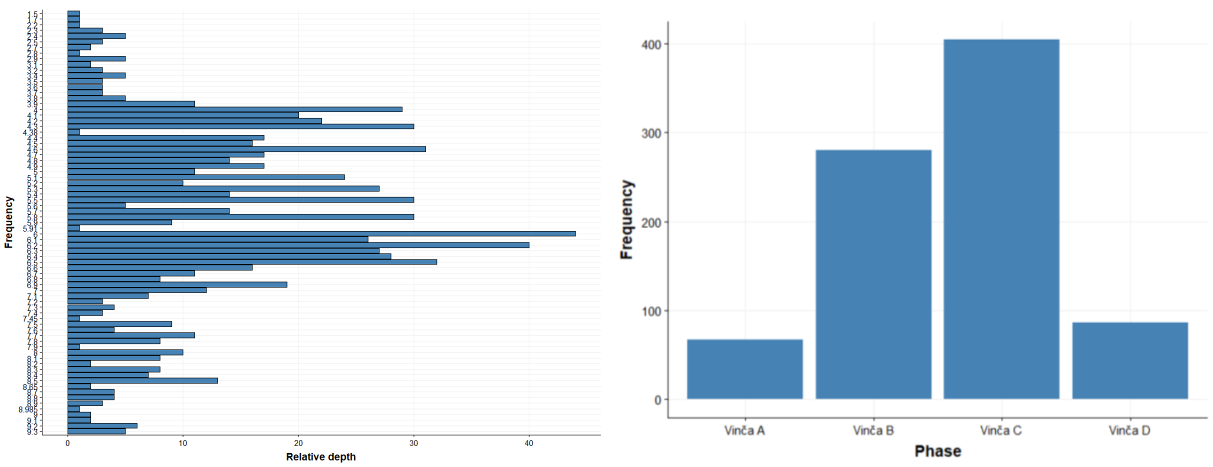


Figure 5.14. Distribution of figurines according to relative depths and Milojčić's phases.

The subjective assessment of skill level needed for their production, based on the level of elaboration of modeling of their surface and details, has shown that 144 required low skill level, 625 moderate, and the remaining 68 figurines required a high level of skill to be produced. A smooth surface, at least from what can be seen in photographs, is visible on 236 out of 837 figurines. The predominant body position of figurines is standing (n = 248), with a much smaller number of sitting and kneeling figurines (n = 29). The arms are usually spread towards the sides (n = 411), much less frequently placed on the belly or chests (n = 10), and very rarely have other positions (e.g. facing upwards, or placed on a face). The lower body is either cylindrical (n = 84) with no clear separation of the lower body, or there is a distinct lower body with (n = 45) or without (n = 75) modeled legs. The height of figurines that are preserved from top to bottom (they can lack arms) ranges between 2.8 and 16.6 cm, and the mean is 6.3 cm (**Figure 5.15**).

Table 5.1. Combinations of preserved body parts on anthropomorphic figurines from Belo brdo.

Body parts	Frequency
Head, chest, arm(s), abdomen, lower body (whole or almost whole figurines)	75
Head, chest, arm(s), abdomen (no lower body, intentionally)	16
Head, chest, arm(s), abdomen (fragmented)	69
Head	178
Head, chest	23
Head, chest, abdomen	8
Head, chest, abdomen, lower body	12
Head, chest, arm(s)	73
Chest	2
Chest, abdomen	22
Chest, abdomen, lower body	35
Chest, arm(s)	42
Chest, arm(s), abdomen	85
Chest, arm(s), abdomen, lower body	72
Abdomen, lower body	42
Abdomen	4
Lower body	69
Undeterminable arm	9
Undeterminable leg	1
Total	**837**

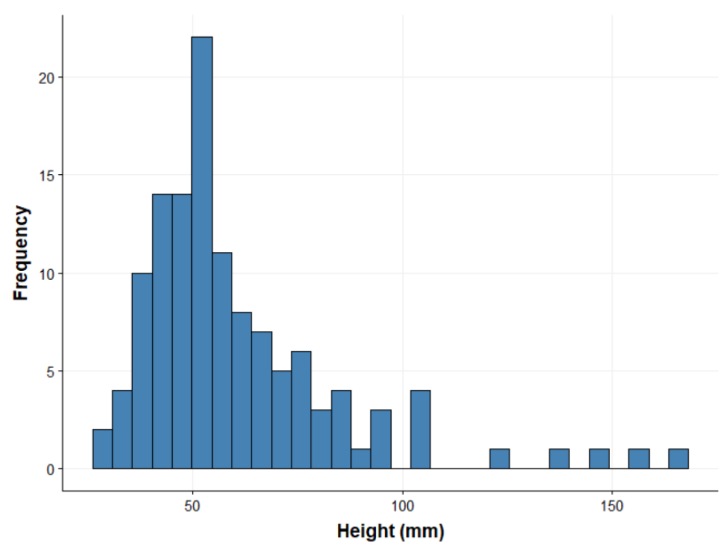


Figure 5.15. Histogram showing the distribution of heights of figurines that are preserved from top to bottom.

The commonly represented bodily attributes are breasts (123 out of 444 figurines, 27.7%), pronounced abdomen (77/377, 20.4%), buttocks (55/215, 25.6%), while navel (17/296, 5.7%), vulva (1/189, 0.5%), and penis are rarely depicted (5/189, 2.6%). Although the female bodily attributes predominate on Belo brdo, the question of determining sex is more complicated than counting these attributes (Vuković 2021a; Tripković et al., in preparation). Almost all the figurines have heads that are facing forwards. Typical facial characteristics are eyes of various shapes, nose, mask (or mask-shaped face) (**Figure 5.16**), or less commonly ears and hair. In some cases, heads and other body parts (abdomen and chests, arms, and lower body) are ornamented with lines or other incised patterns. The lower body can have a representation of a 'skirt' – distinct ornaments on the lower body with various patterns that resemble a skirt.

Figure 5.16. Figurine with a clear representation of a mask (courtesy of Nenad Tasić).

From **Table 2**, it is evident that the relative frequencies of figurines produced by different skill levels are similar in all of Milojčić's phases, while the Chi-Square shows that there is no significant relationship between the two variables ($n = 837$, $\chi 2 = 10.206$, $df = 6$, $p = 0.12$). In other words, all phases have similar proportions of low-skilled, moderately, and highly skilled production of figurines, so their inclusion should not systematically influence the observation of temporal trends. However, I will make a brief comparison of figurines production in relation to skill level, by analyzing several commonly discussed attributes – body position, presence/absence of breasts, presence/absence of eyes, and height. This comparison is by no means extensive, but it is intended to make some preliminary insights regarding the comparability of unskilled and skilled figurines, and the influence of skill level on figurine variability.

Table 5.2. Crosstabulation of skill-level and Milojčić's phases.

	Skill level		
	Low	Medium	High
Vinča A	15 (22.4%)	49 (73.1%)	3 (4.5%)
Vinča B	47 (16.8%)	217 (77.5%)	16 (5.7%)
Vinča C	70 (17.3%)	290 (71.8%)	44 (10.9%)
Vinča D	12 (13.9%)	69 (80.2%)	5 (5.8%)

Figurines of all skill levels have similar relative frequencies of different body positions (**Figure 5.17**), as indicated by bar graph and the results of Chi-square test ($n = 272$[13], $\chi 2 = 6.39$, $df = 4$, $p = 0.17$). In the case of the presence of breasts, the percentage of figurines with modeled breasts is higher for medium- and especially high-skill figurines (**Table 5.3**), and the Chi-Square test confirms the association between the two variables ($n = 444$, $\chi 2 = 25.288$, $df = 2$, p-value < 0.01, Cramer's $V = 0.24$). Finally, the height of figurines that are preserved from top to bottom is larger in the case of very elaborated figurines than for low-skill and medium-skill figurines (**Figure 5.18**). The statistically significant differences between the heights of these three group are indicated by Kruskal-Wallis test ($n = 123$, $H = 17.2$, $df = 2$, $p < 0.01$), while the pairwise comparisons using Wilcoxon rank-sum test show that the significant differences in height between all pairs (low-medium – $p = 0.049$; low-high – $p < 0.01$; medium-high – $p < 0.01$). The results of this small comparison show that, while the skill level does indeed influence the variability of figurines, this influence is a matter of scale, not kind, as similar attributes are present in all skill-level groups. Moreover, the impact of skill is similar in all Vinča phases, as shown above, so it should not bias the results of this study of diachronic changes in any way. Nevertheless, skill seems to be an important factor for exploring and explaining the variability of figurines and should be further studied.

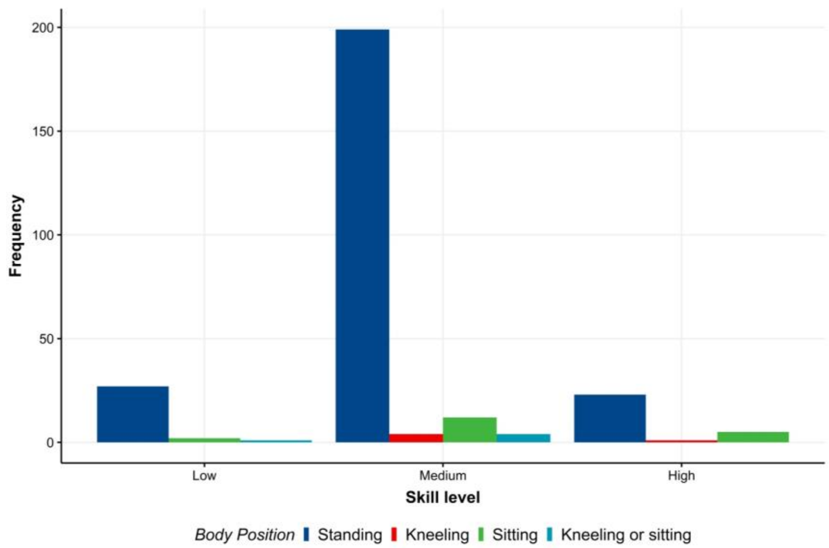


Figure 5.17. Bar graph showing the body position for figurines of different skill levels.

Table 5.3. The contingency table with crosstabulation of skill level and presence of breasts on figurines.

	Absent	**Present**
Low	71 (84.5%)	13 (15.5%)
Medium	239 (72.4%)	91 (27.6%)
High	11 (36.7%)	19 (63.3%)

[13] The "Kneeling or sitting" figurines were not included in the Chi-Square test.

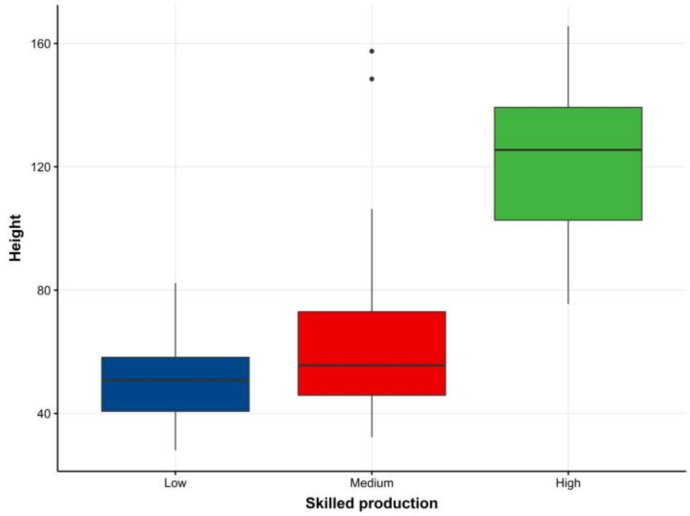


Figure 5.18. Box-plot showing the height of figurines that are preserved from top to bottom, grouped by different levels of skill.

As in the case of lithics, there is no information about the archaeological context for figurines from Vasić's collection. However, there is some evidence from the latest excavations of Vinča-Belo brdo (Tasić 2011) and the other sites in the region with similar figurines. Different authors (e.g. Greenfield 1991; Porčić 2012a; Tasić 2011a) have indicated that the figurines were found in various contexts – houses, pits, cultural layers, hearts, etc. – and there are no clear indications of ritual places or specialized workshops for figurines production.

5.2.2. 2004-2014 excavations (N. Tasić)

The excavations in Sector I of the site, conducted in 2004-2005 and 2012-2014, were initiated because a part of the site was endangered by cracking and slippage (Tasić et al. 2016). The excavations of this part mainly concerned the vertical (temporal) dimensions of the site and were named *deep sounding*. Some preliminary data about these excavations were published by Tasić et al. (2016) and will be presented here. A surface of around 33 m^2 was opened in the upper layers, but it was reduced to ~15 m^2 in the lowest layers, around 4.5 m beneath the surface. The excavations were based on the recording of single contexts and the position of all the objects, features, and finds was precisely located with a theodolite. The location of prominent objects and features is shown in Figs. 9 and 10 of their article, including 9 houses and 6 ovens (Tasić et al. 2016, Table 3). A large number of 101 radiocarbon dates from these excavations were subject to Bayesian modeling (Tasić et al. 2016), improving the understanding of the site chronology. This part of the site seems to have been settled at a somewhat later date than the area that Vasić excavated, during the 52 century BC (cf. Tasić et al. 2015b), and constantly occupied until the late 47th or 46th century BC.

Lithic sample (Tasić 2004-2014)

The lithic collection from new excavations of Vinča-Belo brdo will be used to roughly assess the validity of Vasić's lithic collection, by comparing certain parameters among the two collections (raw material structure, structure of products, blade size), and to provide certain insights into contextual data. The collection from deep sounding consists of 891 finds, decreasing to 890 when one chert nodule is excluded. The prevailing raw material is chert (n = 830; 93.2%), which comes in different, most commonly fine-grained varieties. Other raw materials are much less numerous: miscellaneous sedimentary (16 pieces; 1.8%), obsidian (14; 1.6%), magnesite (13; 1.5%), undeterminable (13; 1.5%), quartzite (3; 0.3%), quartz (2; 0.2%). Although the percentages of most of these raw materials are not surprising, a much lower percentage of obsidian than previously suggested deserves some attention. Based on Vasić's evidence, it was determined that obsidian makes up to 70% of lithic finds on Vinča-Belo brdo (Radovanović et al. 1984), leading many researchers to suggest that Belo brdo was a "trading knot" (Bogosavljevic Petrovic 2015), "redistribution or exchange" center (Milić 2016: 66; see also Milić 2021), or similar. However, the data from the *deep sounding* contradicts such assumptions and is in line with data from other more recently excavated Late Neolithic sites, which have similar percentages (generally between 1 and 5%) (see Milić 2016; 2021; Tripković 2004). Although this question should be further investigated, these results suggest that the early researchers might have been biased towards obsidian finds, preferring to collect or preserve finds from this raw material – it seems that the sites that were excavated in the first half of the 20th century have higher percentages of obsidian (e.g. Potporanjske Granice – 33.5%; Mileker 1938, cited in Tripković 2004). Another important insight from this collection is that the obsidian does not disappear from Belo brdo in the latest levels – there are 3 finds in Vinča B, 3 in Vinča C, and 7 in Vinča D – as previously assumed based on Vasić's evidence. The implications of these new insights about obsidian from Belo brdo will be discussed in more detail elsewhere (Radinović, in preparation). The following analyzes of lithic material from Belo brdo will concern only the chert finds, as other raw material types do not provide sufficient samples for statistical analyses.

Chert finds

The total number of finds in this collection is 829. There are 23 cores (2.7%), 748 flakes (88.8%), and 58 pieces (8.5%) characterized as undeterminable or waste. These percentages of basic product types are similar for the two collections – *deep sounding* and Vasić's 1929-1934 collection of chert finds (**Figure 5.19**) – which is confirmed by the Chi-square test of homogeneity which shows no differences between collections ($n = 5098$, $\chi2 = 6$, $df = 4$, $p = 0.2$). The blade cores (n = 19; 79.2%) are more numerous than flake cores (n = 5; 20.8%), as in the Vasić's collection. The patterns of removals of blades cores are predominantly unidirectional or bidirectional (**Figure 5.20**), their shape is usually either conical/pyramidal or tabular, with triangular, semi-oval, or rectangular debitage surface. Blade negatives on these cores are moderately regular in most cases and irregular for only two cores. Flake cores have unidirectional, bidirectional, or multidirectional patterns of removals. The mean mass of blade cores is 20.5 g, and for the flake cores, the mean is 12.16 g.

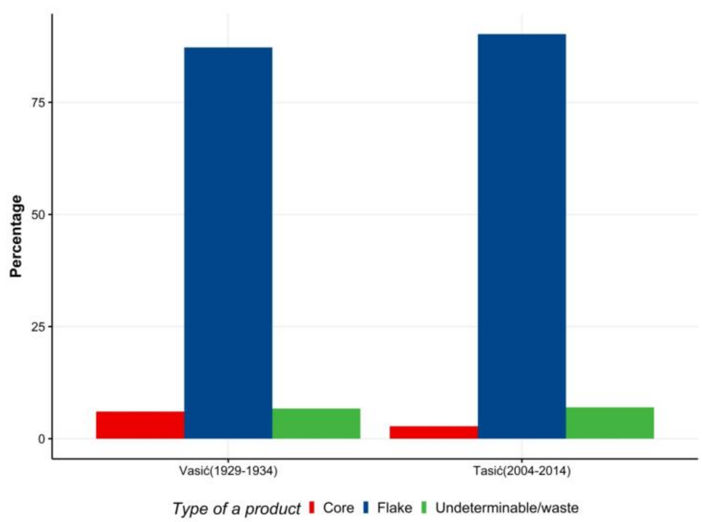


Figure 5.19. Structure of two collections of chert finds, recovered during the excavations of Vasić (1929-1934) and Tasić (2004-2014).

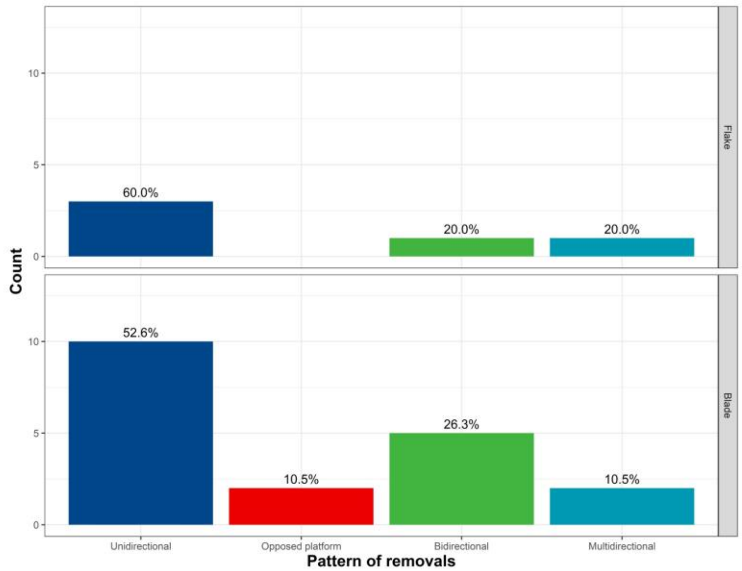


Figure 5.20. Patterns of removals on flake and blade cores (Tasić 2004-2014).

Out of 790 flakes in a broad sense, there are 372 flakes (47.1%) and 418 blades (52.9%). These percentages are quite similar for chert finds from Vasić's and Tasić's excavations, as confirmed by applying the Chi-square test of homogeneity to the frequencies of flakes and blades in these collections ($n = 4514$, $\chi2 = 0.115$, $df = 1$, $p = 0.73$). The existence of the early core exploitation phase on Belo brdo is indicated by the presence of cortex on 7.2% of blades, as well as by 3 crested blades, 4 cortical, and 5 core rejuvenation flakes. Compared to the 57.0% of fragmentation rate for flakes and blades from Vasić's chert collection, a slightly higher percentage of flakes and blades from the new excavations is fragmented (59.5%; 470 out of 790). The percentage of blades with sickle gloss is slightly lower in this collection than for 1929-1934 finds (16.7%). The maximal length of 57 whole blades from this collection ranges between 1.5 and 4.9 cm, and the mean is 3.1 cm. The difference in maximal length of whole blades from the two collections is significant at $\alpha = 0.05$ ($n = 356$, $W = 13326$, $p < 0.01$) – the blades from Vasić's excavations are longer on average (**Figure 5.21**), indicating that they were biased towards collecting or preserving somewhat larger chert blades, which is expectable in the absence of sieving.

The retouch is present on 132 from 790 flakes and blades (16.7%). When observed separately, 93 or 22.2% of blades and 39 or 10.5% of flakes have retouch. Both whole and fragmented blades usually have a light retouch – the mean Clarkson's index of invasiveness is 0.1 – on lateral sides or distal/proximal end. In some cases, they were shaped into borers by invasive retouch. The flakes were most often retouched into sidescrapers and endscrapers.

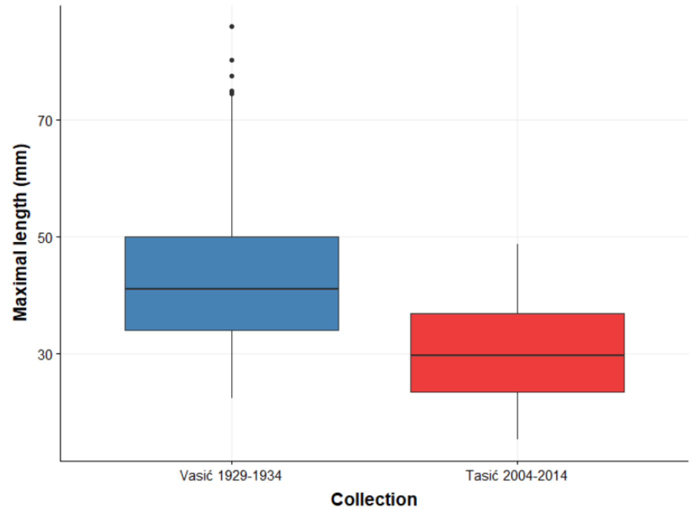


Figure 5.21. Comparison of length of whole blades from Vasić's and Tasić's excavations.

The lithic finds from *deep sounding* excavations were found in various contexts – house floors, around ovens, in the cultural layer, pits, infillings, within concentrations of ceramics, shells, etc. A more detailed analysis of single contexts and more general spatial distribution of finds will be done in the future.

The presented comparison between the two lithic collections shows general agreement in their basic parameters, indicating that knapped pieces were meticulously collected during Vasić's excavations. The only notable difference is that the percentage of obsidian is much higher in Vasić's collection. One possibility is that Vasić has moved the obsidian finds from all excavations campaigns under his supervision from the Belgrade National Museum to the Archaeological Collection of the University of Belgrade, but this is just speculation. In any case, the chert collections from both old and new excavations show a high level of comparability, indicating that the Vasić's collection provides suitable samples for reaching the research goals in this work.

6. Methods of data collection

In this research, the diachronic cultural dynamics on Vinča-Belo brdo are investigated by observing the variability of morphological and metric characteristics of knapped stone tools and anthropomorphic figurines from Vinča-Belo brdo. In order to reach this goal, it is necessary to define the analytical units for describing the variability of these two artifact classes and tracking the continuities and changes in their production technologies. When it comes to variability, hardly any two objects (e.g. artifacts, buildings) studied by archaeologists can be considered identical. Ceramic vessels can be very similar in terms of shape and ornamentation but differ in chemical composition, color, dimensions, and other attributes. The way in which similarities and differences between entities are compared plays a major role in the interpretation of the past, and special attention needs to be paid to analytical concepts which should formally explore the variation in material culture.

As described in the introductory chapter of the thesis, the prominent culture-historical scholars (e.g. Garašanin 1979; Срејовић 1968) have described the variability of artifacts by using subjective typologies, usually based only on a selection of finds. These typologies were unsystematic, arbitrary, and very general, and their suitability for summarizing the artifact variability is questionable. One of the most problematic aspects of these typologies is the fact that they were often presented as natural, commonsensical, so there was no need to question them and their suitability for researching different aspects of the past. Consequently, traditional types „are very poor analytical devices ... easily mistaken for 'real' or, even worse, as showing an essence." (Okumura, Araujo 2014: 64).

Today, there is a wide set of different tools that are more suitable for investigating the complex variation in artifacts (e.g. Altaweel, Squitieri 2020; Okumura, Araujo 2019), whether or not they can be classified into discrete, homogenous groups (types). As there are no analytical units that are universally suitable for analyzing the past, they should be tailored according to our research questions (e.g. Lyman 2021). The idea behind data collection here is to construct analytical units that would track the transmission and modification of technological knowledge or "recipes" (Lyman, O'Brien 2003) for the production of lithics and figurines. During the production process, a manufacturer applies a set of learned (and modified) technological knowledge and skills in reaching the desired material outcomes. A basic assumption is that these learned strategies (technologies, recipes, memes, traditions) will be reflected in the formal properties of the material culture, where formal properties can be defined as "physical attributes of artifacts which result from different methods or techniques of manufacture and/or use such as form, shape, color, material, and so on" (Stone 1970: 90). For example, a knapper's knowledge of a suitable knapping technique will be reflected in the properties of a blade (e.g. Pelegrin 2006). The goal of data collection in this research is to assess this learned (and modified) technological knowledge by describing the variability of these two artifact classes, and to observe the population-level distribution of these cultural ideas and their changes throughout the Late Neolithic on Belo brdo.

Although archaeologists often implicitly assume that any sort of similarity between artifacts is an indication of some sort of transmission of ideas (e.g. "parallels" in culture-historical research), the analytical units in this research are explicitly defined and discussed in the context of relevant literature, and it was acknowledged that multiple factors, including social learning, individual factors, copying error, and other factors influence the artifact variability (e.g. Gandon et al. 2014; 2018; 2019; 2020). In this study, three analytical approaches were used for describing the variability of material culture: attribute analysis, formal typology (paradigmatic classification), and geometric morphometrics. As mentioned in Chapter 4 about research aims, one of the goals of this study is to examine how the choice of analytical units influences the observation of cultural changes, and consequently the interpretation of the past. A brief overview of the three analytical approaches will be presented in the following text.

Attribute analysis

Attribute analysis represents the recording of certain physical characteristics of artifacts (e.g. platform type, retouch position and invasiveness in the case of lithics), to determine how they vary in time and space. Instead of lumping multiple features of objects together into types, we can divide artifacts into sets of features that could vary independently or not. For example, in the case of arrowheads, the variability of their base can be examined separately from other features, or in the case of figurines their body position can be considered as one attribute. These attributes are commonly aimed at reconstructing relevant features of artifacts, that could point to the technological (or other) choices of their makers (e.e. Stone 1970). During the production process, individuals continually make choices about actions that are intended toward reaching the desired goal(s), and the assumption is that we can reconstruct these choices by studying the relevant attributes of artifacts. This analytical approach should be particularly suitable when attributes vary independently.

In this research, both qualitative and quantitative attributes were recorded to describe the studied artifacts with a sufficient resolution. Although a higher number of attributes leads to a more detailed observation of variability, the data collection in this research was primarily aimed at capturing the attributes of artifacts that could be relevant in tracking the transmission of knowledge within the community. By quantifying the frequencies of these attribute modalities through time, we can observe when they appear, change in frequency, or disappear, and reconstruct the possible reasons for underlying changes in technological choices.

Paradigmatic classification

Paradigmatic classification represents a formal approach for classifying artifacts into groups (types) (e.g. Edinborough et al. 2015; Eren et al. 2016; O'Brien, Lyman 2000). Instead of constructing subjective, often heterogeneous types, paradigmatic classification is performed according to predefined criteria for forming the types, based on the intersection of the presence of different attributes. In such a manner, the resulting groups are homogenous as they consist of artifacts that have the same attribute combinations, and new finds are easily incorporated into the classification scheme. For instance, we can classify bowls by their color and ornamental motifs, and we noted two modalities for each attribute – red and black color; linear and zigzag ornamental motifs. These modalities are then combined (intersected) to create bowl types that share the same features and are mutually exclusive – red-burnished bowls with a linear motif (type 1), red-burnished bowls with a zigzag motif (type 2), black-burnished bowls with a linear motif (type 3), and black-burnished bowls with a zigzag motif (type 4). We might find only types 1, 3, and 4 in an archaeological assemblage, but new finds (e.g. type 2), attributes (e.g. texture), or modalities (e.g. meander motif) can be easily incorporated into this classification scheme.

Geometric morphometrics

Geometric morphometrics (GMM) is a set of quantitative approaches for formally analyzing the morphological variation of objects (e.g. Mitteroecker, Gunz 2009). It has been developed within the field of biology, but during the last decades, it has been successfully applied in investigating the morphological variation in different artifact classes (see Okumura, Araujo 2019 for an overview), including lithics (e.g. Archer et al. 2021; Hashemi et al. 2021; Hoggard et al. 2019; Lycett 2009; Lycett et al. 2006; Valletta et al 2021) and figurines (Bourdeu, Pitzalis 2010; Starbuck 2014). In geometric morphometrics, shape (morphology) is defined as "geometric properties of an object that are invariant to location, scale, and rotation" (Slice 2007: 3). The GMM approaches can be used for either 2D or 3D shape analysis and can be applied to landmarks (sets of corresponding points) (e.g. Buchanan, Collard

2010; Birch, Martinon-Torres 2019; Topi et al. 2018), contours (e.g. Iovita 2010; Wilczek et al. 2014), or surfaces of objects (e.g. Delpiano, Uthmeier 2020; Herzlinger et al. 2017). The GMM tools offer many advantages over investigations of shape using simple linear measurements (e.g. Zelditch et al. 2012) – size and shape can be independently observed, it offers powerful visualizations of similarities and differences, and allows the use of a range of statistical methods for exploring variability and evaluating different hypotheses. Thus, these approaches represent a very suitable tool for investigating the continuities and changes in the morphology of artifacts (e.g. Okumura, Araujo 2014).

6.1. Lithic analysis

Knapping is a skill that necessitates some kind of instruction to be learned, at least in the case of more complex reduction sequences, such as the Levallois method (Lycett et al. 2016) and laminar technology (Muller et al. 2022). Ethnographic and experimental research has contributed to the understanding of the learning process of knapping (e.g. Geribàs et al. 2010; Roux et al. 1995; Stout et al. 2002; Stout 2005), i.e. how individuals acquire knowledge (*connaissance*) and know-how (*savoir-faire*) of different technological operations. It takes years of learning and practice to gain theoretical and practical knowledge about different technological stages related to knapping – raw material acquisition, conceptual models of removals, knapping techniques, etc. – and different options and decisions that can be made during the process. Through the learning process knowledge about lithic technology is passed down through generations, creating "... 'tradition' or ... a repeated 'pattern' of behavior..." (Lycett et al. 2016: 20).

In order to reconstruct the transmission of knowledge about the lithic production on the Vinča-Belo brdo site, the standard technological analysis (e.g. Inizian et al. 1999) was conducted on all the knapping products. However, the focus of this study was on assessing the transmission of knowledge about blade production (laminar technology), for two reasons: 1) blade production was the main goal of the lithic organization on Belo brdo (Bogosavljević, Petrović 2015; Radovanović et al. 1984); 2) blades are the only suitable class for the study of cultural transmission due to their abundance. Despite a much smaller sample of cores, their variability was also thoroughly analyzed to obtain additional information concerning the technology of blade production and cultural transmission of the learned choices. For other classes of knapped stone tools (nodules, flakes in a narrow sense, waste) only the basic information was collected (relative depth, context, unit, raw material, fragmentation) to obtain a general image of the lithic production on the site.

It is generally acknowledged that different technological choices - such as the choice of applied method or technique (e.g. Inizian et al. 1999) – are reflected in the formal attributes of knapped pieces. Thus, for each temporal unit, the variability of knapped pieces will be described and used as a proxy for the structure of technological choices on the assemblage level. However, different factors can influence the knapping technology and variability of stone tools, including available raw materials (e.g. quality, abundance, size, and shape of nodules) (e.g. Andrefsky 1994; Herzlinger, Grosman 2018), mobility (e.g. Shott 1986), function, individual factors (e.g. visual perception, skill, strength, context) (e.g. Eerkens 2000; Sollberger, Patterson 1976; Williams, Andrefsky 2011), etc. As the goal of this study is to record variability related to laminar technology, i.e. production and maintenance of blades, the attempt was made to control other factors as much as possible (e.g. raw material properties). Variables (artifact features) that were observed on the studied pieces are related to basic information about finds, raw material properties, comparability of collections, fragmentation, knapping technology, and post-depositional traces. In the following text, an explanation of the recorded variables is provided.

Basic info

For every find, a unique *serial number* was given, and the previously given *inventory number* was recorded. *Relative depth* was noted for the finds from old excavations, while for the finds from new excavations spatial *unit*, *context*, and *spatial coordinates* were noted, as these data were necessary for obtaining the spatial and temporal context of the finds. *Photo number(s)* were also recorded, as photographs were used for making measurements, geometric morphometric analysis on blades, and creating digital documentation.

Raw material

Raw material properties and abundance can affect the organization of technology (e.g. Andrefsky 1994; Brantingham et al. 2000; but see also Eren et al. 2014). Thus, the technological organization was analyzed and discussed separately for different *raw material types*. In this study, raw materials were classified into commonly used *types* and *subtypes* using macroscopic observation, and their *color* was noted. It was suggested that macroscopic observation is suitable for rough classification and the studies of lithic organization in the case of larger sample sizes (Bustillo et al. 2009). As raw material quality can influence technological choices (e.g. Andrefsky 1994), the *texture of raw material* was recorded and it served as a proxy for the raw material quality. Concerning the size and shape of nodules used for making lithics found on Belo brdo, it is difficult to infer these properties without a large-scale refitting project or profound knowledge of exploited raw material sources. As neither of these was an option for this study, it was assumed that people were using similar, suitable raw materials nodules of good quality, as suggested by previous analyses of material from Vinča-Belo brdo (Radovanović et al. 1984). As mentioned in the Materials Section, the diachronic changes in lithic technology were observed primarily based on numerous chert finds.

Comparability of collections

Structure of collections, defined as a proportion of different lithic products, is needed to determine the comparability of assemblages, i.e. if they roughly come from the same type of context (e.g. on-site vs. off-site knapping) (e.g. Tostevin 2012: 142-147). A low percentage of waste (small flakes, debris) would indicate that the knapping process was done outside of the settlement, or in its unexplored part. The material was categorized into different *types of products* (nodule, core, flake, waste, undeterminable), and it was assessed if the temporal units are roughly comparable regarding the structure of collections. Other criteria for roughly inferring the comparability of collections for the study of transmission are, similarly to Tostevin (2012), *percentage of cortical blade blanks, percentage of retouched blades*, and *Clarkson's index of invasiveness* (Clarkson 2002).

Taphonomy

As fragmentation can impede observation of certain attributes, as well as geometric morphometric analysis, blade *fragmentation* was recorded. While attribute analysis was done on both whole and fragmented blades, shape analysis using geometric morphometrics was possible only for whole and almost whole (slightly damaged) blades. It was also noted if the state of preservation of the finds is good, where *post-depositional surface modifications* are absent or present in small amounts, or poor, with pronounced post-depositional damage. The presence/absence of *pseudo-retouch* on blades was also noted.

Variability in lithic technology

There are different technological stages that lithics go through - selection of raw material, heat treatment, reduction, hafting, resharpening, etc. (Kooyman 2000: 49). This study is focused on the knapping technology, i.e. choices that individuals made during the reduction process. Following Tostevin (2012), who studied the transmission of knapping choices during the Middle to Upper Paleolithic transition, exploration of variability in this study was focused on two manufacturing stages – technology of blank production; shaping and maintenance strategies (retouch). He suggested that knowledge about blank production requires social intimacy between individuals to be transmitted, while the morphology of retouched tools can be copied only by observation of the finished products, not requiring social intimacy. Although Tostevin used this dichotomy to study the nature of interactions between groups of hunter-gatherers, his concept was used here to determine if knowledge about different operations was transmitted in a different manner.

Blank production

Variability in the technology of blank production is related to the method and technique of production. The method can be described as a sequence of actions (e.g. Inizian et al. 1999), i.e. organization of removals in time and space. Previous researchers have evidenced different patterns of removals (unidirectional, bidirectional, multidirectional, irregular) by observing cores from the Vinča-Belo brdo site (Bogosavljević-Petrović 2015; Radovanović et al. 1984), determining that their frequencies did not change much through time. However, cores often reflect only the last episode of removals, not the whole reduction sequence. Hence, besides certain attributes of blade cores (*core type – flake or blade* (Shea 2013), *pattern of removals*, *shape of the core, shape of the debitage surface, mass*), blade blank features related to the knapping method were also recorded. To reconstruct the core rotation and exploitation, the *number and orientation of dorsal negatives* were observed. *Lateral edge type* and *distal end termination* depend largely on the morphology of the debitage surface of a core, which is shaped by previous removals. However, distal end termination can also have a specific morphology related to knapping accidents (e.g. Inizian et al. 1999: 34-38), which can be caused by a knapper's mistake or raw material irregularities (e.g. Bratingham et al. 2000). Observation of knapping errors could be significant for the study of social learning (e.g. Goldstein 2019). *Striking platform type* was examined to infer the possible preparation of the core platform, which is done to create a suitable striking surface or a suitable angle for detaching a blade - exterior platform angle (EPA). Basic *metric attributes (mass, maximal length, width and thickness, index of elongation, volumetric index*) were also recorded to make a comparison of blank production in different time units.

Technique "refers to the way in which the force is applied" (Newcomer 1975: 98), including the mode of application of force, properties of percussor, gesture, and body and core position (e.g. Pelegrin 2006). Force can be applied dynamically, by directing a forceful blow directly to the core (e.g. direct handheld percussion, bipolar knapping on an anvil) or through a punch that is placed on the desired spot of a core (indirect percussion); or statically, where the pressure is gradually increased until the flake is removed (pressure debitage) (e.g. Kooyman 2000). Apart from the manner in which the force is applied, percussors of different materials and shapes can be used for detaching flakes. Three main production techniques were used for blade production: direct handheld percussion, indirect percussion, and pressure debitage (e.g. Inizian et al. 1999: 74).

Direct handheld percussion is probably the most commonly used technique during prehistory (e.g. Debénath, Dibble 1994: 22). Percussors of different materials were used, commonly referred to as hard hammers (hard stone, metal) and soft hammers (soft stone, antler, bone, wood) (e.g. Kooyman 2000). It is generally considered that flakes produced using a hard hammer are thick and have a large butt, point of impact, pronounced bulb, bulbar scar, ripples, and fissures, while those produced using soft hammers are longer, thinner, have smaller, diffuse bulb, a lip between butt and ventral surface, and less developed ventral features (e.g. Debénath, Dibble 1994: 22; Inizian et al. 1999: 74). However, although it is known that properties of percussor "can have a significant influence on the nature of the resulting flakes" (Odell 2004: 59), due to fracture mechanics (Cotterell, Kamminga 1987), differences are still not well understood. As shown by different studies, there is a significant overlap in features of flakes made with hard and soft hammers (e.g. Driscoll, Garcia-Rojas 2014; Pelcin 1997), and even different kinds of soft hammers (e.g. Pelegrin, Inizian 2013), making inference on individual pieces often troublesome. Besides the materiality of percussors, variables such as hammer weight (Lengyel, Chu 2016), platform thickness, and angle of blow (Magnani et al. 2014), can generate certain differences in blade attributes.

Indirect percussion or punch technique appears during the Mesolithic (Inizian et al. 1999: 75; Pelegrin 2006). It was generally used for knapping small- and medium-sized blades, although large blades were also produced using this technique (see Pelegrin 2006 for an overview). It is performed by placing one end of an intermediate tool (punch) on the core and hitting the other end with a percussor. Such application of force allows for greater precision (e.g. Debénath, Dibble 1994: 22-23), resulting in greater regularity of products when compared with direct percussion. There are some distinct features of products obtained using this technique (e.g. Inizian et al. 1999; Pelegrin 2006; Sørensen 2006). The flaking angle is usually around 90°, the butt is small (even punctiform), and can be lens-shaped. There is a combination of bulb and lip, mesial belly is present, and ripples on the ventral side are absent. When antler punch is used a lip is present, while with copper punch there is a circular or sub-circular crack and there is no lip (Pelegrin 2006). However, "... products [are] halfway between those of debitage by direct percussion and by pressure-flaking, and are sometimes difficult to distinguish from either of the two." (Inizian et al. 1999: 76), as punch technique "...can imitate very well the direct soft percussion technique, and attains a regularity close to that achieved by pressure" (Pelegrin 2006: 41).

Pressure debitage has its roots in the Upper Paleolithic of East Asia (see Inizian 2012 for an overview), although it was used much earlier as a faconnage (shaping) technique (e.g. Mourre et al. 2010), called pressure flaking. In pressure debitage the force is applied statically – by placing a flaker on the core and increasing pressure until a flake detaches - allowing for high precision and regularity of removals (standardization) (e.g. Dibble, Rezek 2009; Inizian et al. 1999). Although having a single name, pressure debitage includes a range of modes (Pelegrin 2012). The simplest form involves the use of a hand-held tool to apply pressure (Mode 1). Usage of a shoulder or abdominal crutch in a sitting or standing position (Modes 2, 3, and 4) increases the amount of force that can be applied (Kooyman 2000), while the largest amount of force can be applied with the use of lever (Mode 5). A device is often used to immobilize a core during the pressure debitage (Inizian et al. 1999: 76; Pelegrin 2012). Very long blades can be made using this technique, reaching 40 cm in modern experiments (Pelegrin 2012) and 43.3 cm in the archaeological record (Pelegrin 2006).

The appearance of pressure debitage is of particular importance, as it is a highly complex and specialized activity, the transmission of which probably necessitated active teaching by an expert, at least for more complex varieties of this technique (Pelegrin 2012). It is also frequently associated with heat treatment which can improve the properties of the raw material (Domansky, Webb 2007), as well as with the trade of fine-grained and homogenous raw materials, such as obsidian (Inizian et al. 1992). Blade production using the pressure technique could be the most efficient knapping technique in terms of raw material economy, as suggested by knapping experiments (e.g. Muller, Clarkson 2016), although there are different opinions on that subject (Eren et al. 2008). Pressure knapping has been identified on Mesolithic and Neolithic sites in different parts of Europe, including the Balkan peninsula

(Inizian et al. 1992; Inizian 2012). V. Bogosavljević-Petrović (2015) has identified the presence of the pressure technique in the Late Neolithic of the Central Balkans, and noted a certain decrease in its use (cf. Bogosavljević-Petrović 2018). In this study, this will be tested by gathering quantitative data about the frequencies of attributes related to pressure debitage on Vinča-Belo brdo, and transmission of this demanding activity will be explored.

Different technical stigmata are used to recognize the pressure blades (e.g. Brunet 2012; Inizian et al. 1999; Kooyman 2000; Milić, Horejs 2017; Sørensen 2006; Pelegrin 2006; 2012). They have very regular and parallel edges and ridges, and there is marked straightness of the profile, i.e. curvature starts in the distal part of long blades. Thickness is reduced and constant, even in the mesial part of the blade. The butt is small (even punctiform), thick and narrow, always narrower than the maximum width of the blade, which is very rapidly reached. The bulb is pronounced but concentrated (high and short), less diffused than a bulb created by indirect percussion, and there are no ripples. In the case of obsidian, the platform is usually rubbed down to avoid slippage of the flaker (Inizian et al. 1999: 76). Pelegrin (2012) determined the platform thickness range for different modes of pressure knapping, which could help to distinguish between them, although there is some overlap in this measure. Cores reduced by pressure debitage also have very regular and parallel arrises (Inizian et al. 1992), and their shape is conical, semi-conical, and very rarely cylindrical and flat (Milić, Horejs 2017). Completely reduced conical and semi-conical cores are bullet-shaped.

As described above, some of the main characteristics of flakes and cores obtained by each technique and the differences between them have been already determined by experimental research. Based on some characteristic features, it is possible to recognize the presence of certain technique(s) in the assemblage, especially pressure debitage. However, differences are usually described in qualitative and relative terms, making interpretation of the used technique on individual specimens a largely subjective endevour, potentially prone to inter-researcher variability. Even for specialists, the task of determining the exact technique can be troublesome, as there are many varieties of knapping techniques, with subtle differences between them, and there is an overlap between features of products obtained by different techniques (e.g. Damlien 2015; Driscoll, Garica-Rojas 2014; Muller, Clarkson 2016; Radinović, Kajtez 2021). Suggested diagnostic features of a particular technique can be produced by other techniques (e.g. Johnson 1978). As Pelegrin (2006) notes, it is even difficult to distinguish the indirect percussion and pressure knapping for "smaller" blades (15-20 cm long) when the former is done meticulously. Furthermore, there is a notable amount of variation between products made by different knappers using the same technique (Sollberger, Patterson 1976), when different raw materials are used (Kooyman 2000), and there are other variables that affect the flake morphology (e.g. platform thickness, exterior platform angle) (Magnani et al. 2014; Whittaker 1994: 91, cited in Kooyman 2000: 81).

For these reasons, it is difficult to determine the used technique individual finds, and the currently developed methodology seems more suitable for relative comparisons on assemblage level (Damlien 2015), to "use these trends to give a basic idea about the overall type of reduction occurring" (Kooyman 2000:78). Therefore, changes in frequencies of certain qualitative attributes or changes in central tendencies and dispersion of quantitative measurements related to knapping technique were assessed in this research and used for inferring the possible changes in the used techniques.

Different variables, related to the above-mentioned blade features, were recorded on unretouched blades for the study of knapping techniques. They largely correspond to variables observed in other recent studies of knapping techniques (Damlien 2015; Driscoll, Garcia-Rojas 2014; Lengyel, Chu 2016; Muller, Clarkson 2016). Commonly used *metric variables (maximal length, maximal width, thickness of the medial part, thickness of the distal part, mass, index of elongation, volumetric index*), and variables related to the striking platform (*platform type, width, and thickness, circular crack, crushed platform, abraded platform*) and bulb of percussion (*bulb type, bulbar scar*) were recorded, as well as other qualitative attributes (*presence of lip, presence of ripples, mesial belly, debitage profile type, parallel and regular edges and ridges*). In order to recognize pressure cores, *regularity of removals/negatives* was observed.

Additionally, 2D geometric morphometric analysis was employed to explore if there are diachronic changes in blade shape and symmetry. I. Kajtez and I have recently shown that the Elliptic Fourier Analysis (EFA) can be a powerful tool for exploring and explaining the blade outline variability, and contributing to the recognition of different knapping techniques (Radinović, Kajtez 2021). The EFA is suitable for shape analysis of thin objects that vary predominantly in two dimensions (e.g. Buchannan, Collard 2010), such as prismatic blades. The goal of GMM analysis was to explore if there are changes in morphology and regularity of unretouched blades, which could be related to knapping technology.

A set of procedures had to be done before assessing the variability of blade outlines. All the blades were photographed and subsequently edited to remove the background for an easier selection of outlines. After creating a .tps file using tpsUtil 1.78 (Rohlf 2019), outline digitization was done in tpsDig 2.31 program (Rohlf 2017) with 3000 equidistant points. Digitized outlines were imported to the R programming language (R Core Team 2020), where outline normalization was performed to eliminate differences related to location, scale, and rotation. All subsequent statistical analyzes of blade outline shape and symmetry were also performed in R software, largely relying on code from Hoggard et al. (2019).

Retouched blades

Retouched blades were analyzed to investigate another aspect of knapping technology – shaping and maintenance strategies. Retouch can be done to shape or resharpen the blank (Odell 2004). In this research, a more detailed analysis of shaping and maintenance strategies was done only for retouched blades, while the retouched flakes were only classified into commonly used types (Debénath, Dibble 1994). Retouch features that were recorded include *retouch distribution, invasiveness, and scar morphology*. For distribution, the *retouch distribution* was done by dividing the blades into quadrants and recording the presence and absence of retouch in them. To compare the reduction intensity through the sequence*, Clarkson's index of invasiveness* was used (Clarkson 2002), suitable for both unifacially and bifacially retouched pieces. Retouch scar morphology was classified according to Inizian et al. (1999), for revealing general patterns of change in the morphology of retouch scars, which could be further analyzed using more sophisticated methods (Buchanan et al. 2015). The shaping of blades was investigated by determining *distal end morphology* (Tostevin 2012: 137) and *lateral edge type* (Tostevin 2012: 133).

The research protocol for lithic analysis can be found in **Appendix 1**.

6.2. Figurine analysis

Some of the previous descriptions of the change in anthropomorphic figurines were, as presented in Section 2 about previous research, largely subjective insights. These insights are very broad and subjective, identifying only some major trends in figurine iconography (e.g. from naturalistic to; flattened to cylindrical). As pointed out by Lazić (Лазић 2008; 2015), these typologies were only done on representatative samples and were describing only the typical figurines, i.e. the ones that are most common for a certain phase. In this research, a more detailed study of figurine change is performed, where features of every single figurine (both typical and atypical) were recorded with a clearly defined methodology. In this manner, continuities and changes in figurine production can be appropriately described and explained using the cultural transmission theory.

As manufacturing technology could not be analyzed from photographs, this study was focused on analyzing the appearance of figurines and especially on recording features that could exhibit heritability. Although the figurine variability might leave the impression of a creative ("artistic") process where an individual can freely express and be innovative, it was already shown that some features occur consistently (e.g. Лазић 2008; 2015; Letica 1964), and the goal of this work is to try to capture both the tradition and variation in features of anthropomorphic figurines. As in the case of lithics, the assumption is that the learned technological choices (recipes) are reflected in the formal properties of figurines. P. Ucko (1968) has been one of the main proponents of a more formal analysis of figurines' appearance, analyzing and quantifying their formal attributes instead of making some very general, subjective insights. Such an approach was applied to Belo brdo figurines (Vuković 2021a; Лазић 2008; 2015), but it was done only on a selection of attributes.

In this study, the protocol for describing the variability of anthropomorphic figurines using attribute analysis was largely based on the analytical protocol of M. Porčić (2012a; Porčić, Blagojević 2014), which is especially suitable for analyzing figurines from photographs and incorporates many attributes discussed by previous researchers (e.g. Latica 1964; Garašanin 1979; Tasić 2011a; Vuković 2021a; Лазић 2008; 2015; Срејовић 1968; Тасић 2008). Different data on basic information about figurines, fragmentation, technological features, taphonomy, body share and posture, metrics, anatomy, head features, and clothes and ornaments were collected. Firstly, some basic information about the figurines was recorded – *serial number*, *inventory number*, *relative depth*[14], and *context*. As many figurines are intentionally or unintentionally *fragmented* (e.g. Chapman, Gaydarska 2007, cited in Bailey 2017), the presence and absence of different body parts was noted: *head, torso, chest, arms, abdomen, lower body*. For each of these body parts, it was also noted if the left and right sides are present – e.g. left/right part of the abdomen, left/right arm. In some cases, it was not possible to determine the laterality of limbs, so it was characterized as an *undeterminable arm/leg*. The presence/absence of different body parts is important for proper comparison of figurines, and for determining if roughly equal proportions of each body part are present in different temporal units.

Certain technological features (*skill level, surface smoothness, self-standing*) were recorded for each figurine, as well as the information about figurine taphonomy (*presence/absence of post-depositional surface modifications*). Where possible, figurine *body and arm position* (e.g. Hansen 2007; Лазић 2008; 2015) and *lower body type* were examined. Various *metrical attributes (height, preserved height, head height, maximal head width and thickness, torso length, waist width and thickness, hip width and thickness, buttocks thickness, left arm length, right arm length, undetermined arm length, lower body length, leg length, lowest part width*) were recorded to assess the size and proportions of figurines and their body parts. The presence and absence of bodily attributes that are related to representations of sex on figurines (*vulva, penis, breasts, belly, navel, buttocks*; e.g. Hudson, Aoyama 2007; Лазић 2015; Mina 2007; Tripković et al. 2017: Vuković 2021a) were noted. Concerning the head of figurines, certain qualitative attributes were analyzed (*head shape and position, presence of eyes, nose, ear, mask, hair*), with a particular focus on creating a typology of the *eye* and *head shape*, as the previous studies inferred some diachronic changes in these attributes (e.g. Letica 1964; Garašanin 1979; Тасић

[14]As already mentioned in the previous chapter, between 1929 and 1934 Vasić was adding a certain value to his relative depths to relate the finds from different trenches and excavation campaigns (Palavestra 2020). In this research, these reconstructed values were used were used for all temporal divisions of the material.

2008). Finally, the presence/absence of possible *clothes*, *ornaments*, and *perforations* was recorded, and the analysis of *skirt ornamentation* was conducted (see Biehl 1996).

Besides attribute analysis, some basic properties of figurine morphology were analyzed by applying geometric morphometrics to photographs of figurines (frontal view). While the figurines vary in all three dimensions, the 2D approaches are the only option for analyzing morphological variation from photographs. In this study, the utility of Elliptic Fourier Analysis in assessing outline shape of figurines will be assessed. As for lithics, the outlines were digitized in tps softwares (tpsUtil 1.78, tpsDig 2.31; Rolhf 2017; 2019) and stored in a .tps file which was imported to R programming language (R Core Team, 2020) for all subsequent analyses (see above for a more detailed description of procedures).

The analytical protocol for describing the variability of anthropomorphic figurines can be found in **Appendix 2**.

Following the principles of open science (Marwick 2017; Marwick et al. 2017), the analytical protocols, basic information about lithics and figurines, and code for reproducing a selection of results in this research are available at Open Science Framework (OSF) platform (https://doi.org/10.17605/OSF.IO/JRC9D).

7. The character of cultural changes on Belo brdo

In order to assess the character of cultural dynamics on Vinča-Belo brdo, it is first necessary to define the temporal (stratigraphic) units for observing them. The finer resolution in terms of shorter temporal units should be better at spotting sudden cultural changes than aggregating the material from many centuries into one unit. However, a balance between a high temporal resolution and sufficient sample sizes had to be made. Another factor that was taken into account was the duration of time units. Theoretical predictions indicate a dependence of material culture diversity on the time-averaging (Porčić 2015; Premo 2014), where temporal units of unequal duration are incomparable in terms of their cultural content. For this reason, it was decided to use approximately equal temporal intervals for investigating the character of cultural changes in two classes of artifacts, as enabled by a firmly established chronology of the site (Tasić et al. 2015a; Tasić et al. 2015b; Tasić et al. 2016; Whittle et al. 2016). Such temporal division aims to avoid differences in samples resulting from their uneven durations, which could affect research results and create a distorted image of cultural changes over time. Finally, an effort was made to incorporate the boundaries of hypothesized sudden changes when creating the temporal units.

Tables 5 and 8 from Tasić et al. (2015b: pp. 41, 54-55) were used for choosing a convenient temporal division of Belo brdo stratigraphy. In these tables, there is a most likely estimate of a true age (a higher posterior density interval based on the Bayesian modeling) for many relative depths that were relevant for creating the previous periodizations. As the site was occupied for around 800 years (~5300 cal BC ~ 4500 cal BC), a division into eight 100-year-long temporal units with the boundaries roughly at the turns of the centuries seemed appropriate and reasonably balanced in terms of temporal resolution and sample sizes (see below). The boundaries of these temporal units (in terms of Vasić's relative depths) and their corresponding chronological estimates based on the modeling of radiocarbon dates are presented in **Table 7.1.** The temporal units should be of fairly equal duration, but some deviations in the form of shorter and longer intervals are probably unavoidable, due to the shortcoming of Vasić's evidence (Palavestra 2020), the uncertainty of radiocarbon estimates, and a limited set of relative depths with corresponding ages. The temporal intervals were named according to relative depths that mark their beginnings and endings. Although the boundaries of phases do not perfectly correspond with all the proposed „turning points" (e.g. at 8.0 m, Radovanović et al. 1984; Spataro 2018), they should suitable for investigating the temporal variability with sufficient resolution and testing the research hypothesis 1 regarding the character of changes with the Gradac phase.

Table 7.1. Temporal units for assessing the character of cultural changes, and age estimates for their boundaries (after Tasić et al. 2015b, Table 8).

Temporal unit	Start (Highest Posterior Density interval, 95% probability)	End (Highest Posterior Density interval, 95% probability)
9.3-8.3 m	5305-5255 cal BC	5230-5170 cal BC
8.3-7.2 m	5230-5170 cal BC	5135-5060 cal BC
7.2-6.5 m	5135-5060 cal BC	5045-4955 cal BC
6.5-6.05 m	5045-4955 cal BC	4940-4855 cal BC
6.05-4.95 m	4940-4855 cal BC	4830-4755 cal BC
4.95-3.5 m	4830-4755 cal BC	4730-4640 cal BC
3.5-2.5 m	4730-4640 cal BC	4655-4560 cal BC
2.5-1.3 m	4655-4560 cal BC	4570-4460 cal BC

7.1. Inferential methods

It is difficult to define what "significant" or "sudden" changes are in some absolute terms and to relate them to one of the many possible scenarios that could have produced the cultural patterns that we observe in the archaeological record (e.g. Zvelebil 2001). While it is evident that the changes in material culture do occur during the Late Neolithic occupation on Belo brdo (e.g. Letica 1964; Garašanin 1979; Schier 1996; 2000), the question is how to distinguish between noticeable and unnoticeable, sudden and gradual changes, while controlling for other effects such as sampling. In this research, it will be examined if there is evidence for continuous transmission of knowledge about the production of prismatic blades and anthropomorphic figurines. In such a scenario, qualitative cultural modalities (e.g. eye types) should either have fairly unchanged frequency distributions throughout the sequence or they should gradually increase/decrease in frequencies, and there should be no discontinuous (sudden) changes in their distribution in different temporal units. For quantitative elements, there should be no drastic changes in their distributions. Besides inferring cultural continuities and discontinuities, it will be explored if there is a higher dissimilarity between certain pair(s) of temporal units, which could signify some notable socio-cultural changes on Belo brdo. By assessing the cultural continuity and magnitudes of changes on the site, it will be possible to eliminate certain historical scenarios as unlikely.

In this research, two approaches are used for assessing the character of cultural changes on the site: 1) visualization of artifact variability (qualitative and quantitative attributes, paradigmatic types, morphotypes) through time, where any marked changes (e.g. sudden appearances and disappearances of elements) should be visible; 2) quantification of magnitudes of changes between the adjacent temporal units, to determine if the relative magnitude of changes between certain temporal units is larger than between other units. These approaches will be used to observe the nature of changes (such as sudden vs. gradual) in analytical units defined in the previous chapters – attributes of artifacts, paradigmatic types, and artifact morphologies. A more detailed explanation of each of these inferential methods will be described below.

Possible sampling effects for the compared assemblages (collections of artifacts in different temporal units) were assessed using bootstrapping (e.g. Lipo et al. 1997). The goal of bootstrapping is to evaluate how well some sample statistics that we use – e.g. richness for qualitative attributes, mean for quantitative attributes – estimate the underlying population-level parameters. The bootstrapping is conducted by resampling with replacement from our data (samples) and observing the stability of desired statistics. It starts with a low number of resampled observations, for example 10, meaning that 10 observations will be randomly selected from our sample, followed by a calculation of the desired statistic (e.g. mean or richness). Such procedure is repeated for the incrementally larger number of resamples (e.g. 10, 20, 30, etc.) until our original sample size is reached. For every number of resamples, a random generation of observations is repeated 1000 times to incorporate the effects of chance. If our sample size is sufficient, the desired statistic should stabilize around a certain value before reaching our original sample size. If not, the observed statistic will vary in each resampling and will not stabilize.

In the following text, two approaches for assessing the character of cultural changes on Belo brdo will be described.

Visual observation of artifact variability in different temporal units

Visualization is one of the first steps in exploring the data, and it is one of the most intuitive ways to reveal patterns in the data (e.g. Lyman 2015). To compare the variability of different analytical units throughout the sequence of Belo brdo, the appropriate visualizations will be created. For qualitative data, i.e. qualitative attributes (e.g. platform type for lithics, eye shape for figurines) and paradigmatic types, the battleship plots (e.g. O'Brien, Lyman 2000) will be created. Battleship plots, originally devised as a tool for relative dating, display the proportions of each cultural element (attribute modality such as the triangular shape of eyes; or paradigmatic types) in each temporal unit (TU). In this way, it is possible to see if there are changes in the presence/absence and relative frequency of different attribute modalities and if these changes are sudden or gradual. For univariate quantitative attributes, i.e. measurements, the changes in the distribution of values will be observed using the box-plot diagrams (e.g. Van Pool, Leonard 2011: 57). Box-plot is a suitable tool for exploring the changes in both central tendency and dispersion of continuous traits. Finally, for the multivariate data from shape analysis using the geometric morphometrics, the temporal dynamics will be observed on the PCA plots. The Principal Component Analysis is a multivariate technique that is suitable for summarizing the variability of multiple variables in a low number of dimensions (usually two or three) and for exploring the patterns in the data (e.g. Shennan 1997: 265-303).

All graphical visualizations in this thesis were created using the R programming software version 3.6.3 (R Core Team, 2020) and the following packages: *ggplot2* v. 3.3.3 (Wickham 2016), *plotrix* 3.8-1 (Lemon 2006), *Momocs* v. 1.3.2 (Bonhomme et al. 2014). For the majority of graphs, the visual theme made by Koundinya Desiraju was used for producing the publication-ready graphs (https://rpubs.com/Koundy/71792, assessed on the 7th April 2022).

Assessing the magnitude of changes between different temporal units

Besides visually observing the differences in artifact variability between different temporal units, quantitative tools were used to further assess the character of these differences. Although different statistical tests were performed to explore if there are notable changes in artifact variability, statistically significant differences do not necessarily imply discontinuous changes – they can be a consequence of an aggregate (cumulative) effect of gradual temporal changes. Therefore, statistical tests coupled with other quantitative tools, such as effect sizes, were used to assess if the relative magnitudes of differences are higher between certain pairs of temporal units (cf. Tostevin 2000; 2003; 2012). For exploring the changes in qualitative attributes, the Chi-square test of homogeneity (e.g. Mann 2013: 540-541) was used for comparing the proportions of qualitative attributes in different temporal units. The Chi-square test of homogeneity aims to assess whether two (or more) groups are from the same population or not, based on the proportions of different modalities in each of them. The magnitude of changes in qualitative attributes between adjacent pairs of temporal units was measured using the Brainerd-Robinson (BR) coefficient (Robinson 1951), suitable for comparing frequencies of attribute modalities and paradigmatic types in different temporal units. It was calculated using the *BRsim* function by G. Alberti (http://cainarchaeology.weebly.com/r-function-for-brainerd-robinson-similarity-coefficient.html). The original BR similarity coefficient ranges from 0 (maximum dissimilarity) to 200 (maximum similarity), but it was rescaled to values between 0 and 1 by choosing this option in the *BRsim* function. In order to transform this similarity measure into a dissimilarity coefficient, the values of the coefficient of similarity were subtracted from 1. The resulting values of the Brainerd-Robinson dissimilarity coefficient represent a quantitative measure of differences in the structure of frequencies for the two artifact collections (for types it can be labeled 'typological distance'). By calculating the BR distance as a measure of differences between the pairs of adjacent temporal units, it will be determined if the relative magnitudes of differences are higher between certain pairs of temporal units, e.g. between 7.2-6.5m and 6.5-6.05m if research hypothesis 1 is correct.

For univariate quantitative traits (linear measurements), the Kruskal–Wallis H test was employed for examining if there are significant differences in values of temporal groups, as the assumptions for one-way ANOVA test were continually violated. The relative magnitudes of changes between the temporal units were assessed by using the *r*-value, the effect size for the Mann-Whitney U test (Field 2012: 664-665), which was used because of unbalanced samples and constant violations of the assumption of normality. The value of *r* ranges between 0 (no effect) and 1 (large effect size).

Finally, to compare the morphology of artifacts in different time units, the permutational Multivariate Analysis of Variance (PERMANOVA) (e.g. Anderson, Walsh 2013) was used, which examines if groups differ on a combination of variables, i.e. whether the multivariate means of groups are significantly different. The magnitudes of changes in the morphology of artifacts in different time units were also analyzed using *r*-values for differences on each of the main principal components, as there is no standard measure of effect size for the pairwise PERMANOVA test which is appropriate for the multivariate comparisons between the groups when the assumptions of normality and homoscedasticity are not met.

All statistical analyses in this research were done using the R programming language (R Core Team, 2020) and the following packages: *dplyr* v. 1.0.3 (Wickham et al. 2021), *lsr* v. 0.5.2 (Navarro 2015), *vegan* 2.5-7 (Oksanen et al. 2020).

7.2. The character of changes in lithic production (1929-1934 collection)

As mentioned, only the chert collection was used for a detailed assessment of diachronic changes in lithic technology. The number of chert finds in each temporal unit is shown in **Figure 7.1,** showing some fluctuations in the early and middle part of the sequence, but a more pronounced decline in the final Late Neolithic (temporal units 3.5-2.5 m and 2.5-1.3 m) seem to be more indicative of some decrease in production (cf. Bogosavljević Petrović 2015: 313-404). When only the prismatic blades are selected, the finds are somewhat more equally distributed according to temporal units (**Figure 7.2**).

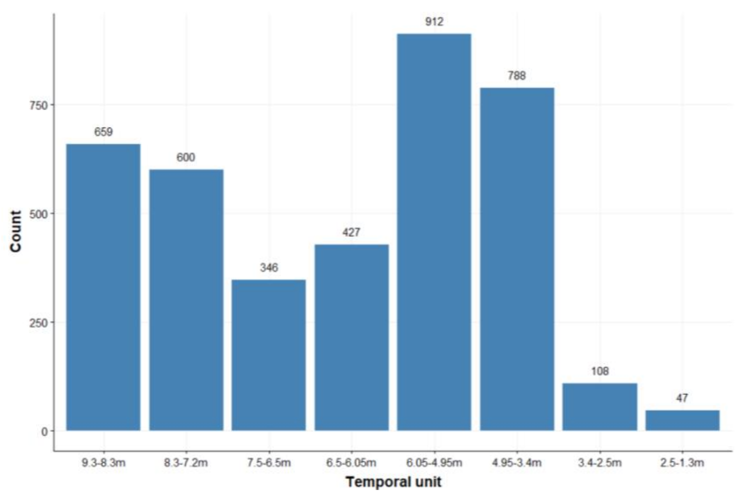


Figure 7.1. Frequencies of chert finds in each 100-year-long temporal unit.

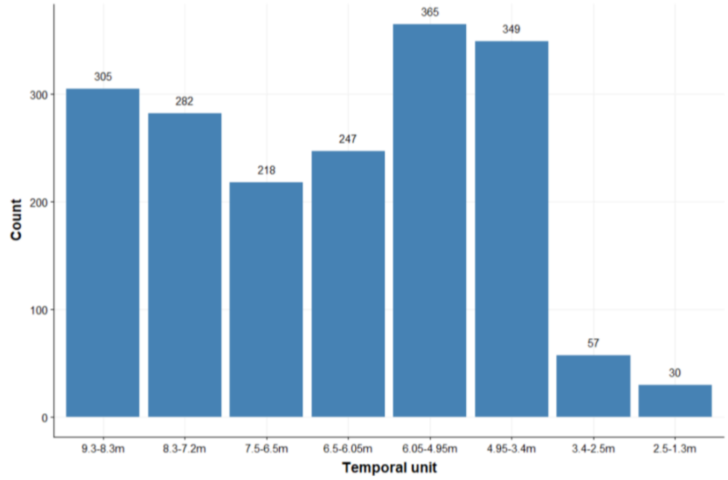


Figure 7.2. Frequencies of blades in each 100-year-long temporal unit.

Before presenting the results of diachronic changes in blade production technology, it will be evaluated if the temporal units have roughly comparable lithic collections. As mentioned (see Chapter 6), the parameters for assessing the comparability of collections are the structure of collections, percentage of cortical blade blanks, percentage of retouched blades, and Clarkson's index of invasiveness. **Figure 7.3** shows that the percentages of different types of products are similar for different temporal units, except for the two latest temporal units (Vinča 3.5-2.5m and Vinča 2.5-1.3m) that have low sample sizes. The Chi-square test of homogeneity shows that the structure of collections between the groups is statistically different (n = 3887[15], $\chi^2 = 37.642$, df = 14, $p < 0.01$). However, the Cramer's V shows a weak effect (Cramer's V = 0.07), indicating that the statistical significance is a consequence of small differences and a large sample size. Concerning the percentages of blades with the cortex, their proportions in different temporal units are significantly different (n = 1853, $\chi^2 = 15.135$, df = 7, p = 0.03), but these differences are slight as shown by the effect size (Cramer's V = 0.09). The proportion of retouched blades in different temporal units is marginally different ($\chi^2 = 13.014$, df = 7, p-value = 0.07), while the Cramer's V shows a weak effect (Cramer's V = 0.08). Finally, there are no statistically significant differences in the values of Clarkson's index of invasiveness between the groups (n = 259, Kruskal-Wallis H = 4.83, df = 7, p = 0.68; **Figure 7.4**). All these parameters indicate that the lithic collections from different temporal units have a similar structure and are comparable.

[15] A lower number of finds here than in the Materials section is a consequence of excluding the finds that do not have a precise relative depth (e.g. 5.5 m), but rather a relative depth in a certain range (e.g. 5.9-5.0 m).

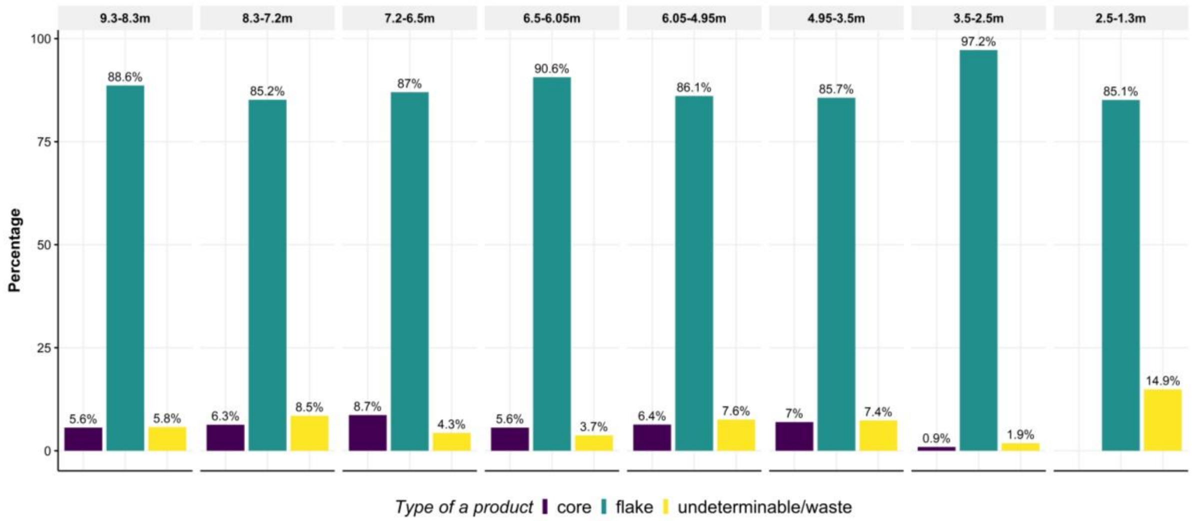


Figure 7.3. Percentages of different types of products in different temporal units.

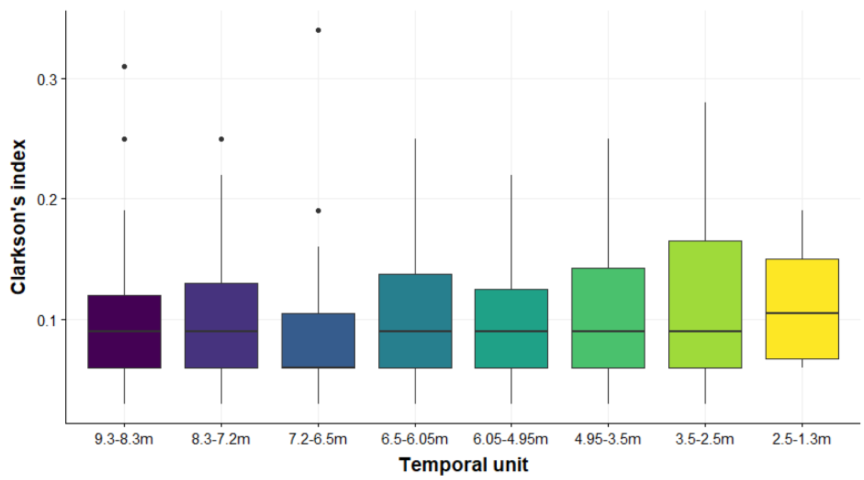


Figure 7.4. The values of Clarkson's index of invasiveness for retouched blades in each temporal unit.

7.2.1. Diachronic changes in attributes of prismatic blades

In this section, it will be explored if there are notable changes in the most relevant attributes of blades that are proxies of various production and maintenance strategies. Assessment of changes in metrical attributes will be followed by a presentation of changes in qualitative attributes.

Length of whole unretouched blades

The bootstrapping, a tool for exploring if the sample statistics provide good estimates of the population parameters, has shown that the population mean of blade length might be very poorly estimated for the youngest temporal units (3.5-2.5m and 2.5-1.3m), as the values of mean in different sampling repetitions do not stabilize (**Figure 7.5**[16]). For other temporal units, the estimation of the mean should be fairly robust. The visual assessment of the length of whole unretouched blades shows that there are

[16] In order to maintain the readability of the text, the bootstrapped distributions will not be shown for other attributes and types. Instead, it will be only noted if samples provide robust estimates of population parameters or not.

no sudden, discontinuous changes in this attribute (**Figure 7.6**), besides a higher mean in the latest temporal unit (Vinča 2.5-1.3 m), but this should be taken with caution due to a small, unrepresentative sample from this period (**Table 7.2**). The mean length of blades gradually increases from the oldest to the youngest levels (from 40.9 to 52.1 mm), although the Kruskal-Wallis H test does not indicate significant differences between the groups (n = 173, H = 7.3, df = 7, p = 0.4).

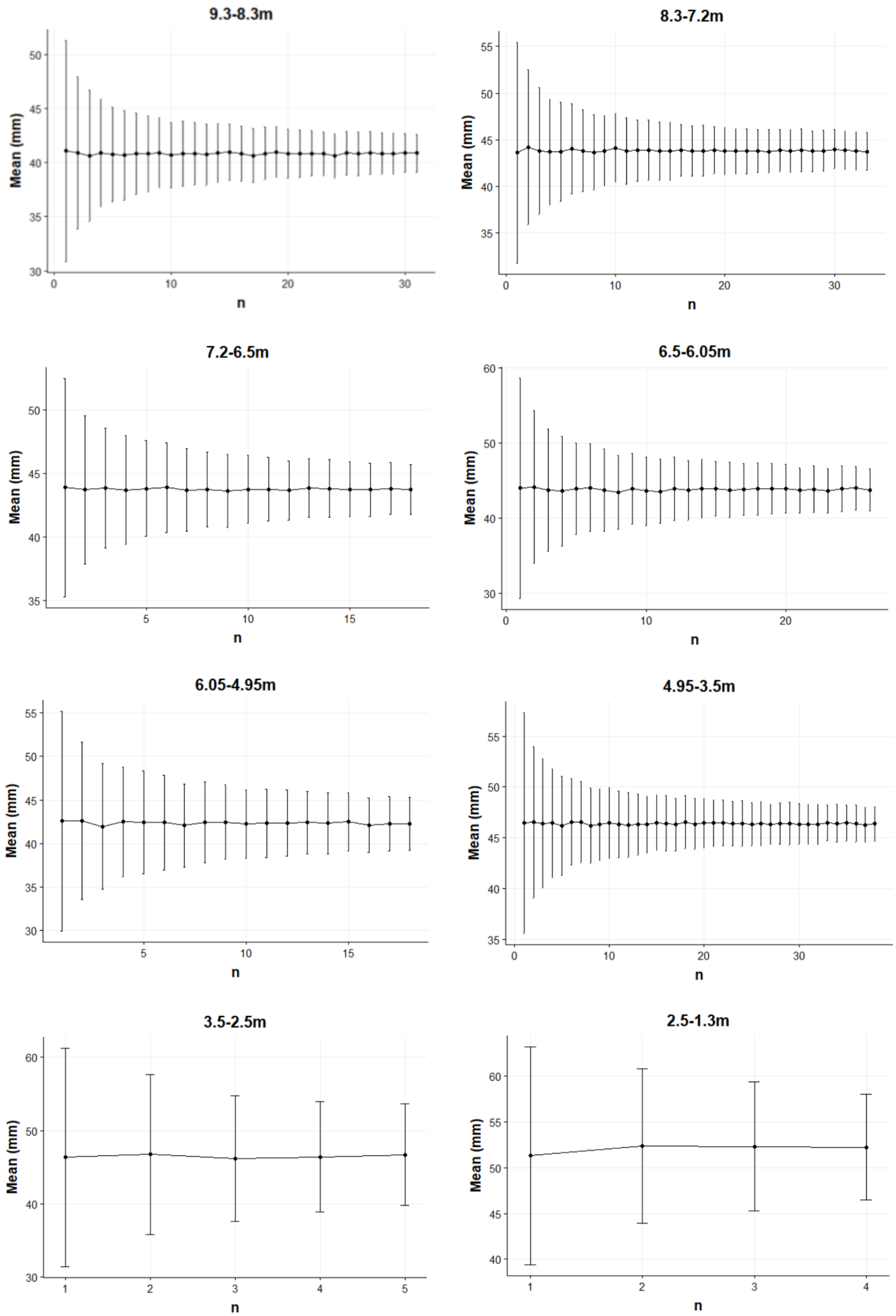


Figure 7.5. Bootstrapped distribution of the mean length of whole unretouched blades for each temporal unit.

Table 7.2. Descriptive statistics for the length of whole unretouched blades grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	31	40.9	10.2
8.3-7.2m	33	43.8	11.6
7.2-6.5m	18	43.8	8.7
6.5-6.05m	26	43.8	14.6
6.05-4.95m	18	42.3	13.2
4.95-3.5m	38	46.4	10.8
3.5-2.5m	5	46.5	17.1
2.5-1.3m	4	52.1	13.6

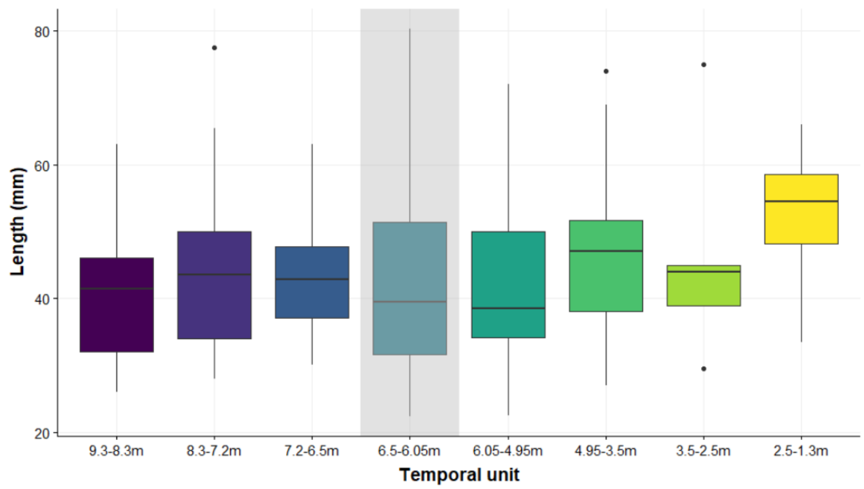


Figure 7.6. Box-plot showing values of length for whole unretouched blades in different temporal units. The Gradac phase is shaded in grey.

Concerning the length of whole unretouched blades, the magnitudes of changes between the adjacent temporal units, as measured by *r* values, show oscillations throughout the sequence (**Figure 7.7**). The *r* values indicate that the largest changes in blade length occur between the following temporal units: 9.3-8.3m and 8.3-7.2m; 6.05-4.95m and 4.95-3.5m; and 3.5-2.5m and 2.5-1.3m. For the transition to the Gradac phase (i.e. between TU 7.2-6.5m and TU 6.5-6.05m), the magnitude of changes in blade length is smaller (r = 0.08) than for some other temporal changes, contrary to expectations of the research hypothesis 1. The largest changes in blade length happen with the transition to the latest temporal unit (2.5-1.3m), but the conclusions based on such small sample sizes (n_1 = 5, n_2 = 4) are questionable. There is a general trend of larger changes in the initial and final Late Neolithic and smaller changes in the middle part of the sequence, but conclusions based on small samples from the two youngest temporal units should be taken with caution.

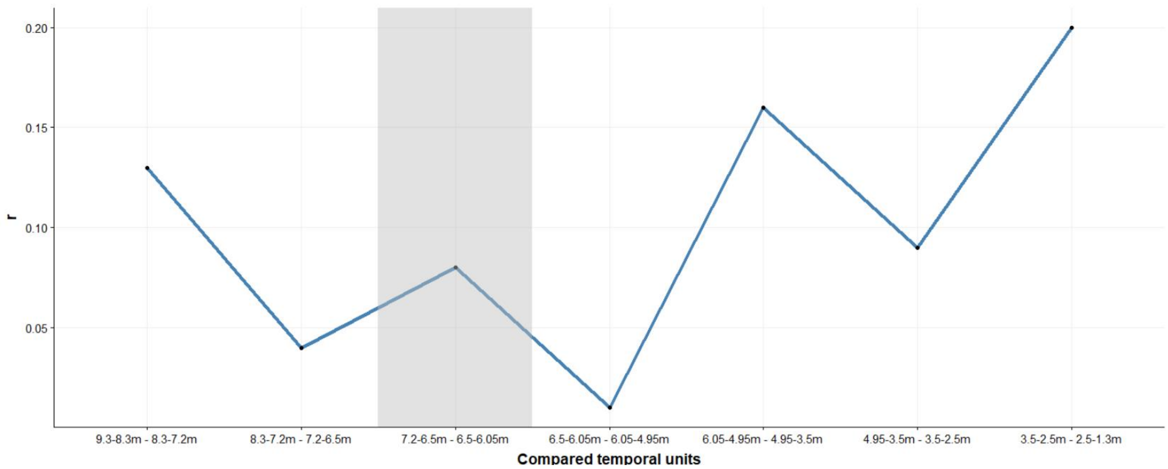


Figure 7.7. Magnitudes of changes in blade length between adjacent temporal units, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Width of the medial part of whole unretouched blades

The bootstrapping of the values of the width of the medial part for whole unretouched blades has indicated the same conclusions about the samples – the estimates of the mean for the youngest temporal units (3.5-2.5m and 2.5-1.3m) are not robust, while for the other temporal units they are sufficient (**Table 7.3**) for making some general insights. The visualization of the width of the medial part of the blades according to temporal units (**Figure 7.8**) indicates certain changes in this attribute, but the differences between the groups are not statistically significant ($n = 173$, $H = 6.09$, $df = 7$, $p = 0.53$). The width of the medial part of blades slightly increases from the earliest temporal unit until the TU 7.2-6.5m, then decreases slightly in the following temporal unit (TU 6.5-6.05m) before increasing gradually again in the later temporal units. The width of the medial part more notably increases in the last two temporal units, but their sample size is not sufficient for making any sound conclusions.

Table 7.3. Descriptive statistics for the width of whole unretouched blades grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	31	11.7	3.3
8.3-7.2m	33	12.0	4.4
7.2-6.5m	18	13.8	3.8
6.5-6.05m	26	12.0	3.7
6.05-4.95m	18	12.2	4.1
4.95-3.5m	38	12.5	3.3
3.5-2.5m	5	13.4	2.8
2.5-1.3m	4	14.9	4.5

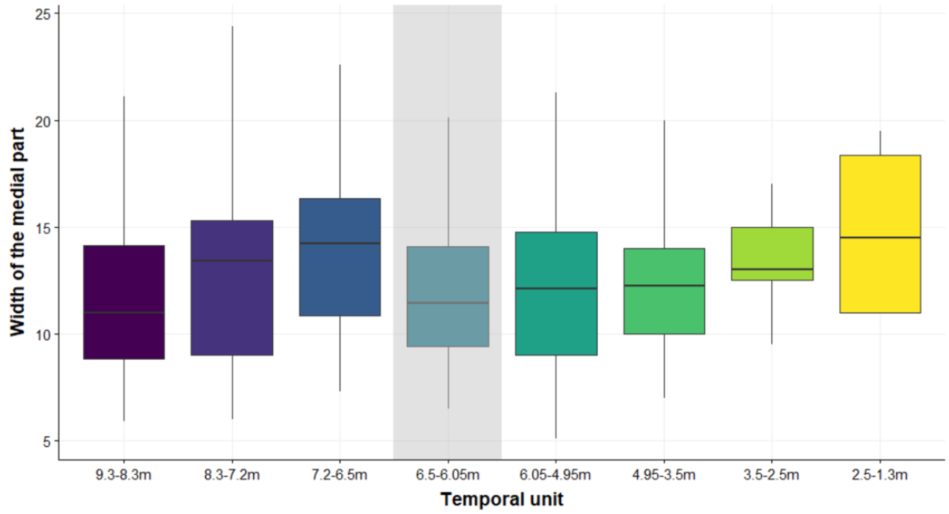


Figure 7.8. The box plot showing the values of the width of the medial parts of blades according to temporal units. The Gradac phase is shaded in grey.

The magnitudes of differences in values of medial width between the pairs of temporal units are shown in **Figure 7.9**. The largest changes are between temporal units 7.2-6.5m and 6.5-6.05m (r = 0.23), i.e. with the onset of the Gradac phase, in line with the research hypothesis 1. Like in the case of blade length, the changes are generally larger in the beginnings and the ends of the sequence, although the changes between 7.2-6.5m and 6.5-6.05m deviate from this pattern.

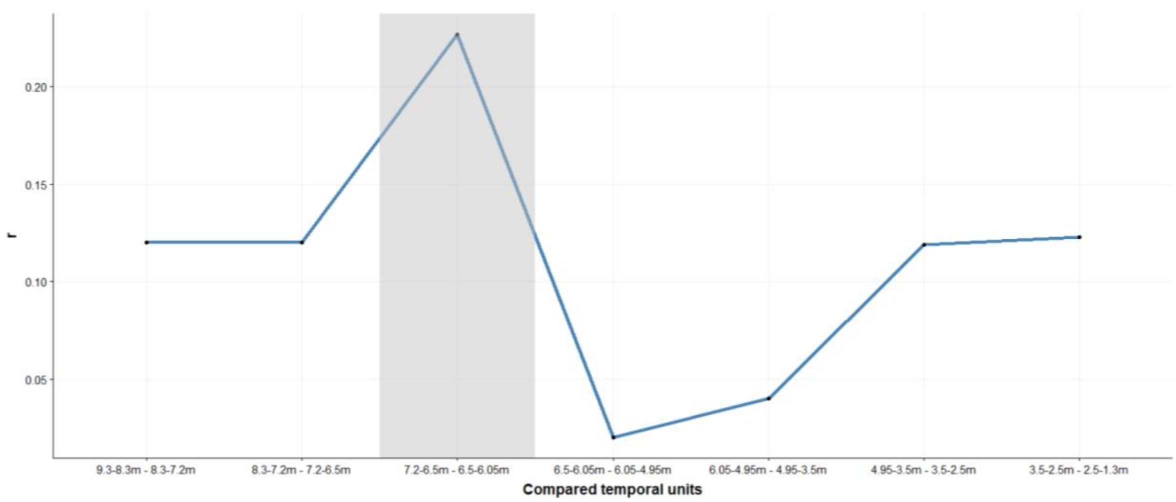


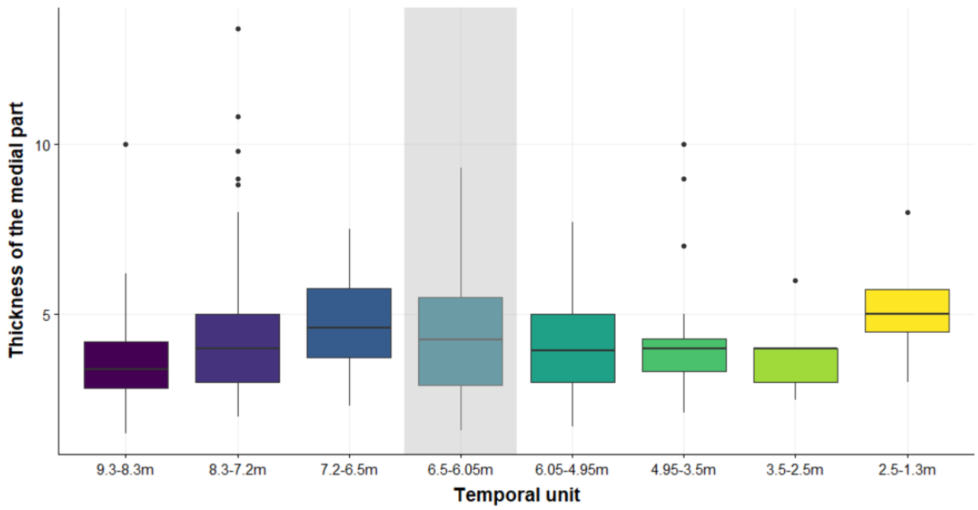
Figure 7.9. Magnitudes of diachronic changes in the width of the medial part of whole unretouched blades, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Thickness of the medial part of whole unretouched blades

The same sample of whole unretouched blades was investigated for changes in the thickness of the medial part, so the bootstrapping again indicated a poor estimation of the population means for the two youngest temporal units. **Table 7.4** with descriptive statistics and the box plot (**Figure 7.10**) show that there is a gradual increase in the thickness from the oldest levels until the Gradac phase, followed by a gradual decrease in thickness in the younger phases, before suddenly increasing in the youngest temporal unit (2.5-1.3m). However, these differences are not statistically significant (n = 173, H = 10.132, df = 7, p = 0.18).

Table 7.4. Descriptive statistics for the thickness of whole unretouched blades grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	31	3.7	1.7
8.3-7.2m	33	4.9	2.9
7.2-6.5m	18	4.8	1.4
6.5-6.05m	26	4.6	2.1
6.05-4.95m	18	3.9	1.5
4.95-3.5m	38	4.2	1.6
3.5-2.5m	5	3.9	1.3
2.5-1.3m	4	5.2	2.1



7.10. Box-plot comparing values of thickness of the medial part of whole unretouched blades in different temporal units. The Gradac phase is shaded in grey.

The magnitudes of changes as measured by *r* show the following trend – the magnitude of changes decreases within the sequence, before first slightly (between 4.95-3.5m and 3.5-2.5m) and then sharply (between 3.5-2.5m and 2.5-1.3 m) increasing for the transition to the last two temporal units (**Figure 7.11**). The value of *r* for the transition to TU 2.5-1.3 m is 0.34, indicating a moderate effect size. Research hypothesis 1 about sudden changes with the Gradac phase is not supported by the diachronic changes in the thickness of the medial part of whole blades.

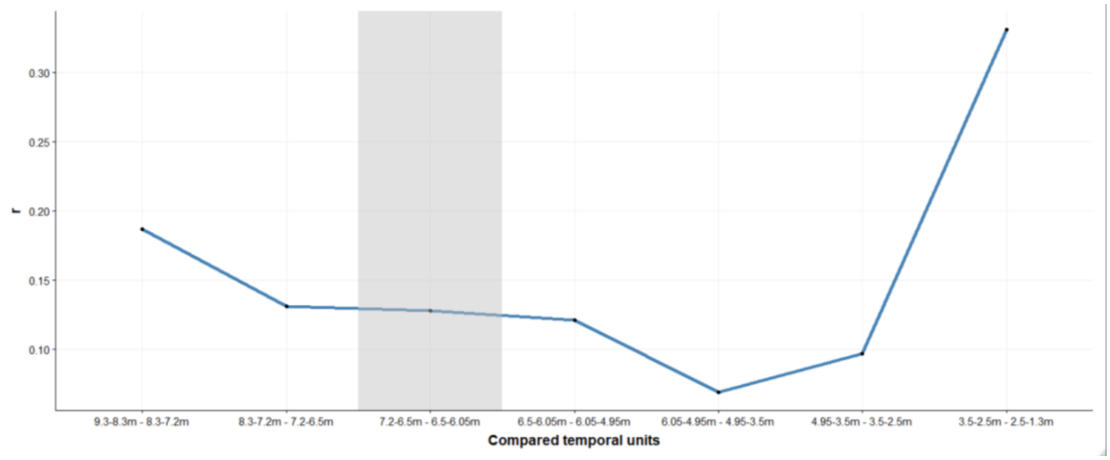


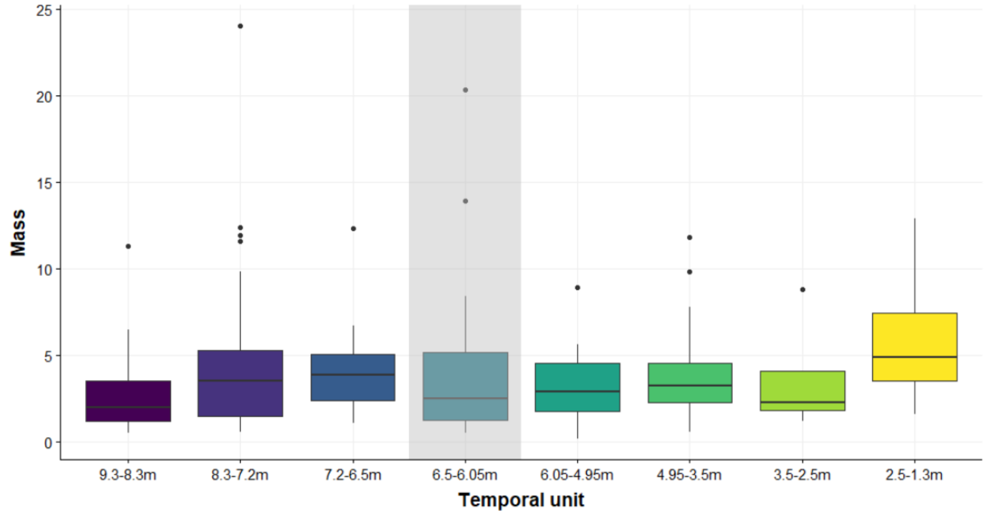
Figure 7.11. Magnitudes of changes in the thickness of whole unretouched blades between adjacent temporal units, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Mass of whole unretouched blades

Mass is a more comprehensive measure of the size of blade blanks. Like in the previously presented results based on whole unretouched blades, the latest two temporal units have small sample sizes. The distribution of mass of whole unretouched blades shows that there are gradual changes in the mass of blades throughout the sequence (**Table 7.5, Figure 7.12**), with the exception of more notable changes in blade mass in the final temporal unit (2.5-1.3m), when the mean mass increases from 3.6 to 6.1 g. However, none of the changes is statistically significant (n = 173, H = 8.03, df = 7, p = 0.33). There are no notable changes in the mass of blades at the beginning of the Gradac phase.

Table 7.5. Descriptive statistics for the mass of whole unretouched blades grouped by temporal units.

Temporal unit	Count	Mean (g)	SD (g)
9.3-8.3m	31	2.8	2.4
8.3-7.2m	33	4.7	4.8
7.2-6.5m	18	4.1	2.6
6.5-6.05m	26	4.2	4.5
6.05-4.95m	18	3.2	2.1
4.95-3.5m	38	3.8	2.4
3.5-2.5m	5	3.6	3.1
2.5-1.3m	4	6.1	4.8



7.12. Box-plot comparing the mass of whole unretouched blades in different temporal units. The Gradac phase is shaded in grey.

The magnitudes of changes as quantified by r values are shown in **Figure 7.13**. The largest changes happen with the onset of the latest temporal unit (2.5-1.3 m) (*r* = 0.33). The magnitude of change is somewhat smaller for the beginning of the 8.3-7.2m temporal unit, while the r values are similar for the beginning of the Gradac phase, the transition to TU4.95-3.5m, and the transition to 3.5-2.5m. The smallest magnitude of changes in the mass of whole unretouched blades happens with the 6.05-4.95 temporal unit.

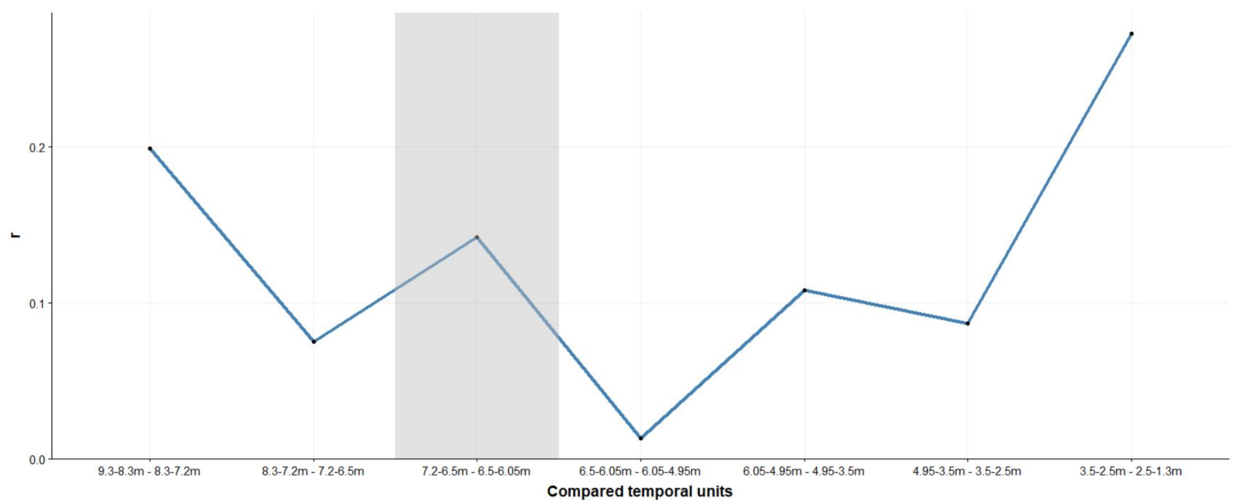


Figure 7.13. Magnitudes of changes in the mass of whole unretouched blades between adjacent temporal units, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Dimensions of the striking platform

As mentioned, a high number of blades are fragmented (see Chapter 5), either intentionally or unintentionally. There is a possibility that the whole unretouched blades are not a representative sample of originally produced blades. For example, Vinča inhabitants might have intentionally fragmented only the larger blades, or there is some other reason to question the representativity of unbroken blades (e.g. thinner blades are more prone to breaking). For this reason, the possible changes in the size of the original blade blanks were also assessed indirectly, by observing the changes in the dimensions of the striking platform. Although there is a complex relationship between the dimensions of the striking platform and the size of blade blanks, larger striking platforms are generally expected for larger blades, especially when the punctiform platforms are excluded (Muller, Clarkson 2014). Thus, the changes in platform dimensions were used here as robust indicators of relative changes in blade size. Note that this approach can be imprecise for the exact estimations of blade mass (Hiscock, Clarkson 2010), but it will be used here as a very robust indicator of relative changes in blade size.

The platform size is calculated as a product of platform width and platform thickness. This measure certainly overestimates the platform area, but there was no better solution at this level of analysis. As both unbroken and broken blades were included in this analysis, the samples are generally much larger (**Table 7.6**) and provide better estimates of population parameters, with the exception of samples of blades from the youngest temporal unit which did not exhibit the stable values of mean platform area in bootstrapping. The diachronic changes in platform area for both whole and fragmented blades are shown in **Figure 7.14**. The visual assessment shows no discontinuous changes in the platform area of blades – there are gradual oscillations in this attribute with a general tendency toward higher values of platform area values in the younger levels. Differences between the groups are significant at 0.05 level (n = 863, H = 20.54, df = 7, $p < 0.01$), but the effect size is small ($r = 0.1$).

Table 7.6. Descriptive statistics for the platform area of whole and fragmented blades grouped by temporal units.

Temporal unit	Count	Mean (mm^2)	SD (mm^2)
9.3-8.3m	154	27.0	18.6
8.3-7.2m	155	31.3	21.2
7.2-6.5m	113	31.4	19.9
6.5-6.05m	119	27.4	17.7
6.05-4.95m	153	25.9	13.2
4.95-3.5m	138	30.2	17.5
3.5-2.5m	22	37.4	22.1
2.5-1.3m	9	40.0	15.6

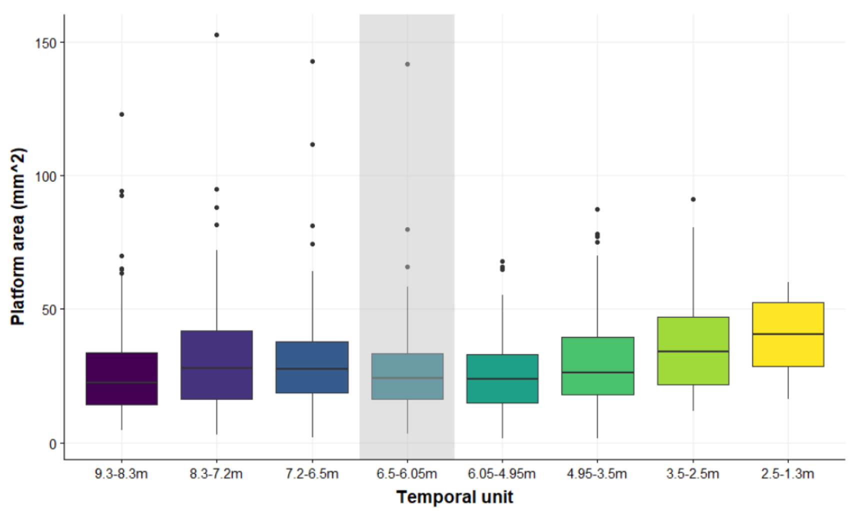


Figure 7.14. Box-plot comparing the values of platform area for whole and fragmented blades in different temporal units. The Gradac phase is shaded in grey.

The magnitude of changes oscillates throughout the sequence (**Figure 7.15**), but the *r* values are generally small, ranging from 0.01 to 0.08. The smallest differences happen with the transition to 7.2-6.5m and 6.05-4.95m temporal units, while other differences are of more or less similar magnitudes. Regarding the platform size, the changes with the Gradac phase are not larger than those at the transitions to most other temporal units.

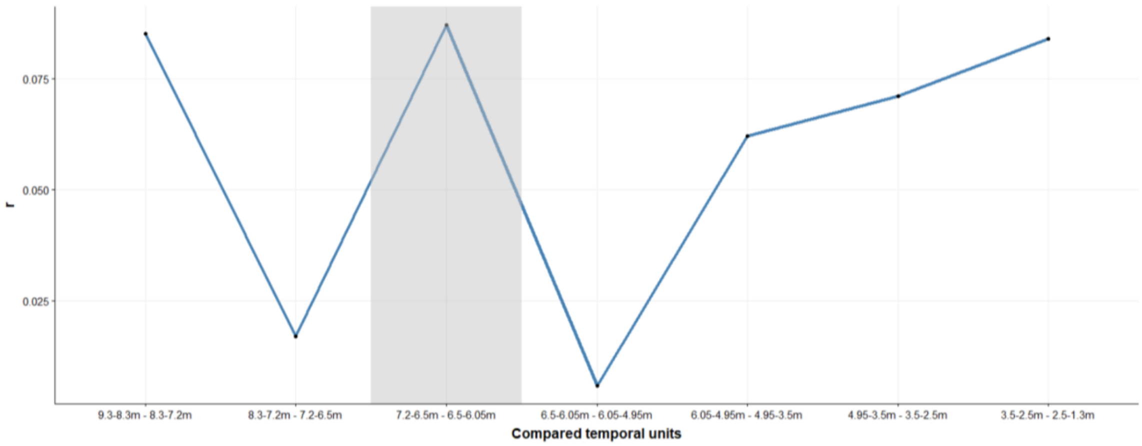


Figure 7.15. Magnitudes of diachronic changes in the platform area of whole and fragmented blades, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Blade elongation

All the previously discussed quantitative attributes were related to the size of blades. The elongation index, calculated as a ratio between blade length and width of the medial part, is a measure related to the shape of blades. As for all other analyses done on whole unretouched blades, the two youngest temporal units have small, unrepresentative samples. Descriptive statistics (**Table 7.7)** and the box plot (**Figure 7.16**) indicate slight diachronic changes in the values of this attribute, with no sudden or discontinuous changes. This is confirmed by the Kruskal-Wallis H test which indicates no significant differences between the groups (n = 173, H = 4.38, df = 7, p = 0.73).

Table 7.7. Descriptive statistics for the elongation index of whole unretouched blades grouped by temporal units.

Temporal unit	Count	Mean	SD
9.3-8.3m	31	3.6	1.0
8.3-7.2m	33	3.6	1.0
7.2-6.5m	18	3.4	1.1
6.5-6.05m	26	3.7	1.0
6.05-4.95m	18	3.6	1.0
4.95-3.5m	38	3.9	1.3
3.5-2.5m	5	3.5	1.2
2.5-1.3m	4	3.6	1.1

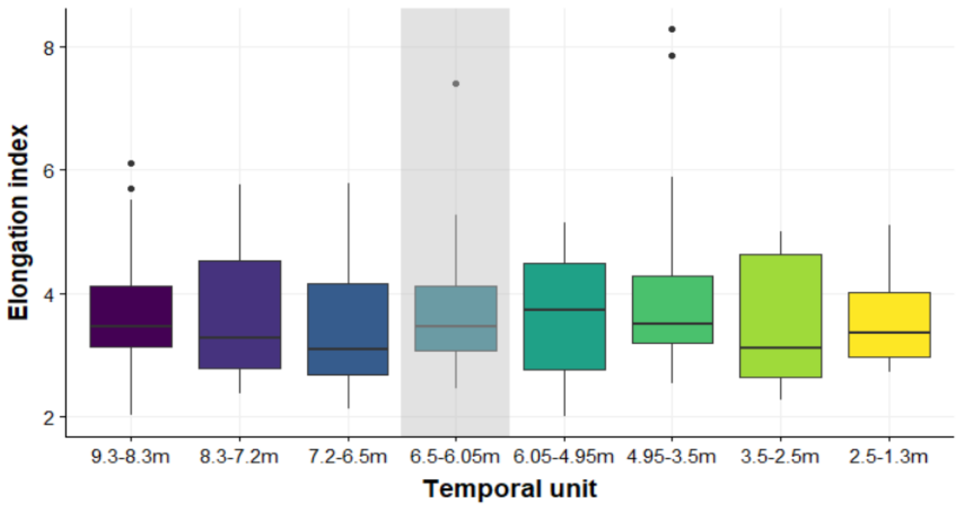


Figure 7.16. Box-plot comparing the values of elongation index of whole unretouched blades in different temporal units. The Gradac phase is shaded in grey.

The magnitudes of changes in blade elongation show certain oscillations within the sequence (**Figure 7.17**). The largest changes occur with the transition to the Gradac phase at 6.5 m (*r* = 0.24). Somewhat less pronounced are the transitions to temporal units 7.2-6.5m, 3.5-2.5m, and 2.5-1.3m, with the *r* values between 0.1 and 0.15. The smallest changes in blade elongation occur with the transition to 8.3-7.2m, 6.05-4.95m, and 4.95-3.5m.

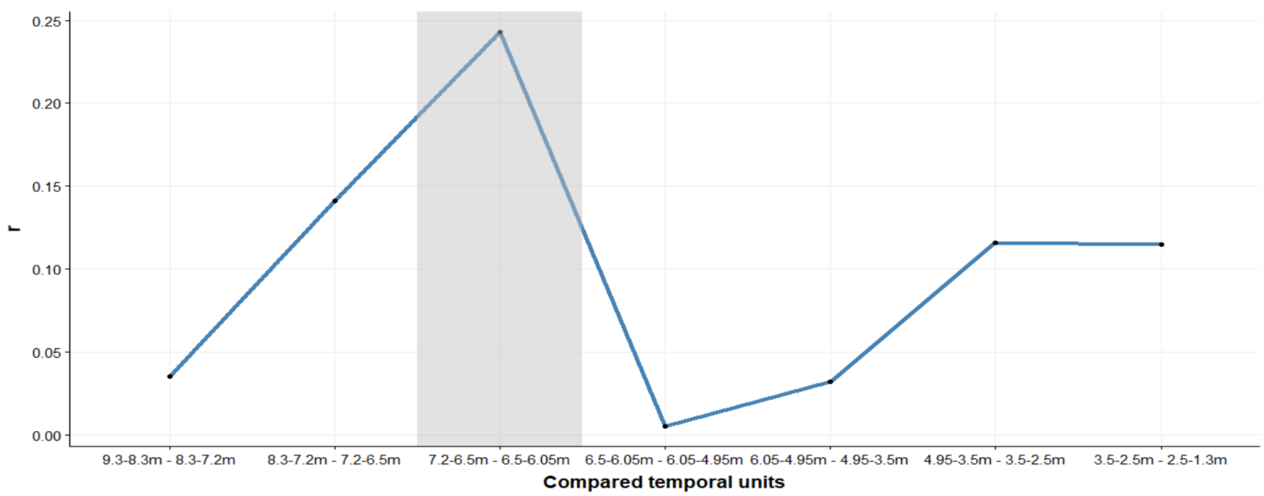


Figure 7.17. Magnitudes of diachronic changes in the elongation of whole unretouched blades, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Number of dorsal negatives

The number of dorsal negatives was counted for both whole and fragmented blades. Due to a large sample size, the bootstrapping has shown that the population estimates are fairly robust for all the samples. The distribution of values is very similar for all the groups, as indicated by the box plot (**Figure 7.18**) and descriptive statistics (**Table 7.8**). This insight is confirmed by the Kruskal-Wallis H test which indicates no significant differences between the groups (n = 1800, H = 8.13, df = 7, p = 0.32). The majority of blades have either two or three dorsal negatives.

Table 7.8. Descriptive statistics for the number of dorsal negatives on whole and fragmented blades grouped by temp. units.

Temporal unit	Count	Mean	SD
9.3-8.3m	305	2.75	0.69
8.3-7.2m	282	2.72	0.69
7.2-6.5m	218	2.68	0.69
6.5-6.05m	247	2.73	0.60
6.05-4.95m	365	2.81	0.76
4.95-3.5m	349	2.77	0.70
3.5-2.5m	57	2.64	0.72
2.5-1.3m	30	2.52	0.74

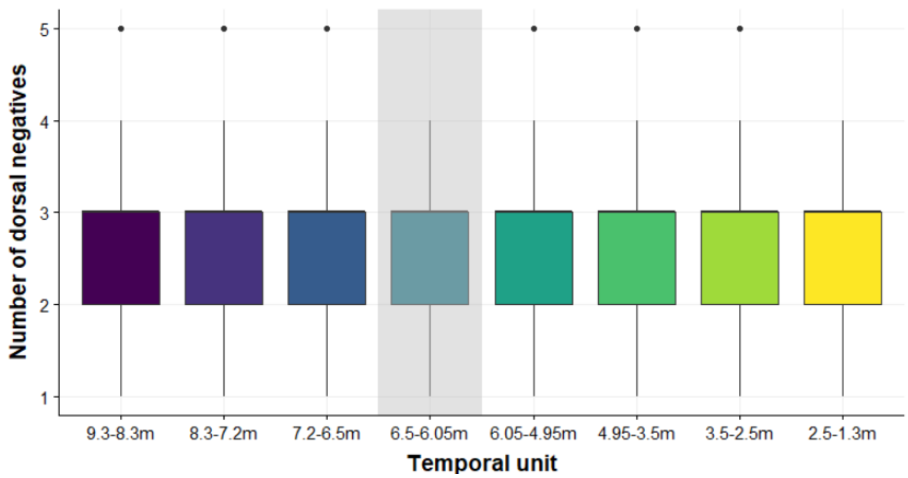


Figure 7.18. Diachronic changes in the number of dorsal negatives on whole and fragmented blades. The Gradac phase is shaded in grey.

The *r* values that measure the magnitude of changes are generally low, ranging between 0.02 and 0.06 (**Figure 7.19**). The most pronounced changes in the number of dorsal negatives occur with the transition to the Gradac phase and with the beginning of the 3.5-2.5m temporal unit.

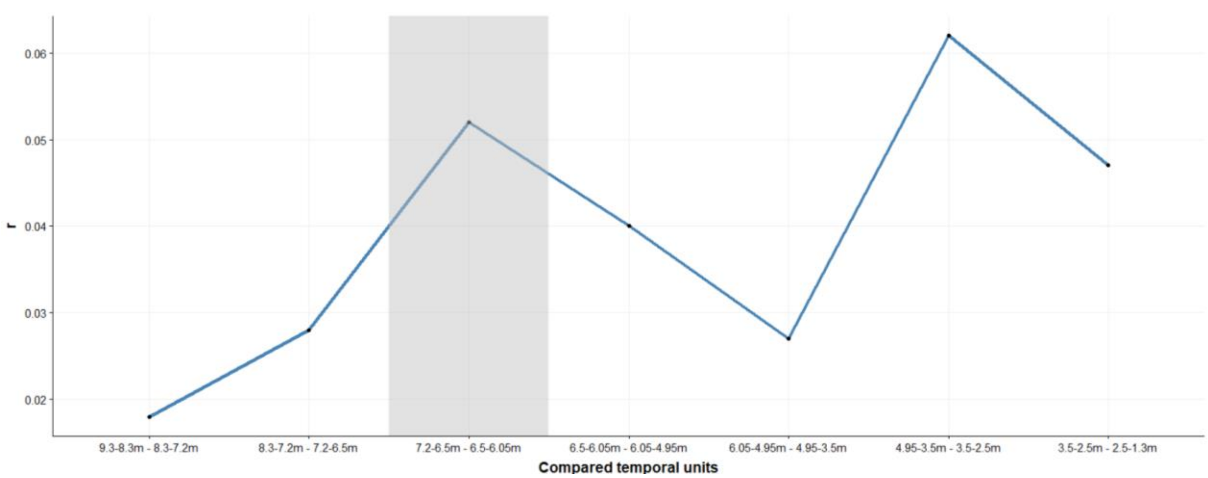


Figure 7.19. Magnitudes of diachronic changes in the number of dorsal negatives on blades, calculated using *r*, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Directionality of removals

Directionality of removals, a qualitative attribute related to a knapping method, was observed on both whole and fragmented blades. The bootstrapping has shown that the estimation of population richness is good for all temporal units except for TU 3.5-2.5m and TU 2.5-1.3m. The battleship plot in **Figure 7.20** shows that the proportion of different patterns of removals is very stable throughout the sequence, where the parallel negatives are most common, while the other modalities are rarely present. This is expected as the unidirectional blade cores predominate in the assemblage (see Chapter 5). There are no sudden changes in the presence/absence or frequency of any modality of this attribute, as the Chi-Square test confirms this insight ($n = 1818$, $\chi 2 = 34.09$, $df = 28$, $p = 0.2$).

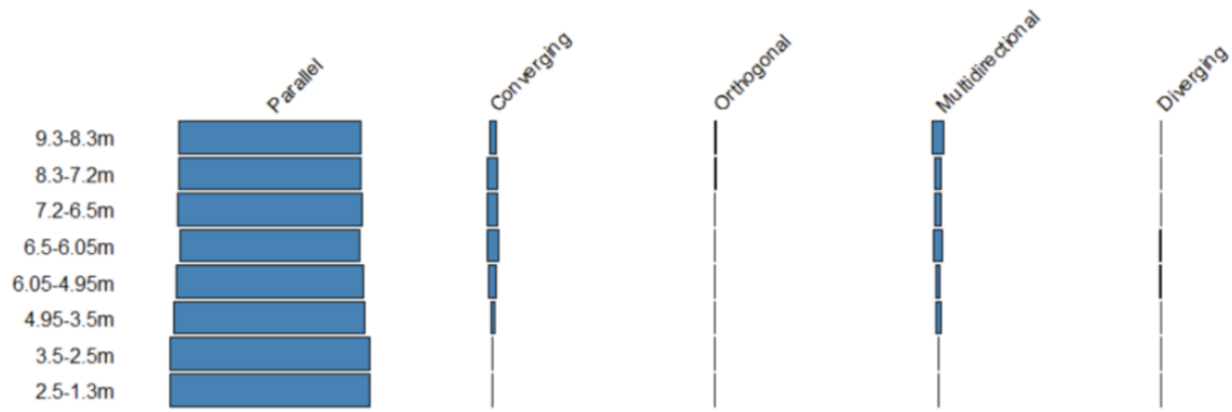


Figure 7.20. The battleship plot showing the proportions of various patterns of directionality of removals in different temporal units.

The magnitude of difference between the temporal units, as measured by the BR dissimilarity coefficient, is generally low (**Figure 7.21**). The coefficient oscillates around 0.02 and 0.03 before increasing to 0.4 with the transition to TU 3.5-2.5m, and subsequently decreasing to the value of 0 for the transition to the latest temporal units, as the two last temporal units have identical proportions of types. However, this might be the consequence of poor estimates of richness for these phases due to low sample sizes.

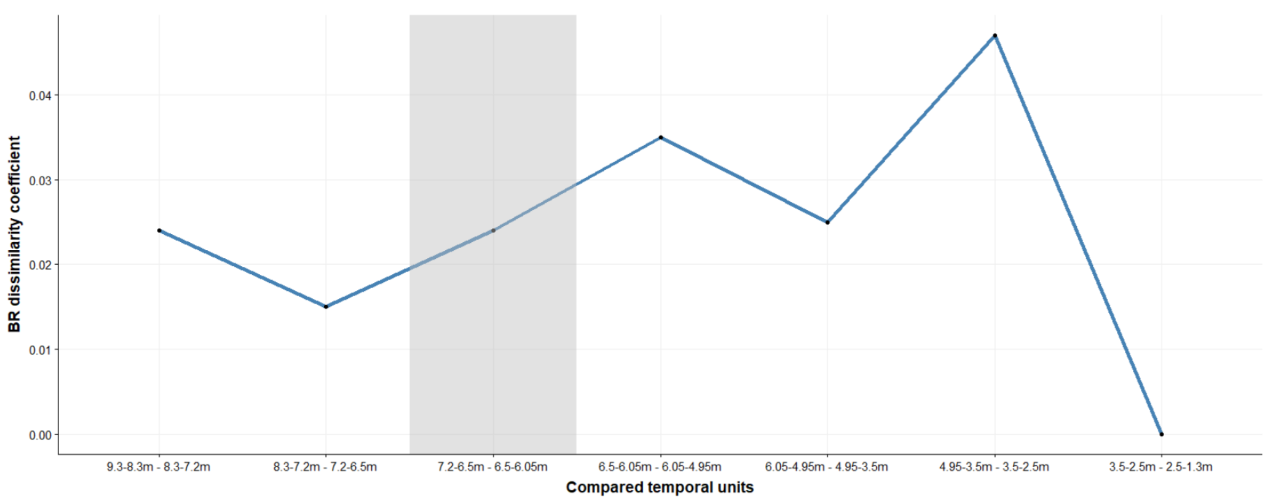


Figure 7.21. Magnitudes of diachronic changes in the directionality of removals on blades, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Debitage profile type

Debitage profile type differs for different knapping techniques (e.g. Pelegrin 2006), so the changes in this attribute would be expected if there are certain changes in the knapping techniques. The bootstrapping has shown that the richness might be very poorly estimated for several temporal units (7.2-6.5m, 6.5-6.05m, 3.5-2.5m, 2.5-1.3m) due to small sample sizes. The battleship plot (**Figure 7.22**) indicates that there are some notable, possibly discontinuous changes in this attribute, but it could be also a consequence of small samples – e.g. 5 and 4 blades in the latest temporal units.

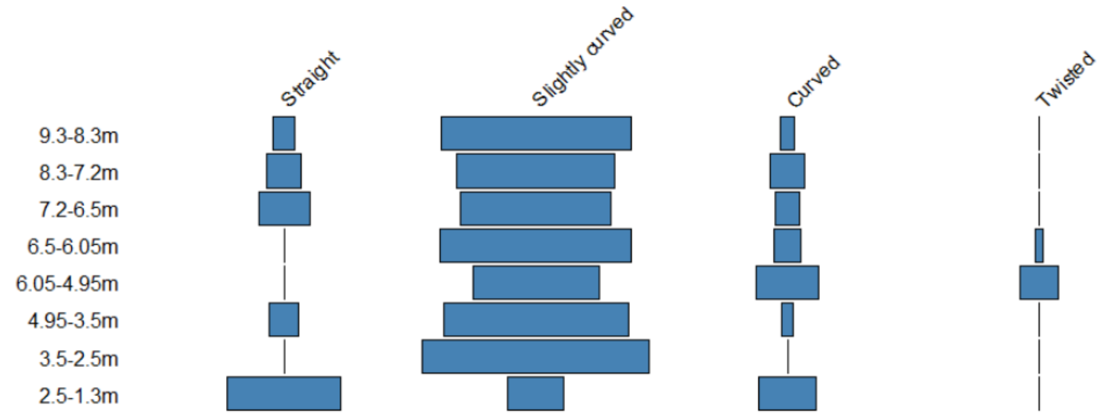


Figure 7.22. A battleship plot showing the diachronic changes in proportions of different profile types for whole unretouched blades.

For this reason, the debitage profile type was also observed for both whole and fragmented blades. Although such an approach probably overestimates the presence of straight blades, as blades can be curved in the non-observed part, there should be no systematic bias that would impact the comparability between the temporal units. When all blades are observed, the distributions of different modalities of debitage profile type do not show discontinuities, but only slight oscillations (**Figure 7.23**). Blades with straight and curved profiles are dominant in all temporal units, while the blades with curved and twisted profiles are rare. The results of the Chi-Square test of homogeneity show that there are differences between temporal units regarding the distribution of different debitage profile types ($n = 1828$, $\chi 2 = 43.53$, $df = 21$, $p < 0.01$), but the effect size is small (Cramer's $V = 0.09$).

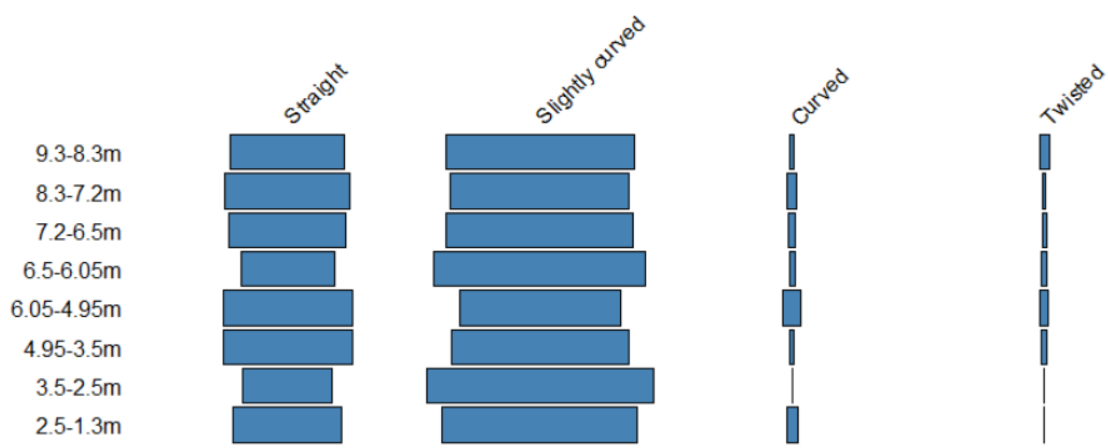


Figure 7.23. A battleship plot showing the diachronic changes in proportions of different profile types for whole and fragmented blades.

The magnitude of changes in debitage profile type of whole and fragmented blades, as measured using the Brainerd-Robinson dissimilarity coefficient, oscillates throughout the sequence (**Figure 7.24**). It is highest (~0.15) for the transitions to 6.05-4.95 and 3.5-2.5 m temporal units, slightly lower for the transition to the latest temporal unit (~0.1), while for the changes with other temporal units it ranges between around 0.04 and 0.08.

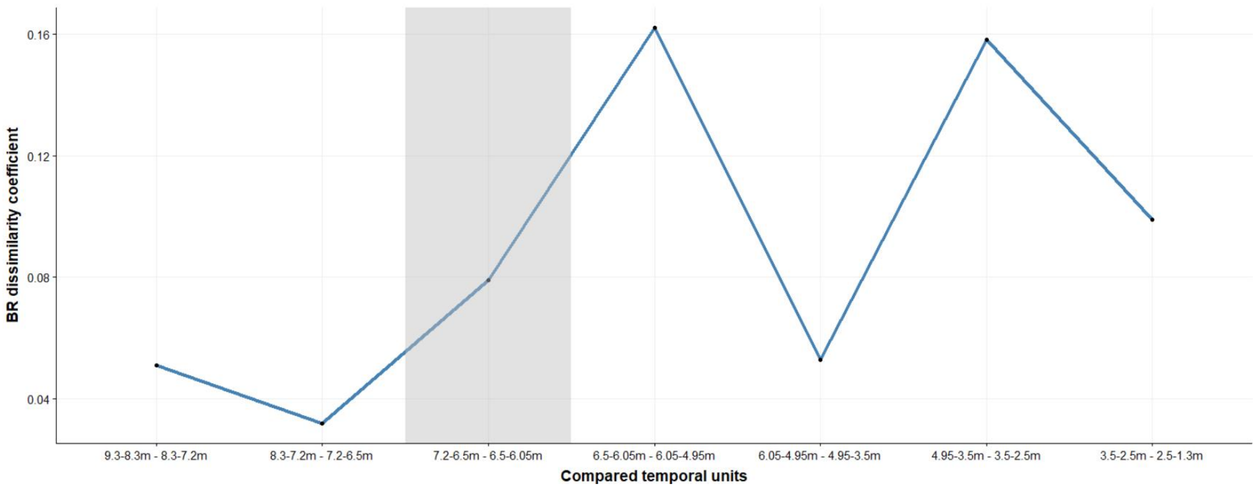


Figure 7.24. Magnitudes of diachronic changes in debitage profile type of whole and fragmented blades, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Distal end

The distal end of blades largely depends on the shape of the debitage surface of cores. This attribute was observed on whole unretouched blades and the distal fragments. The bootstrapping has shown that the increase in sample size could lead to an increase in richness for some samples. The battleship plot shows that the distribution of distal end varieties is largely continuous, with some more notable changes that could be related to the effect of sampling (**Figure 7.25**). Distal ends are most commonly blunt or pointed, while the hinged and overshot distal terminations that indicate knapping errors are quite rare. Interestingly, both hinged and overshot distal ends indicative of knapping errors are present in the earliest temporal units of the site. The Chi-Square test of homogeneity indicates no significant differences between temporal units in the proportions of different distal end types ($n = 453$, $\chi^2 = 19.215$, $df = 21$, $p = 0.57$).

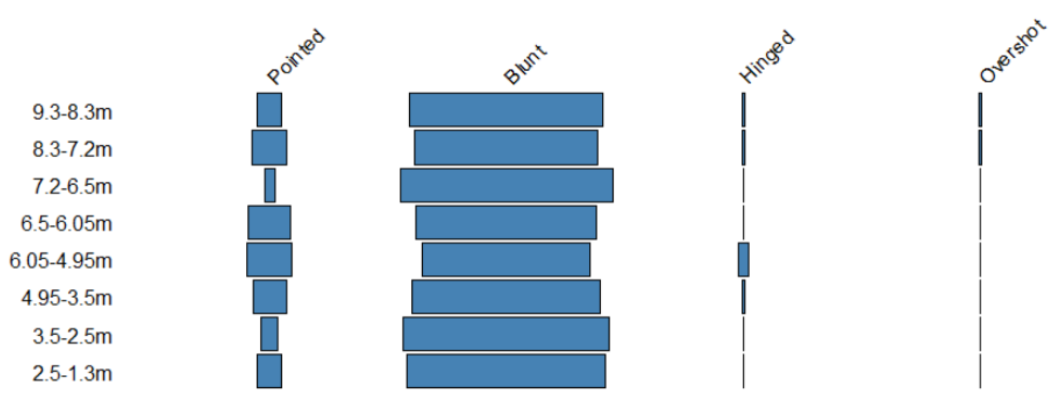


Figure 7.25. A battleship plot showing the diachronic changes in proportions of different distal end types on whole blades and distal fragments.

The magnitude of changes, calculated using the Brainerd-Robinson dissimilarity coefficient, oscillates throughout the sequence (**Figure 7.26**). The lowest values of BR coefficient are for the transition to 8.3-7.2m, 6.05-4.95m, and 2.5-1.3m temporal units, and the highest for the changes at 7.2-6.5m and 6.5-6.05 (Gradac phase) temporal units.

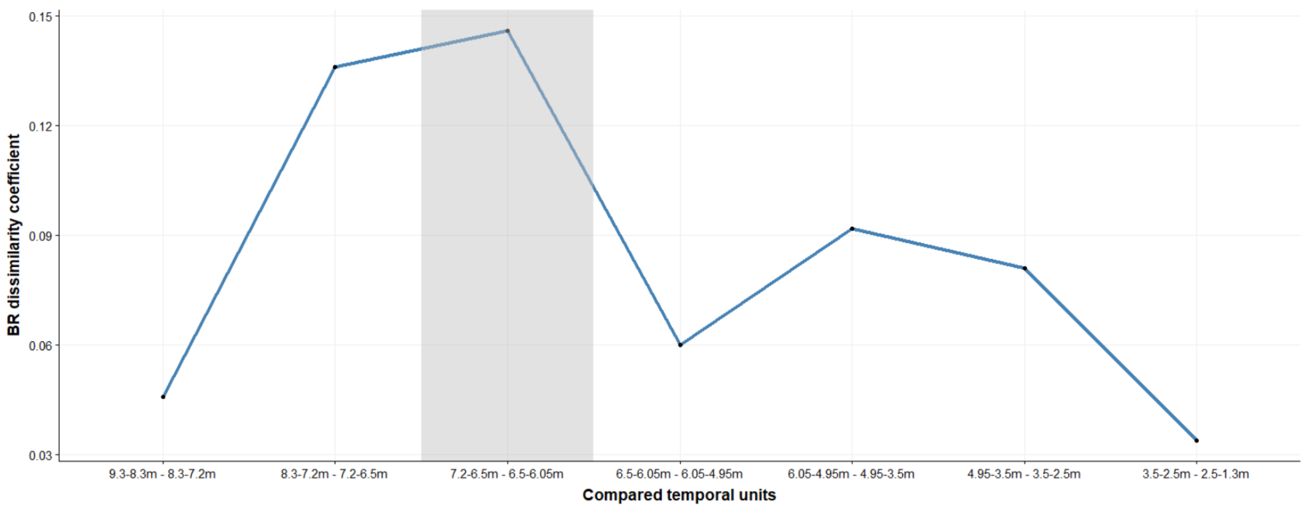


Figure 7.26. Magnitudes of diachronic changes in the distal end termination of whole blades and distal fragments, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Striking platform type

Due to a larger sample size of 731 blades with a preserved striking platform, the bootstrapping has shown that the estimates of richness are fairly robust for most samples except for those from the two latest temporal units. There are no discontinuities in the temporal distribution of platform types, all changes are gradual and the differences between the groups are not statistically significant ($n = 731$, $\chi^2 = 39.79$, $df = 35$, $p = 0.26$). The most common type – smooth striking platform – slowly decreases in relative frequency, while the proportion of facetted striking platform increases (**Figure 7.27**). Other common striking platform types, dihedral and scarred platforms, show gradual increases and decreases throughout the sequence, while the linear platforms are very rare.

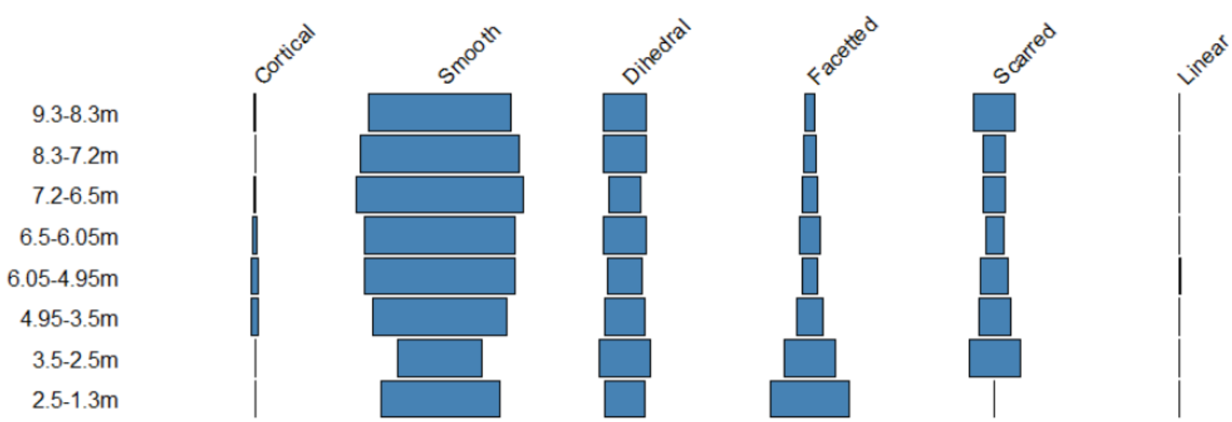


Figure 7.27. A battleship plot showing the diachronic changes in proportions of striking platform types.

The Brainerd-Robinson dissimilarity coefficient is the lowest for the transition to earlier temporal units and the highest for the transition to 3.5-2.5m and 2.5-1.3m temporal units (**Figure 7.28**). The value of the BR coefficient is among the lowest for the transition to the Gradac phase, contrary to the expectation of research hypothesis 1.

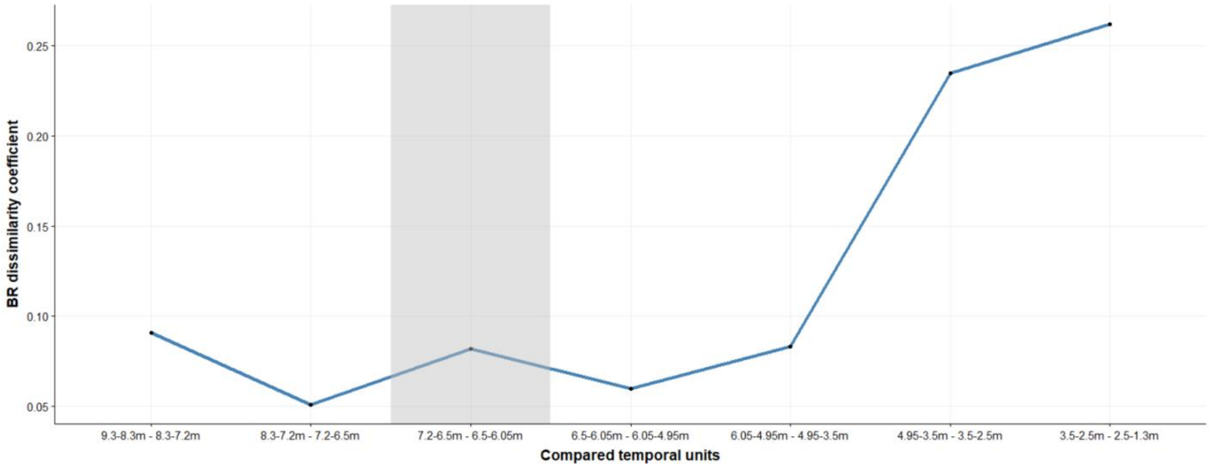


Figure 7.28. Magnitudes of diachronic changes in the striking platform type of blades, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Presence of lip

A lip is an attribute related to the technique of percussion and the type of percussor used. Due to a large sample size of blades with a preserved striking platform and only two modalities – presence/absence of lip – the bootstrapping has shown a stable estimate of richness for all temporal units. There are gradual changes in the percentage of blades with a lip (**Table 7.9**) – the percentage of blades with a lip gradually decreases from the earliest phase until the 6.05-4.95 temporal unit, before increasing in the following two temporal units, and finally decreases again in the youngest temporal unit. The differences between the temporal units are statistically significant ($n = 866$, $\chi^2 = 43.455$, $df = 7$, $p < 0.01$), with an effect size which is between weak and moderate (Cramer's $V = 0.22$).

Table 7.9. Diachronic changes in percentages of blades with a lip.

	Absent (%)	Present (%)
9.3-8.3m	39.1	60.9
8.3-7.2m	39.4	60.6
7.2-6.5m	40.4	59.6
6.5-6.05m	53.3	46.7
6.05-4.95m	69.7	30.3
4.95-3.5m	48.2	51.8
3.5-2.5m	40.0	60.0
2.5-1.3m	55.6	44.4

The magnitude of differences gradually increases from very low values (close to 0) for the transition to 8.3-7.2m and 7.2-6.5m, peaking with the transition to 4.95-3.5m (**Figure 7.29**). The BR coefficient decreases for the transition to TU 3.5-2.5m, and then increases to ~0.15 for the youngest temporal unit.

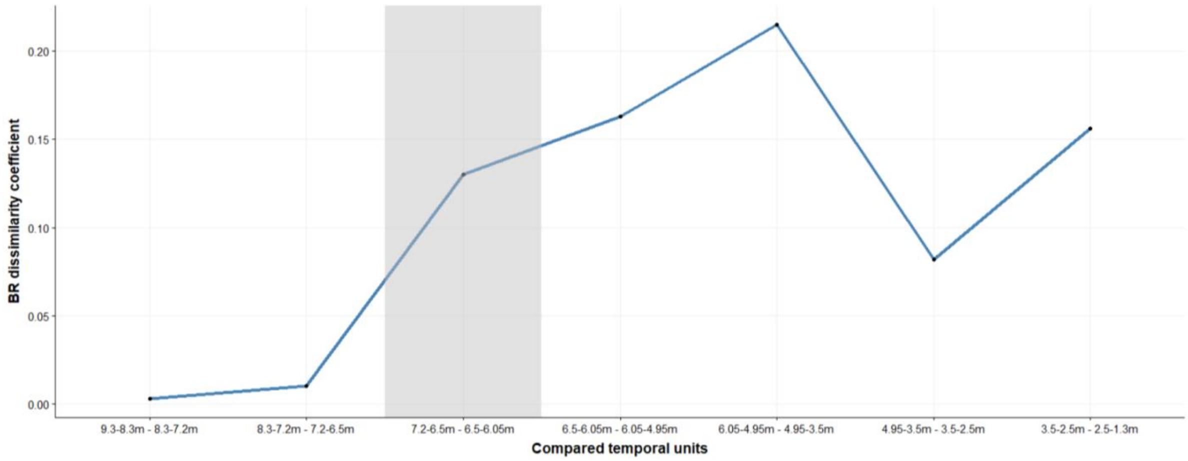


Figure 7.29. Magnitudes of diachronic changes in the proportions of blades with a lip, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Bulb of percussion

The bootstrapping has shown that the richness is well estimated for the bulb of percussion. The blades without a bulb are the least frequent, and their proportions oscillate slightly within the sequence (**Figure 7.30**). The pronounced bulb shows a general trend of increase in the later temporal units, while the diffuse bulb decreases in proportion with time. There are no discontinuities in the modalities of this attribute, although the differences between the temporal units are statistically significant (n = 890, χ^2 = 34.766, df = 14, p-value < 0.01) with a small effect size (Cramer's V = 0.14).

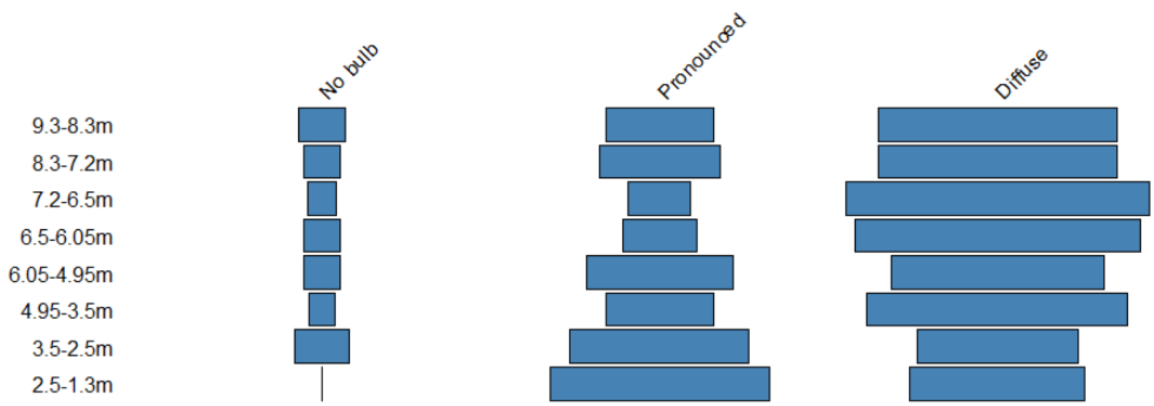


Figure 7.30. A battleship plot showing the diachronic changes in proportions of different modalities related to bulb of percussion.

The BR coefficient shows oscillations through time (**Figure 7.31**). The smallest changes occur with the transition to 8.3-7.2m and the Gradac phase, while the largest changes are between 4.95-3.5m and 3.5-2.5 temporal units.

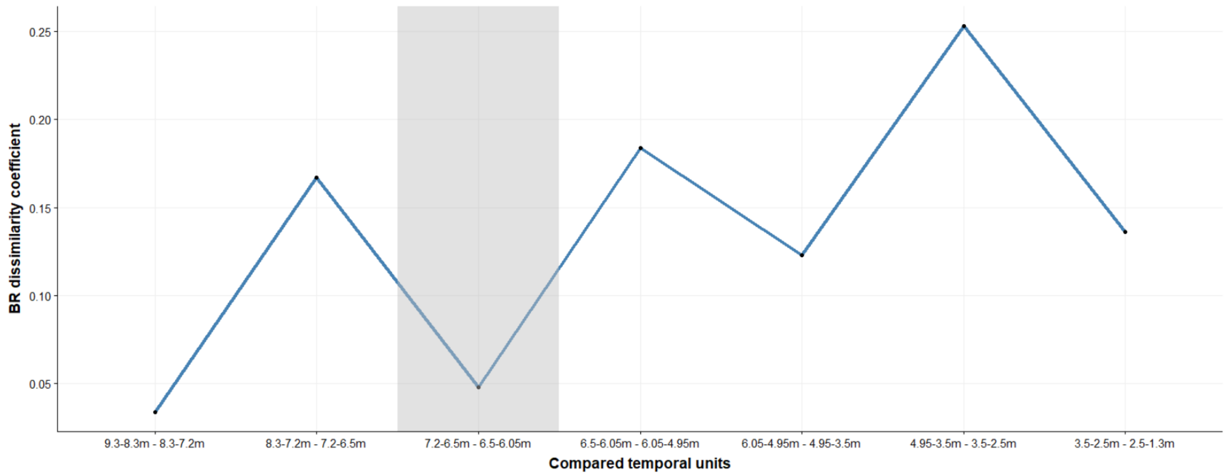


Figure 7.31. Magnitudes of diachronic changes in the bulb type, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Retouch distribution

The number of whole retouched blades (n = 53) is too small for studying the diachronic changes in retouch distribution. Therefore, for both whole and fragmented blades, it was only noted if the retouch is present on the dorsal and ventral surface. There are blades with a retouch on the dorsal surface, ventral surface, or both surfaces, and the percentage of each of these varieties changes throughout the sequence (**Figure 7.32**). Blades with retouch only on the ventral surface exhibit some oscillations in relative frequencies, but they generally have fairly stable proportions. Retouch only on the dorsal surface is the most common modality in the earliest temporal units, but it gradually decreases in proportion in later temporal units before disappearing in the TU 2.5-1.3m. Retouch on both surfaces gradually decreases in frequency before disappearing during the Gradac phase, but after this temporal unit, it appears again with a high frequency which gradually increases towards the end of the sequence. As these modalities are not independent of each other, no statistical test was done and the magnitude of changes was not calculated.

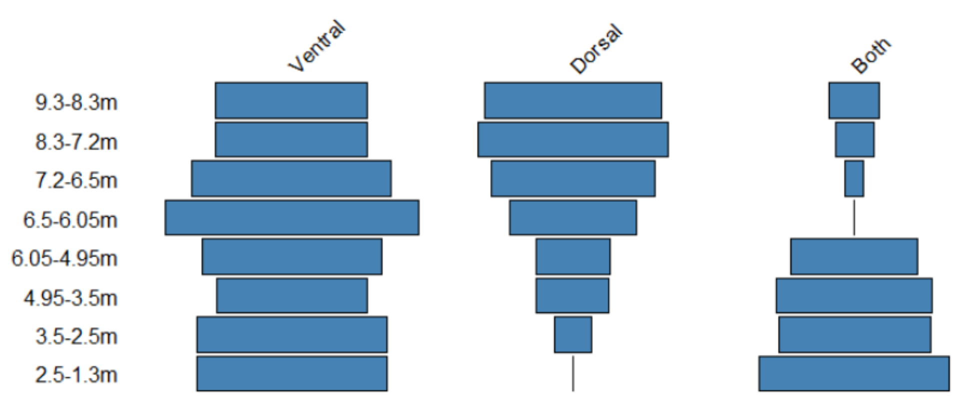


Figure 7.32. A battleship plot showing the diachronic changes in the distribution of retouch on blades.

Summary of the diachronic changes in lithic attributes

It is clear from the results presented above that the largest changes for prismatic blade attributes occur at different moments. To explore if the changes to a certain temporal unit are generally larger than others, two approaches were used – 1) counting the number of times that each temporal unit exhibited the largest changes within the sequence; 2) by calculating how much the value (*r*-value; BR coeffiient) of particular transition (e.g. maximal length for the transition to the Gradac phase) deviates from the mean value for that transition in terms of standardized normal scores (z-scores); and then calculating the average z-score for each transition (e.g. the mean z-score for Gradac phase is 0.32 (**Table 7.10**). While both of these two approaches have their downsides and the results should be taken with some caution, they should be able to provide some general assessment of the intensity of changes. The transitions to the Gradac phase and TU 2.5-1.3m exhibit the largest changes more times than other transitions, while the mean z-score is the highest for the transition to the youngest temporal unit (TU 2.5-1.3m). More generally, the transitions to the Gradac phase, TU 3.5-2.5m, and 2.5-1.3m exhibit the largest changes based on these two parameters, while the changes in the earliest part of the sequence are the least pronounced.

Table 7.10. Summary of the diachronic changes in lithic attributes.

Compared temporal units	Mean z-score	Number of largest changes
9.3-8.3m - 8.3-7.2m	-0.32	0
8.3-7.2m - 7.2-6.5m	-0.41	0
7.2-6.5m - 6.5-6.05m	0.35	4
6.5-6.05m - 6.05-4.95m	-0.38	1
6.05-4.95m - 4.95-3.5m	-0.2	1
4.95-3.5m - 3.5-2.5m	0.46	3
3.5-2.5m - 2.5-1.3m	0.49	4

7.2.2. Diachronic changes in paradigmatic types of prismatic blades

The paradigmatic types were created by combining (intersecting) the modalities of different attributes of prismatic blades. However, it should be noted that the previous research (e.g. Buchannan et al. 2016; Damlien 2015) and the results of this study (see below) have shown that there is a continuous variation in blade variability, so the paradigmatic types should be considered as arbitrary discretizations of continuous variation in blade variability and purely analytical units for analyzing temporal trends in blade variability. The problem encountered when creating paradigmatic types was that a typology created using a high number of attributes and their modalities leads to a very high number of types with very low frequencies, which is both analytical and interpretational problem. Thus, after attempting different combinations of attributes, five attributes with a total of 12 modalities were selected for creating a paradigmatic classification of whole unretouched blades. The five attributes and their modalities are: length (1 – below 50 mm; 2 – above 50 mm); width of the medial part (1 – below 15 mm; 2 – above 15 mm); debitage profile type (1 – straight, 2 – curved; 3 – twisted), lip (0 – absent, 1 – present), bulb (0 – absent, 1 – present). Although even this small number of attributes and modalities gives a total of 48 types – combinations of features shared by all members of the group – the number of types with at least one blade was lower – 24. The battleship plot in **Figure 7.33** indicates that the majority of types have low and discontinuous frequencies. However, almost all types that have somewhat higher frequencies (11101, 11111, 11200, 11211, 12211, 21211, 222001, 22211) are present in both early and late temporal units despite some discontinuities which could be consequences of sampling effects. The most common paradigmatic types of blades are 11201 and 11211, i.e. blades that are up to 50 mm long, up to 15 mm wide, have a curved profile, with or without a lip, and with a bulb. Other common types are 21211 and 22211, i.e. blades that have the same features as the ones previously described, except having larger dimensions.

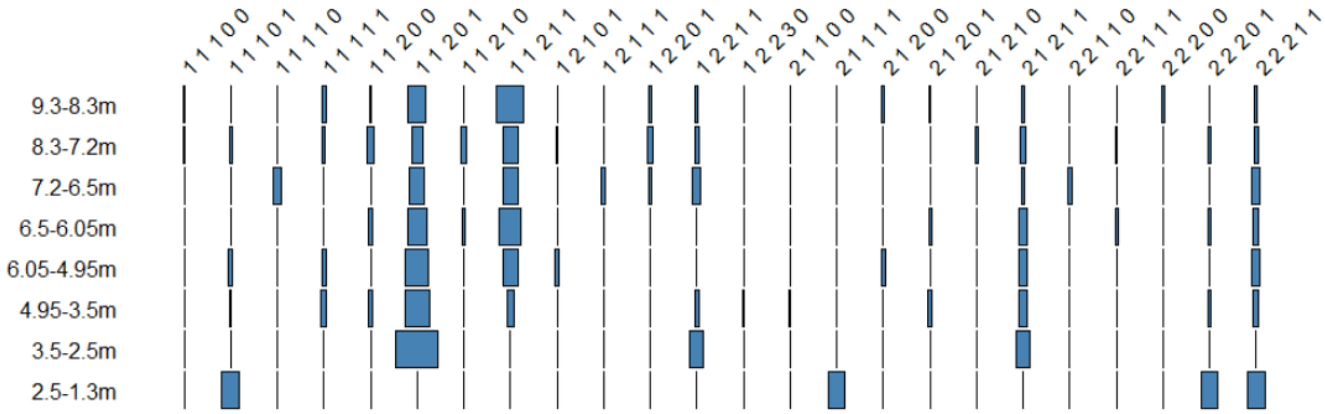


Figure 7.33. A battleship plot showing the diachronic changes in the distribution of paradigmatic types of blades.

The magnitudes of diachronic changes in the structure of paradigmatic types, calculate using the Brainerd-Robinson dissimilarity coefficient, are presented in **Figure 7.34**. The BR coefficient oscillates around the value of 0.4 for the transitions to the majority of temporal units, but then sharply increases to the value of 1 (maximum dissimilarity) for the transition to the youngest temporal unit.

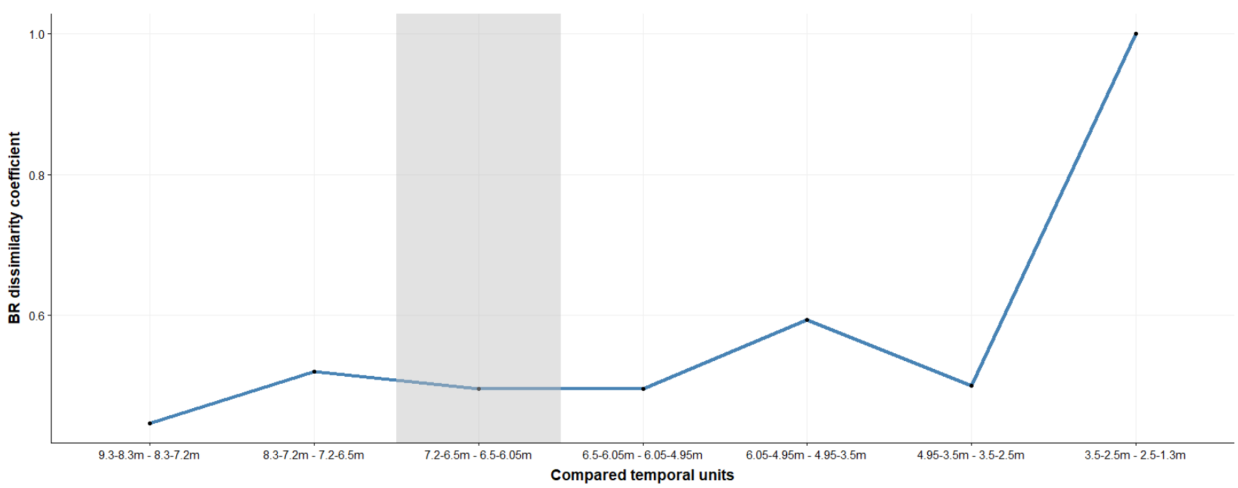


Figure 7.34. Magnitudes of diachronic changes in the structure of paradigmatic types of prismatic blades, calculated using the Brainerd-Robinson dissimilarity coefficient.

7.2.3. Diachronic changes in the outline shape of prismatic blades

The Principal Component Analysis (PCA) was conducted on blade outlines for summarizing and exploring the morphological variation of blades. The first three principal components, which describe a total of 86.0% of blade variability (PC1 – 61.7%; PC2 – 15.5%; PC3 – 8.8%), are related to elongation, side-to-side symmetry, and tip-base width ratio. The observation of PCA plots (**Figure 7.35**) indicates that the outline shape of blades from different temporal units overlaps to a high degree. Blades within all groups differ in both elongation (PC1), side-to-side symmetry (PC2), and tip-base width ratio (PC3). There are also no clusterings of blades with particular shapes nor directional diachronic changes in blade outline shape. The centroids (mean shapes) of all groups are relatively near to each other, indicating that the mean outline shape of blades does not change much throughout the sequence, except for blades from temporal unit 7.2-6.5m with a centroid a bit farther from other groups. The blades from this temporal unit are somewhat less elongated and more frequently curved to a different side than other blades. However, there are no discontinuous changes in blade outline morphology. The permutational MANOVA test performed on the first 16 principal components, that explain 99.9% of blade outline shape, has shown that there are no statistically significant differences between the groups of blades (n = 173, DF = 7, SS = 0.06, MS = 0.008, Pseudo F = 0.78, p = 0.7, R^2 = 0.03).

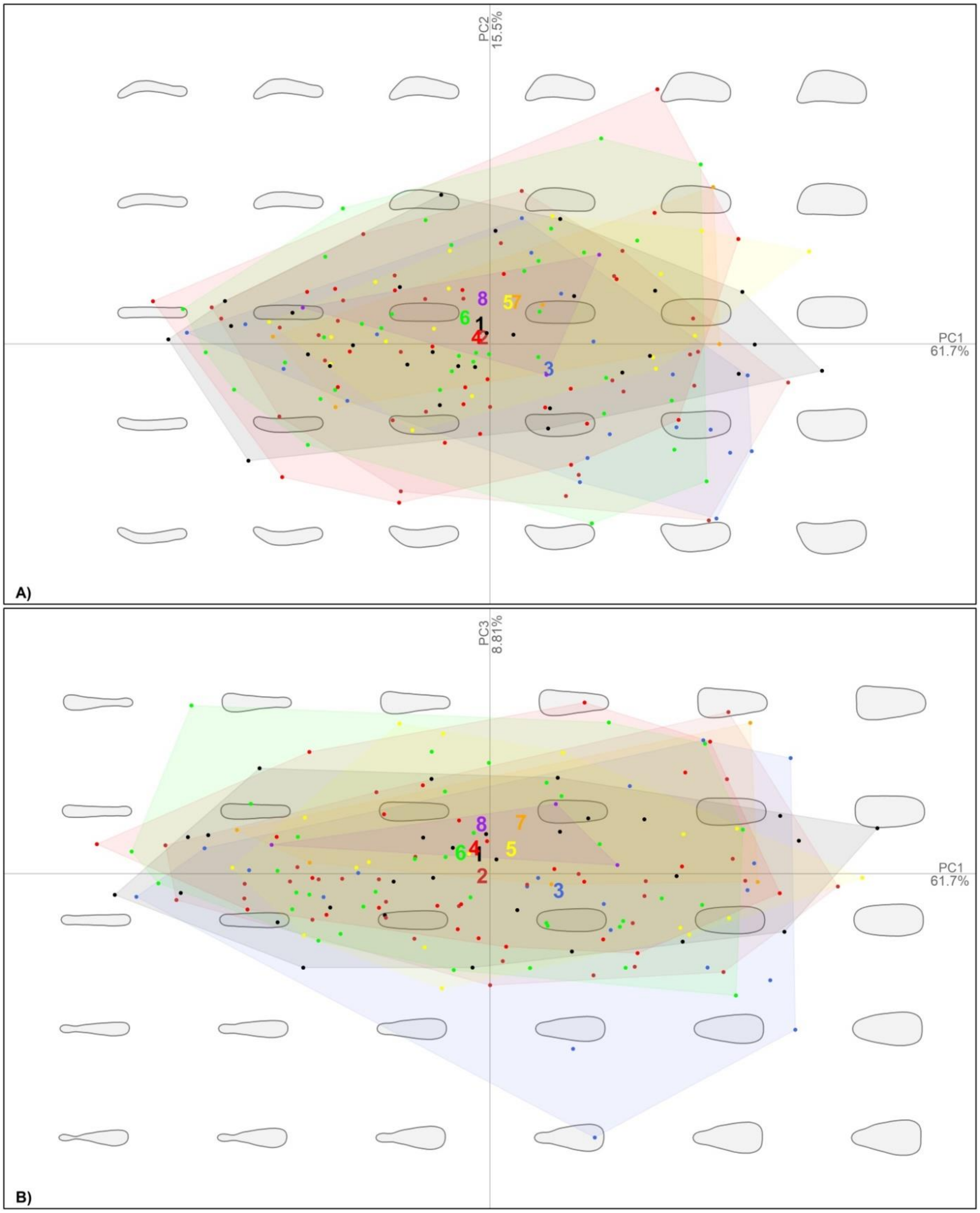


Figure 7.35. Scatter plots of PC1 and PC2 (A) and PC1 and PC3 (B) showing main shape differences in the sample, with visualization of the shape space. Convex hulls and group centroids are shown for each temporal unit – 1) 9.3-8.3m (black); 2) 8.3-7.2m (brown); 3) 7.2-6.5m (blue); 4) 6.5-6.05m (red); 5) 6.05-4.95m (yellow); 6) 4.95-3.5m (green); 7) 3.5-2.5m (orange); 8) 2.5-1.3m (purple).

The diachronic changes in the mean shape of blades were also explored by plotting the mean values of principal components against time (**Figure 7.36**). The mean values of principal components oscillate around zero value, i.e. the centroid or mean shape of all blades. The largest changes in the outline shape of blades seem to occur at the transition to TU 7.2-6.5m. There are some slight tendencies of changes – the blades in the later temporal units tend to be curved to the different sides than those from earlier units (on average they have higher PC2 values), and generally have a slightly higher tip-base width ratio (higher PC3 values) compared to those in the preceding temporal intervals.

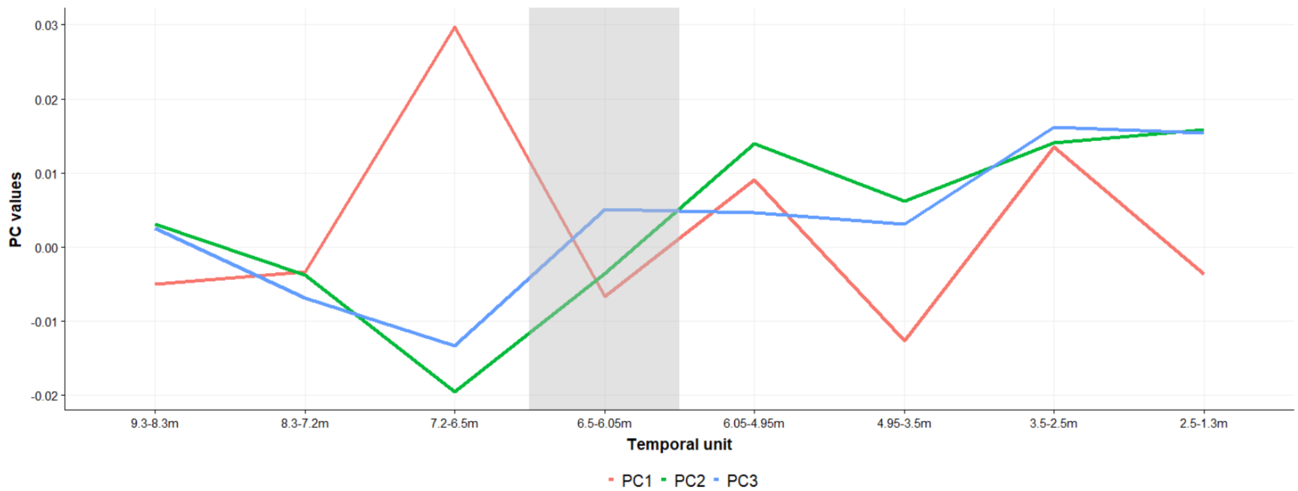


Figure 7.36. The diachronic changes in the mean values of principal components. Note that both positive and negative deviations from zero indicate divergence from the mean shape. The Gradac phase is shaded in grey.

The magnitude of changes was compared individually for each principal component, using the *r*-value, the effect size for the Mann-Whitney U test. Before calculating r values, the PC scores were normalized to values between 1 and 10 using the min–max normalization function (Wang and Marwick 2020). The magnitudes of diachronic changes in all the principal components are shown in **Figure 7.37**. The trajectories of change vary for each principal component, but the largest changes seem to occur with the transition to 7.2-6.5m temporal unit and the Gradac phase, and the smallest for the transition to TU 4.95-3.5m and TU 2.5-1.3m.

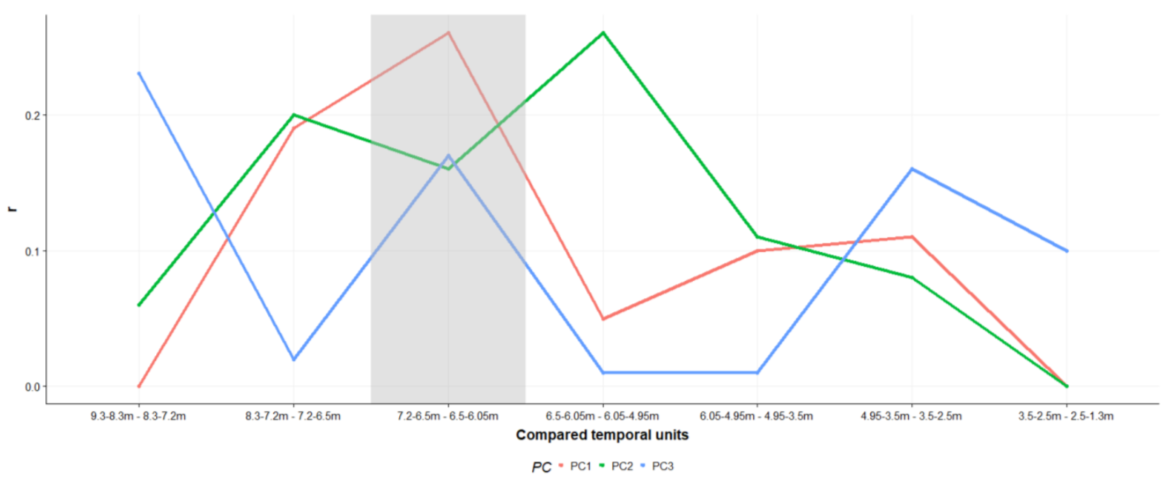


Figure 7.37. Magnitudes of diachronic changes for each of the first three principal components of morphological variation of blade outlines, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

The EFA also allows the assessment of bilateral symmetry of objects (Iwata et al. 1998). The box plot shows that there are small oscillations in the median of symmetry values from the earliest temporal unit until the 4.95-3.5m temporal unit, after which there is a more discontinuous change in blade symmetry (**Figure 7.38**). Although there are small, possibly unrepresentative samples in the youngest two temporal units (n1 = 5, n2 = 4), the symmetry values of blades notably increase in these periods, but these differences between the groups are not statistically significant (n = 173, H = 6.41, df = 7, p = 0.49).

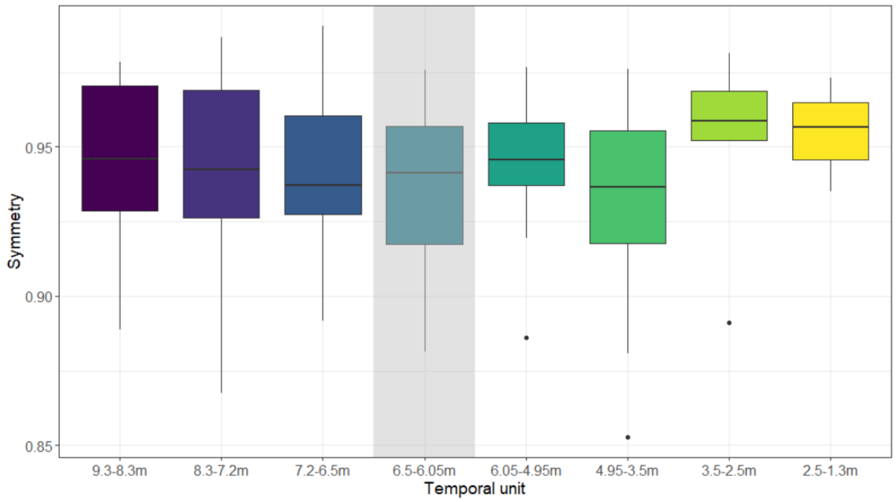


Figure 7.38. The diachronic changes in the symmetry values of blades, calculated using the Fourier coefficients. The Gradac phase is shaded in grey.

The magnitude of changes, calculated using the *r*-value shows a trend of increase through time, peaking with the transition to the 3.5-2.5m temporal unit, and then sharply decreases for the transition to the youngest temporal unit (**Figure 7.39**).

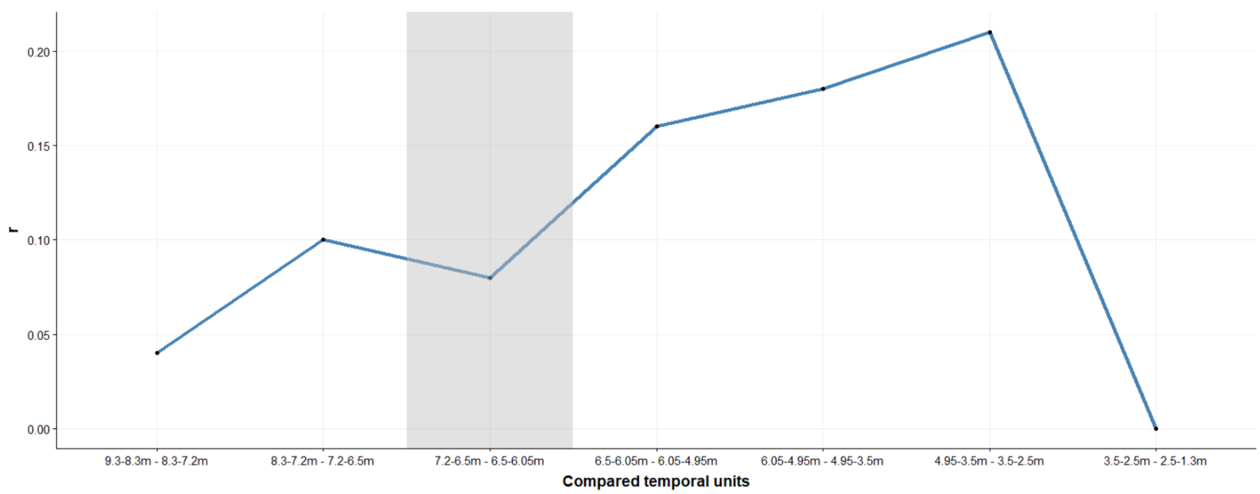


Figure 7.39. Magnitudes of diachronic changes in the symmetry of blades, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

7.3. The character of changes in the production of anthropomorphic figurines

The distribution of a total of 837 Late Neolithic figurines from Belo brdo according to 100-year-long intervals is shown in **Figure 7.40**. The number of figurines increases from the earliest temporal unit, reaching the highest frequency during the TU 4.95-3.5m, and then sharply decreases in the latest two temporal units. As mentioned, the decrease in the production of figurines in the final phases of the Vinča culture has already been noted (Borić 2015).

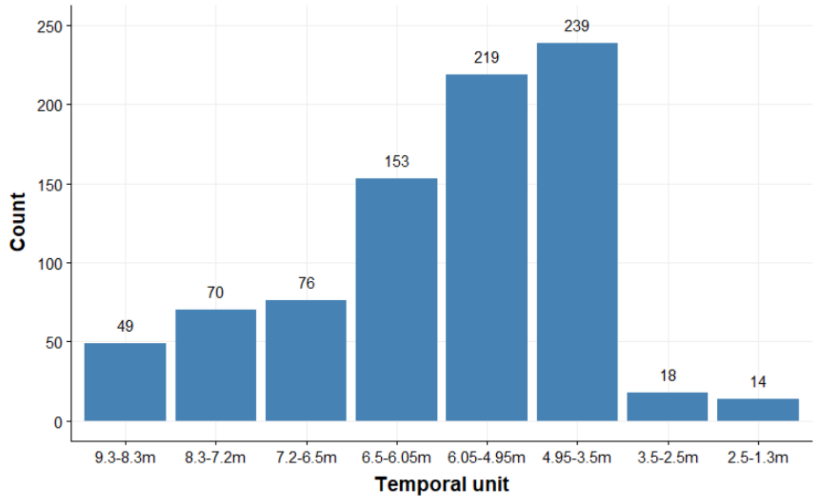


Figure 7.40. The frequencies of anthropomorphic figurines in different temporal intervals.

To assess the comparability of collections of figurines from different temporal units, the frequencies of different body parts in each of them were observed. The Fisher's exact test indicates that the distribution of different body parts does significantly differ between different temporal units ($n = 837$, sim. p-value < 0.01), but with a weak effect size (Cramer's $V = 0.19$). Thus, the collections are roughly comparable in terms of the presence of different body parts.

7.3.1. Diachronic changes in figurine attributes

In this section, the assessment of the changes in certain quantitative and qualitative attributes of anthropomorphic figurines from Vinča-Belo brdo will be presented.

Height

There are 123 figurines that are preserved from top to bottom, where it was possible to measure the original height of figurines. The bootstrapping has indicated that the estimates of population mean are poor for the two earliest and two latest phases. Both the descriptive statistics (**Table 7.11**) and the box plot (**Figure 7.41**) indicate that there are some notable changes in the height of figurines, but the Kruskal-Wallis H test has shown that these differences are not statistically significant ($n = 123$, $H = 7.29$, $df = 7$, $p = 0.34$). The figurines of the TU 8.3-7.2m are shorter than the figurines from the previous temporal unit, as the mean reduces from 89 to 59 mm. After this notable change, the figurine height has only slight oscillations in the subsequent temporal unit, before notably decreasing in the TU 2.5-1.3m. In this temporal interval, the mean height of figurines is 44 mm, markedly lower than the mean height of figurines in the previous temporal unit (57 mm).

Table 7.11. Descriptive statistics for the height of figurines that are preserved from top to bottom, grouped by temp. units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	6	88.8	43.8
8.3-7.2m	4	59.2	16.0
7.2-6.5m	11	54.6	10.1
6.5-6.05m	23	58.8	19.0
6.05-4.95m	37	64.4	29.7
4.95-3.5m	32	59.1	22.0
3.5-2.5m	5	56.6	18.4
2.5-1.3m	5	44.4	6.3

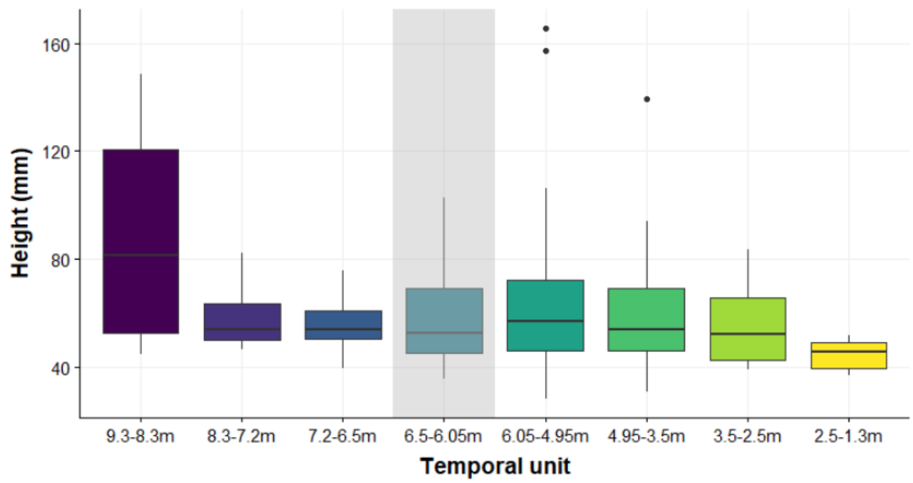


Figure 7.41. Box plot showing the diachronic changes in the height of figurines that are preserved from top to bottom.

The *r*-value for differences in figurine height between the earliest two temporal units is 0.07. The magnitude of changes decreases for the transitions to subsequent phases (between 0.01 and 0.03), before the notable increase for the transition to the latest temporal unit (2.5-1.3m) (**Figure 7.42**).

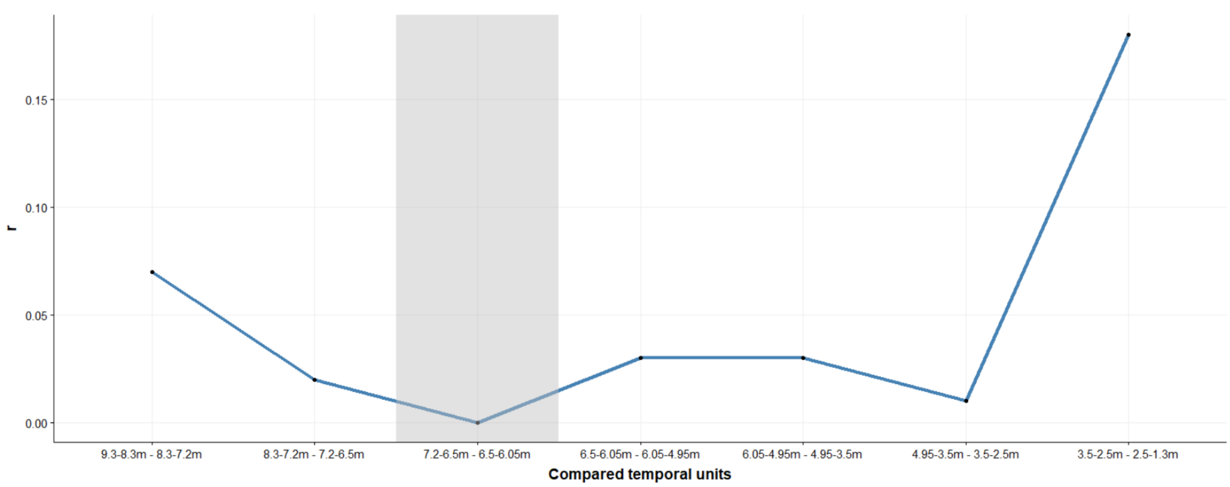


Figure 7.42. Magnitudes of diachronic changes in the head height of figurines, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Head height

Despite a much larger number of figurines where the head height was measured (n = 392), the figurines from the youngest temporal units (TU 3.5-2.5m and 2.5-1.3m) did not provide sufficient samples for robust estimates of the mean. The descriptive statistics (**Table 7.12**) and the box plot (**Figure 7.43**) indicate that there is a gradual trend of decrease in the head height of figurines, but the Kruskal-Wallis H test indicates no significant differences between the groups (n = 392, H = 8.62, df = 7, p-value = 0.28). The most notable changes occur in the 3.5-2.5m temporal unit.

Table 7.12. Descriptive statistics for the head height of figurines, grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	23	31.0	11.1
8.3-7.2m	38	30.3	12.7
7.2-6.5m	34	28.9	14.7
6.5-6.05m	77	27.4	11.2
6.05-4.95m	109	28.6	12.7
4.95-3.5m	98	29.0	13.0
3.5-2.5m	7	21.8	11.6
2.5-1.3m	6	21.2	16.6

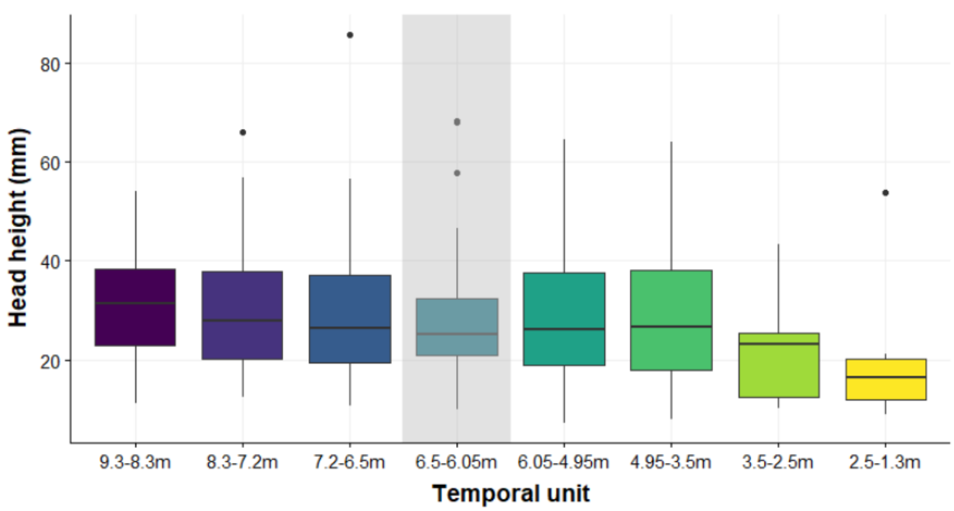


Figure 7.43. Box plot showing the diachronic changes of the head height of figurines. The Gradac phase is shaded in grey.

The *r*-value, which measures the magnitude of changes, is higher for the transitions to the oldest (TU 8.3-7.2m and TU 7.2-6.5m) and youngest (TU 3.5-2.5m and TU 2.5-1.3m) temporal units than for the transitions in the middle part of the sequence, where it approaches zero (**Figure 7.44**).

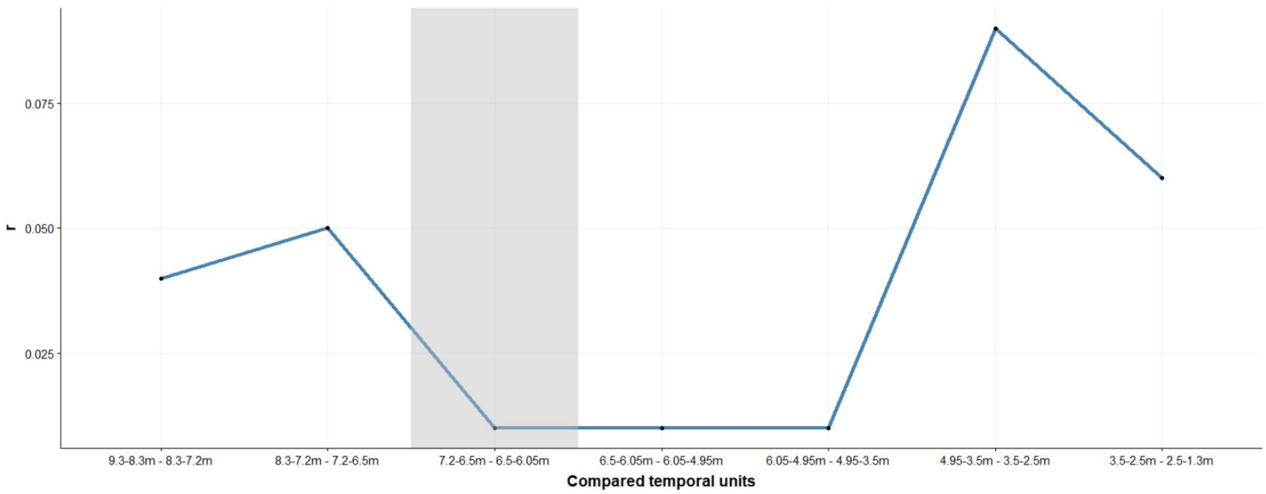


Figure 7.44. Magnitudes of diachronic changes in the head height of figurines, calculated using the *r*-value, the effect size for the Mann-Whitney U test.

Head height/width ratio

Diachronic changes in the vertical elongation of the head of figurines were observed by calculating the ratio between head height and maximal head width, where a higher ratio indicates a more vertically elongated head. As in the case of head height, only the two youngest temporal units have small, possibly unrepresentative sample sizes. The mean ratio oscillates around the value of 1 for all temporal units from the earliest until the 4.95-3.5m, and then decreases slightly in the last two temporal units to 0.92 and 0.84 (**Table 7.13, Figure 7.45**), indicating that the relative head height decreases. All the changes in the head height/width ratio seem to be gradual, but there are certain outliers in TU 8.3-7.2m and TU 6.05-4.95m. The Kruskal-Wallis H test confirms the existence of some diachronic changes as there are marginally significant differences between the groups (n = 368, H = 12.551, df = 7, p = 0.08).

Table 7.13. Descriptive statistics for the head height/width ratio of figurines, grouped by temporal units.

Temporal unit	Count	Mean	SD
9.3-8.3m	23	1.00	0.18
8.3-7.2m	36	1.12	0.36
7.2-6.5m	32	1.02	0.16
6.5-6.05m	72	1.04	0.16
6.05-4.95m	101	1.04	0.21
4.95-3.5m	91	0.97	0.17
3.5-2.5m	7	0.92	0.24
2.5-1.3m	6	0.84	0.19

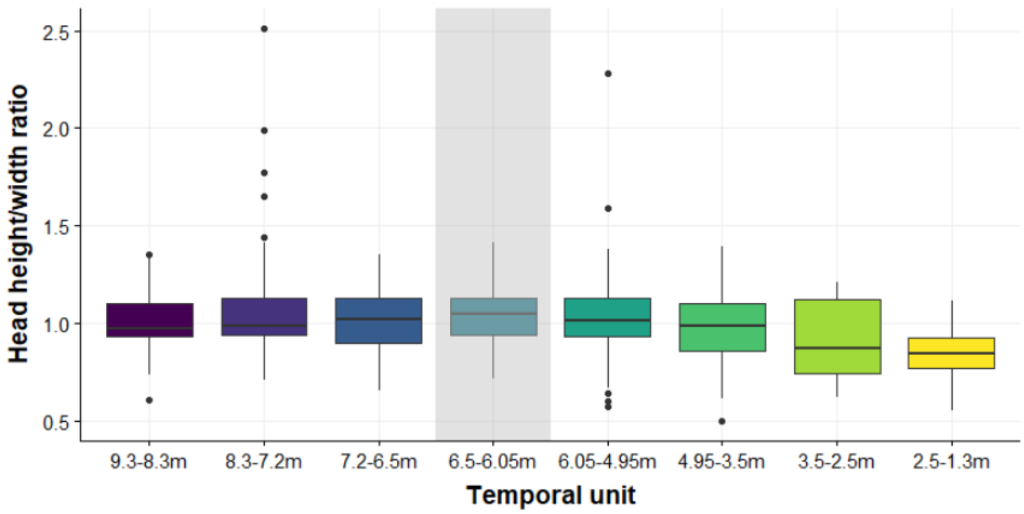


Figure 7.45. Box plot showing the diachronic changes in the head height/width ratio of figurines.

The r-values that measure the magnitude of changes are generally low, ranging between 0.01 and 0.09 (**Figure 7.46**). The changes are the largest for the transition to temporal units 6.05-4.95m and 2.5-1.3m, while the changes with the Gradac phase are among the least pronounced changes within the sequence.

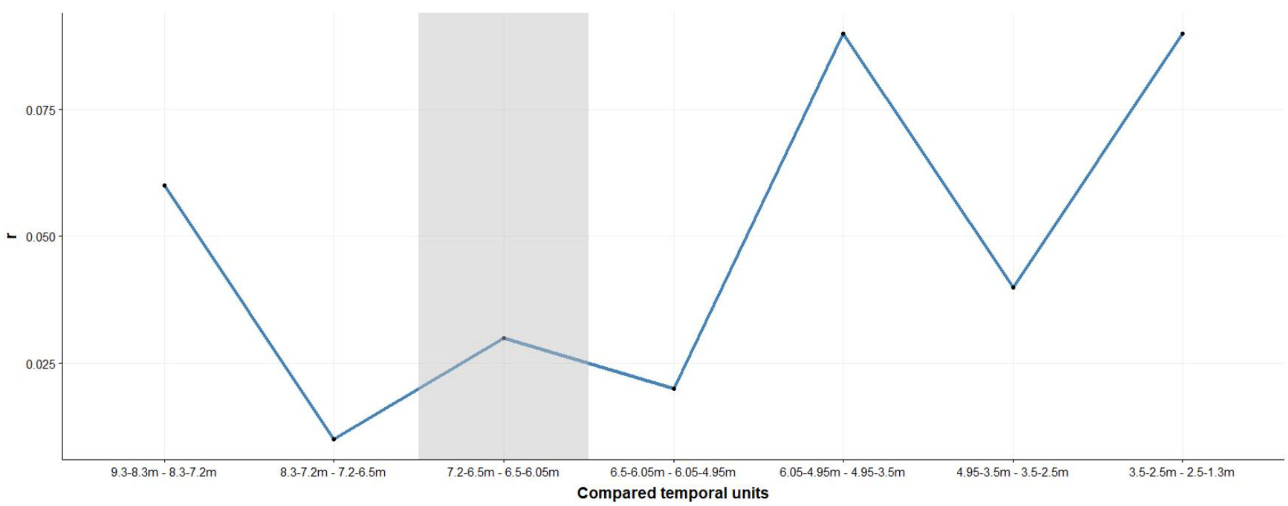


Figure 7.46. Magnitudes of diachronic changes in the head height/width ratio of figurines, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Waist thickness

The changes in the thickness of figurines were assessed by observing the thickness in the line of the waist. The bootstrapping has shown that samples from all temporal units provide good estimates of population parameters. The box plot shows very gradual changes in the distribution of values waist thickness of figurines (**Figure 7.47**), with a gradual decrease in the mean waist thickness of anthropomorphic figurines (**Table 7.14**). The differences in waist thickness between the groups are not statistically significant (n = 238, H = 2.84, df = 7, p = 0.9). Interestingly, the waist thickness stays relatively unchanged despite the slight (non-significant) decrease in the height of figurines.

Table 7.14. Descriptive statistics for the head height/width ratio of figurines, grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	11	18.8	7.1
8.3-7.2m	20	18.4	4.9
7.2-6.5m	22	17.7	6.4
6.5-6.05m	44	18.0	5.1
6.05-4.95m	67	19.0	6.4
4.95-3.5m	59	17.3	4.4
3.5-2.5m	7	17.1	3.6
2.5-1.3m	8	16.8	4.4

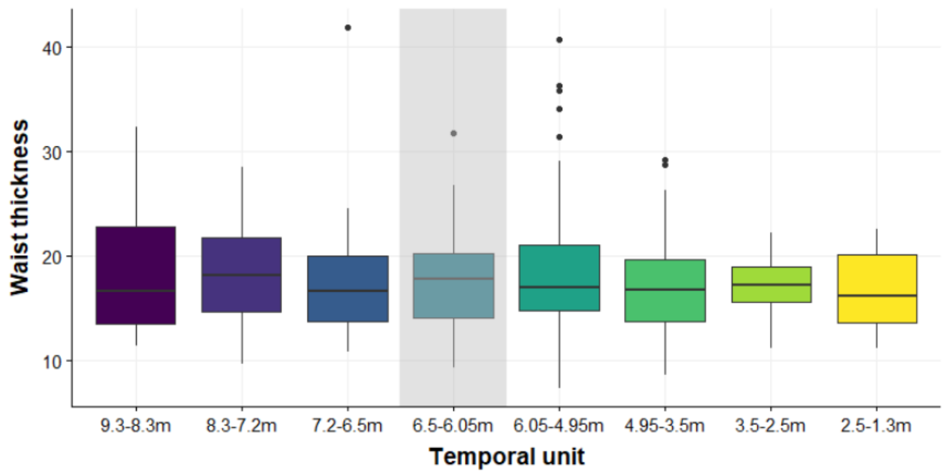


Figure 7.47. Box plot showing the diachronic changes in the waist thickness of figurines.

The r-values are generally low and oscillate throughout the sequence. The magnitude of differences is the highest for the transitions to TU 7.2-6.5m and TU 4.95-3.5m, and the lowest for the transition to TU 2.5-1.3m (**Figure 7.48**).

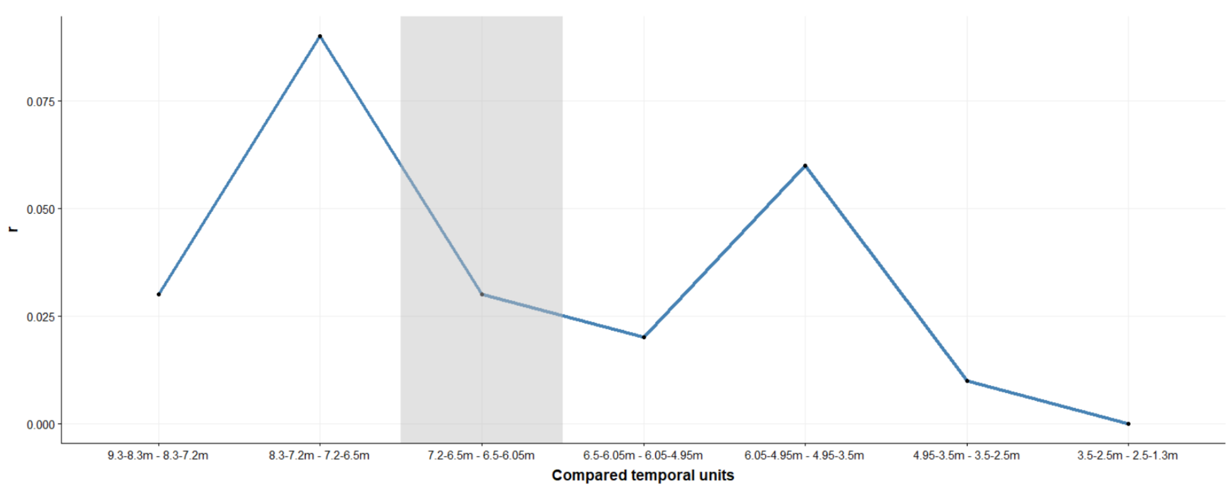


Figure 7.48. Magnitudes of diachronic changes in the waist thickness of figurines, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Arm length

The majority of figurines have the so-called arm-stumps spread to the side. The arm length was calculated as a mean length of the left and right arm lengths, or as the length of the preserved arm if only one arm is preserved. The bootstrapping has shown that all temporal units have sufficient samples for making some general conclusions. The interquartile ranges on box plots show that there are only slight oscillations in this attribute throughout the sequence, although there are certain outliers in the middle part of the sequence (**Figure 7.49. Table 7.15**). The Kruskal-Wallis H test has shown statistically significant differences between the groups (n = 123, chi-squared = 20.07, df = 7, $p < 0.01$). As in the case of waist thickness, it is interesting to note that the arm length stays constant (and even increases) despite the reduction in size (height) of figurines in the later temporal units, indicating that there is an increase in relative arm length through the course of the Late Neolithic (**Figure 7.50**).

Table 7.15. Descriptive statistics for the arm length of figurines, grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	18	10.7	3.6
8.3-7.2m	29	10.1	3.9
7.2-6.5m	38	10.3	3.7
6.5-6.05m	66	10.8	5.4
6.05-4.95m	92	12.8	6.4
4.95-3.5m	115	13.6	7.8
3.5-2.5m	9	11.4	4.3
2.5-1.3m	8	11.0	3.3

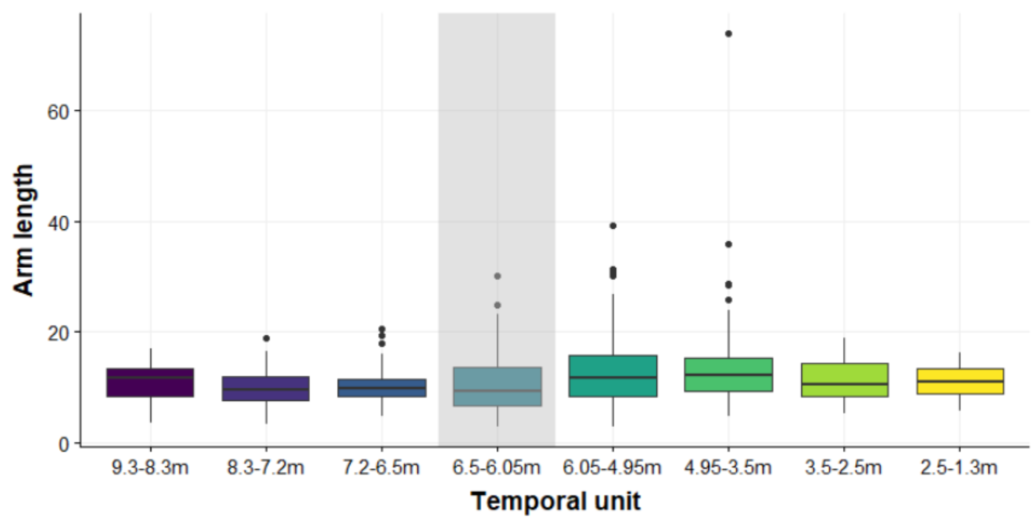


Figure 7.49. Box plot showing the diachronic changes in the arm length of figurines. The Gradac phase is shaded in grey.

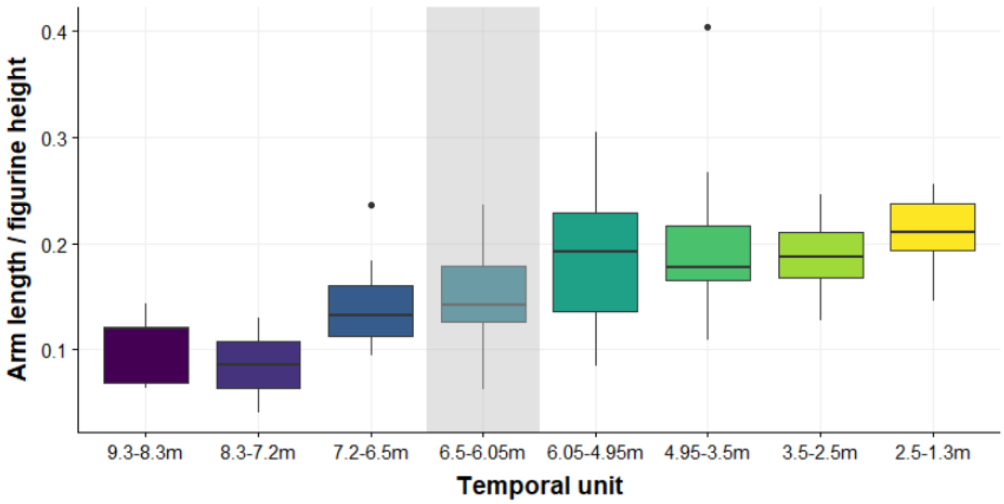


Figure 7.50. Box plot showing the diachronic changes in the relative arm length (arm length / figurine height) of figurines. The Gradac phase is shaded in grey.

The magnitude of changes oscillates throughout the sequence and ranges between 0.01 and 0.11 (**Figure 7.51**). It is the highest for the transitions to TU 6.05-4.95m and TU 8.3-7.2m, and the lowest for the transition to the Gradac phase.

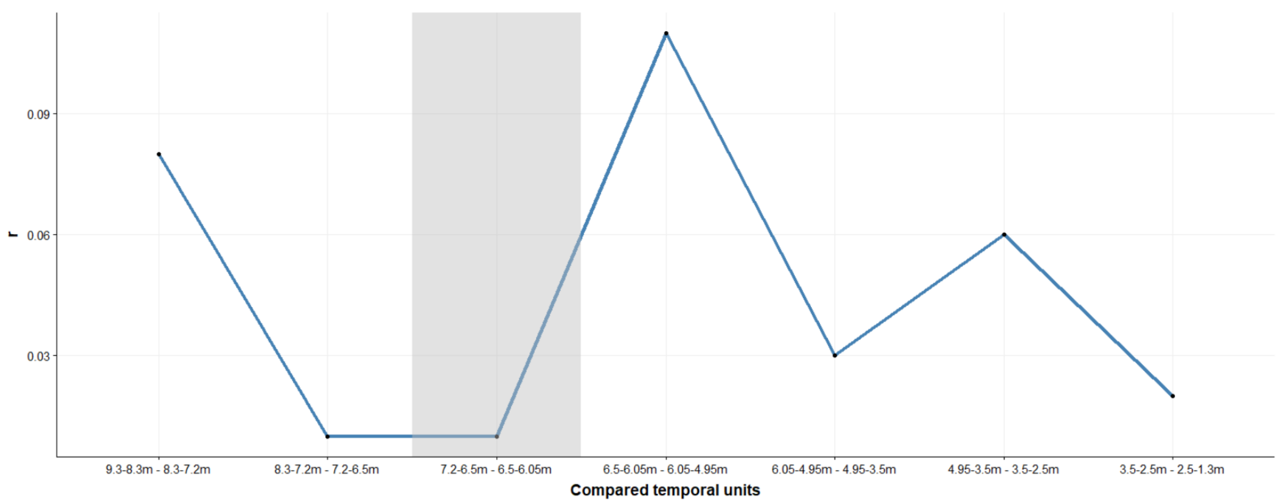


Figure 7.51. Magnitudes of diachronic changes in the arm length of figurines, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Relative width of the lowest part

The relative width of the lowest part was calculated as a ratio between the width of the lowest part and the figurine height. The two earliest and the two latest temporal units provide small, possibly unrepresentative samples, as indicated by the bootstrapping. The relative width of the lowest part of figurines shows a general trend of increase, although with some oscillations (**Table 7.16, Figure 7.52**). The differences between the temporal units are statistically significant (n = 103; H = 18.29, df = 7, p = 0.01). Some of the changes in the relative width of the lowest part seem to be discontinuous, but they could also be consequences of sampling effects.

Table 7.16. Descriptive statistics for the lowest part of figurines, grouped by temporal units.

Temporal unit	Count	Mean (mm)	SD (mm)
9.3-8.3m	5	0.27	0.12
8.3-7.2m	2	0.34	0.01
7.2-6.5m	10	0.39	0.18
6.5-6.05m	21	0.34	0.09
6.05-4.95m	31	0.30	0.06
4.95-3.5m	29	0.35	0.06
3.5-2.5m	3	0.40	0.03
2.5-1.3m	4	0.41	0.05

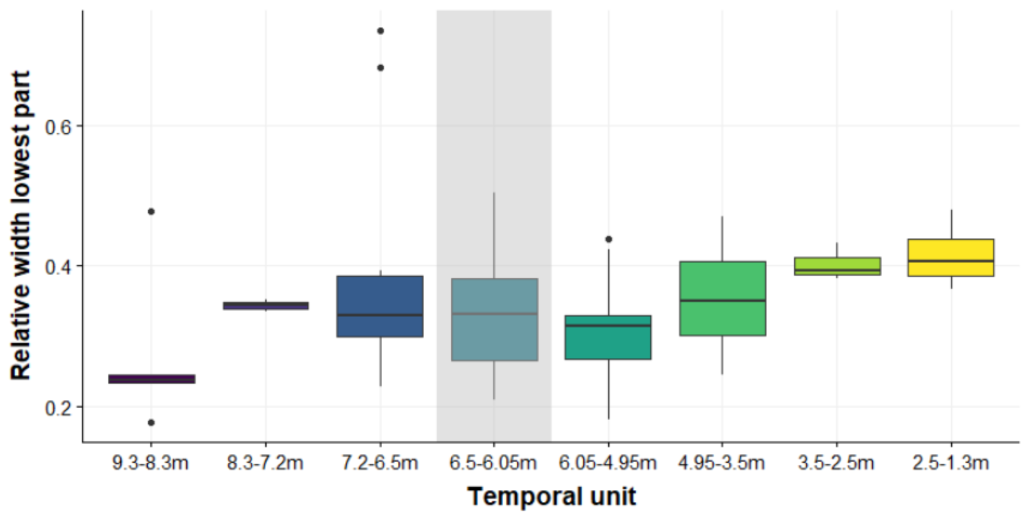


Figure 7.52. Box plot showing the diachronic changes in the relative width of the lowest part of figurines (lowest part width / figurine height). The Gradac phase is shaded in grey.

The magnitude of changes is the highest for the transition to temporal unit 4.95-3.5m and the lowest for the transitions to TU 7.2-6.5m and TU 2.5-1.3m (**Figure 7.53**). The changes in relative width of the lowest part of figurines with the Gradac phase are among the least pronounced changes within the sequence.

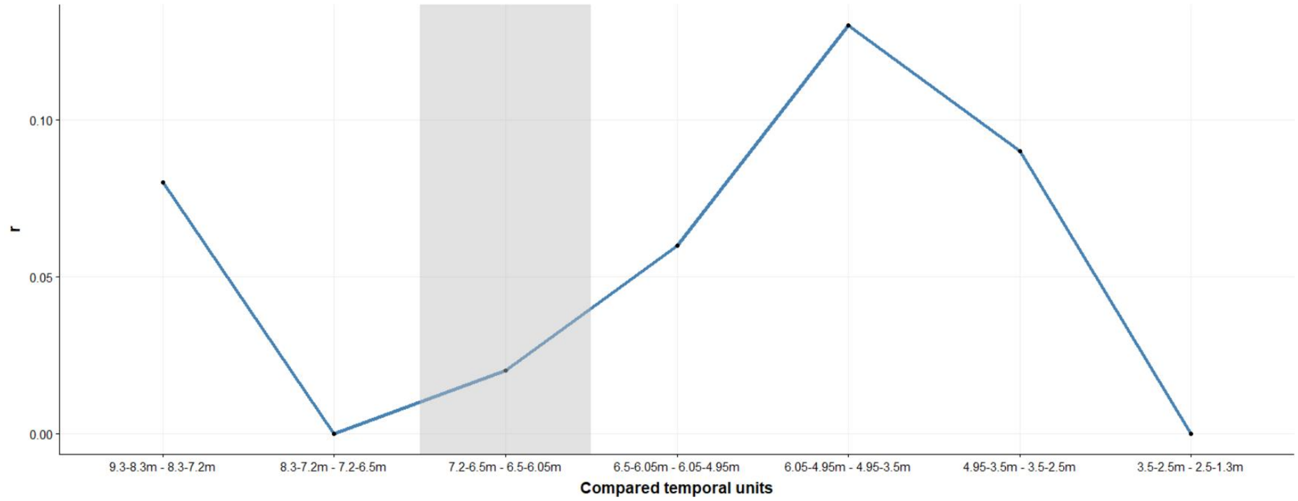


Figure 7.53. Magnitudes of diachronic changes in relative width of the lowest part of figurines, calculated using the *r*-value, the effect size for the Mann-Whitney U test. The transition to the Gradac phase is shaded in grey.

Body position

The body position was observed on a total of 272 figurines from Belo brdo, and there are three main varieties of body position – standing, kneeling, and sitting figurines. The bootstrapping has shown that the two youngest temporal units might have poor estimates of richness, but this is also partly true for the three earliest temporal units. The standing position is by far the most common (n = 248), and their percentages show a general trend of gradual decrease with time as the percentage of sitting figurines slightly increases (**Figure 7.54**). However, the sitting figurines suddenly disappear in the youngest temporal unit where only the standing figurines are present. The kneeling figurines are present only in temporal units 6.05-4.95m and 4.95-3.5m. The Chi-Square test of homogeneity indicates no significant differences between the groups (n = 248, $\chi^2 = 16.01$, df = 14, p = 0.31).

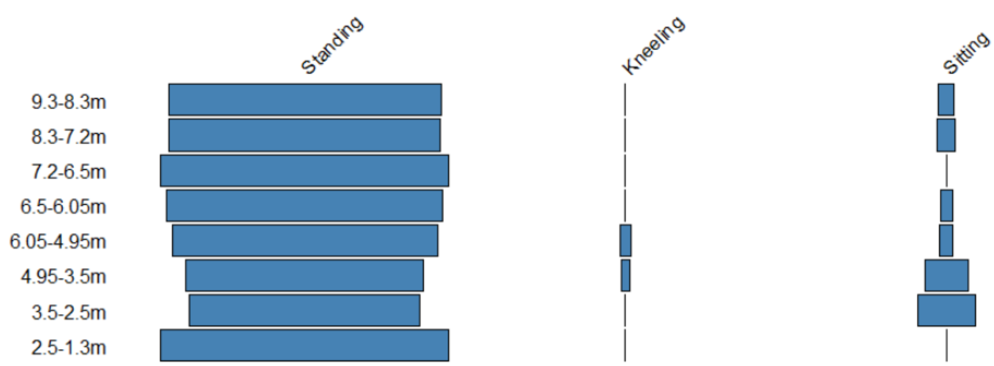


Figure 7.54. The battleship plot showing the proportion of figurines with different body positions according to temporal units.

The magnitudes of changes in the proportions of different body position, calculated using the Brainerd-Robinson dissimilarity coefficient, shows a general trend of a gradual increase from older to youngest temporal units, peaking for the transition to the youngest TU 2.5-1.3m (**Figure 7.55**). The changes at the transition to the Gradac phase are rather low relative to other changes on the site.

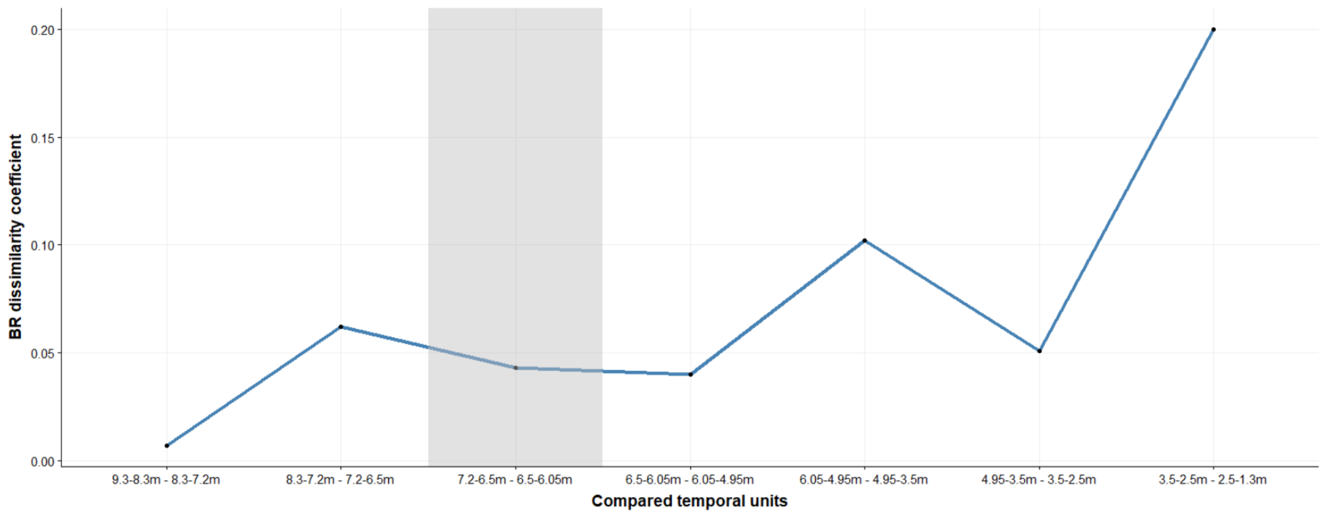


Figure 7.55. Magnitudes of diachronic changes in proportions of different body positions of figurines, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Lower body type

The type of lower body was possible to determine for 189 figurines. Three lower body types defined in this research are: cylindrical (no clear separation of the lower body), a distinct lower body without modeled legs, a distinct lower body with legs. The estimates of richness are poor for the youngest two temporal units. The changes in proportions of different types of lower body types are gradual between some units, but quite sudden for others (**Figure 7.56**). For example, the proportion of figurines with a distinct lower body and modeled legs notably decreases from TU 8.3-7.2m to TU 7.2-6.5m, and the proportion of figurines with a distinct lower body and no legs sharply reduces in the youngest temporal unit of the site. The differences between the temporal groups are statistically significant ($n = 189$, $\chi^2 = 26.28$, $df = 14$, $p = 0.02$) with a moderate effect size (Cramer's $V = 0.26$).

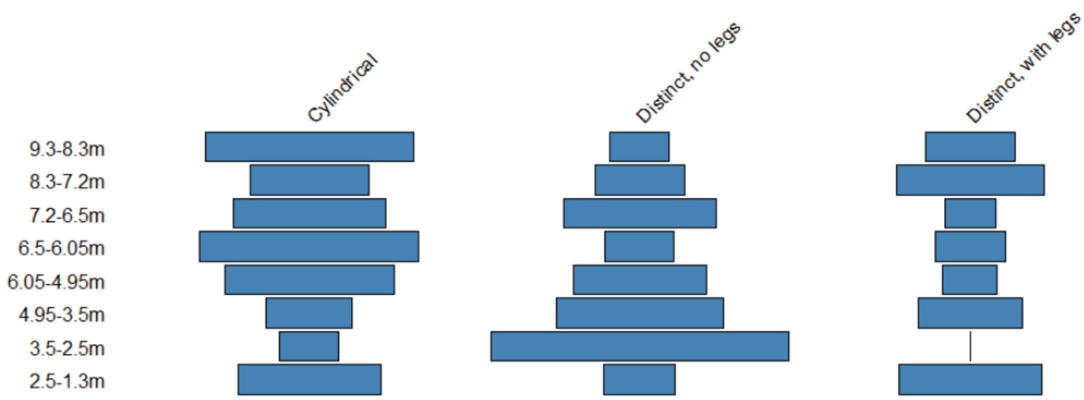


Figure 7.56. The battleship plot showing the proportion of figurines with different body positions according to temporal units.

The BR coefficient ranges from 0.15 to 0.6, being the lowest for the earliest transition (from TU 9.3-8.3m to TU 8.3-7.2m) and the transition to TU 6.05-4.95m, and the highest for the transition to the final temporal unit (**Figure 7.57**).

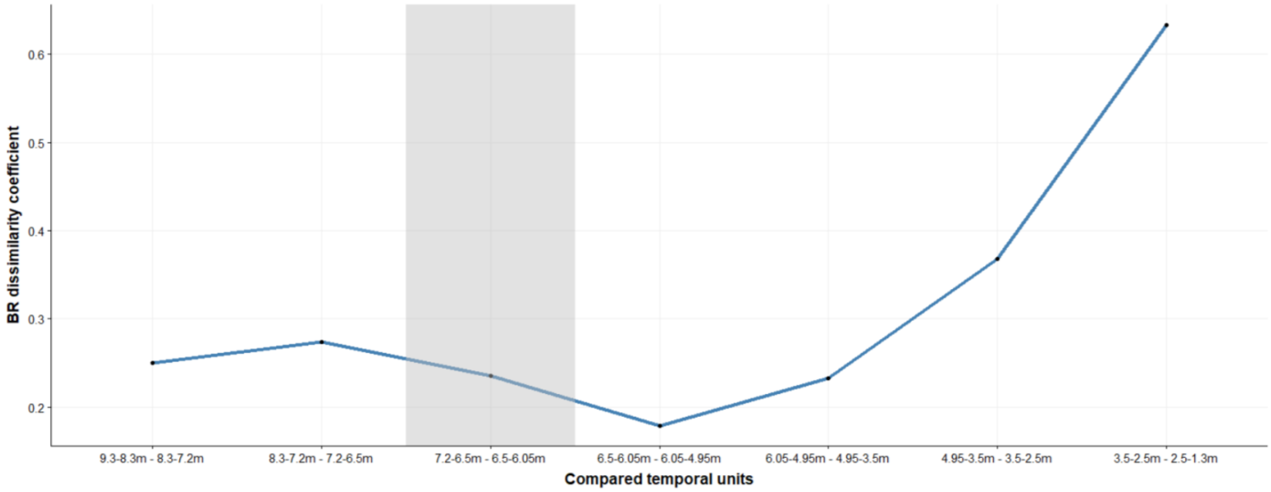


Figure 7.57. Magnitudes of diachronic changes in proportions of different body positions of figurines, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Arm position

For this analysis, the arm positions were classified into five modalities: spread towards the sides, placed on the torso (chests, belly, hips), facing upwards, placed on the face, holding a baby. The earliest and the latest two phases might poorly estimate the population richness. The battleship plot shows no sudden, discontinuous changes in arm position (**Figure 7.58**). The figurines with the arms spread towards the sides are by far the most common, while all other modalities are rare. Other arm positions appear mainly in the middle part of the sequence. The figurines with the arms placed on the torso appear during the Gradac phase and are present in the two subsequent temporal units, disappearing after 3.5 m. Figurines with the arms facing upwards emerge during TU 8.3-7.2 m and have similar proportions in the following temporal units, disappearing in the TU 4.95-3.5m. The figurines with arms placed on a face and holding a baby occur only in TU 6.05-4.95 and TU 4.95-3.5m, respectively. The temporal units do not exhibit statistically significant differences regarding their distributions of arm position modalities (n = 431, χ^2 = 19.26, df = 28, p = 0.89).

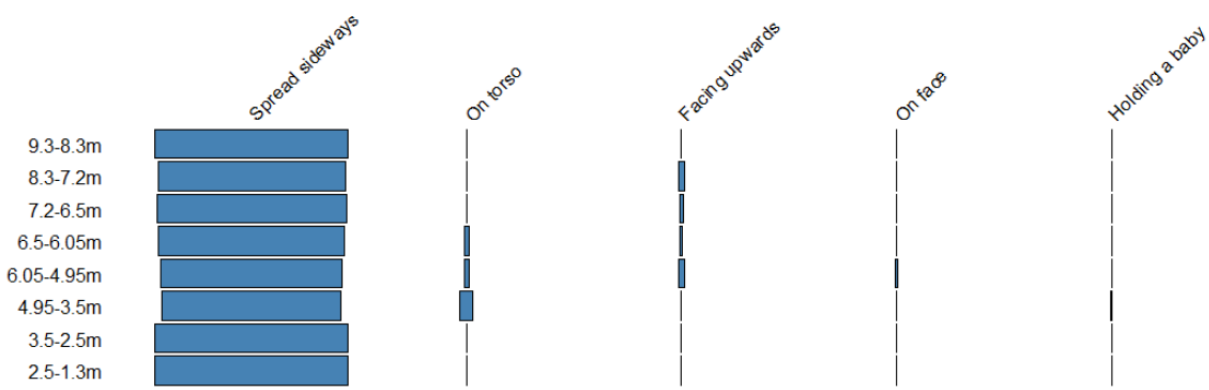


Figure 7.58. The battleship plot showing the proportion of figurines with different arm positions according to temporal units.

The BR coefficients are generally low, being heighest for the transition to TU 3.5-2.5m where the largest changes in arm position occur, and the lowest for the subsequent transition to the youngest temporal unit (**Figure 7.59**). The changes that occur with the transition to the Gradac phase are not pronounced.

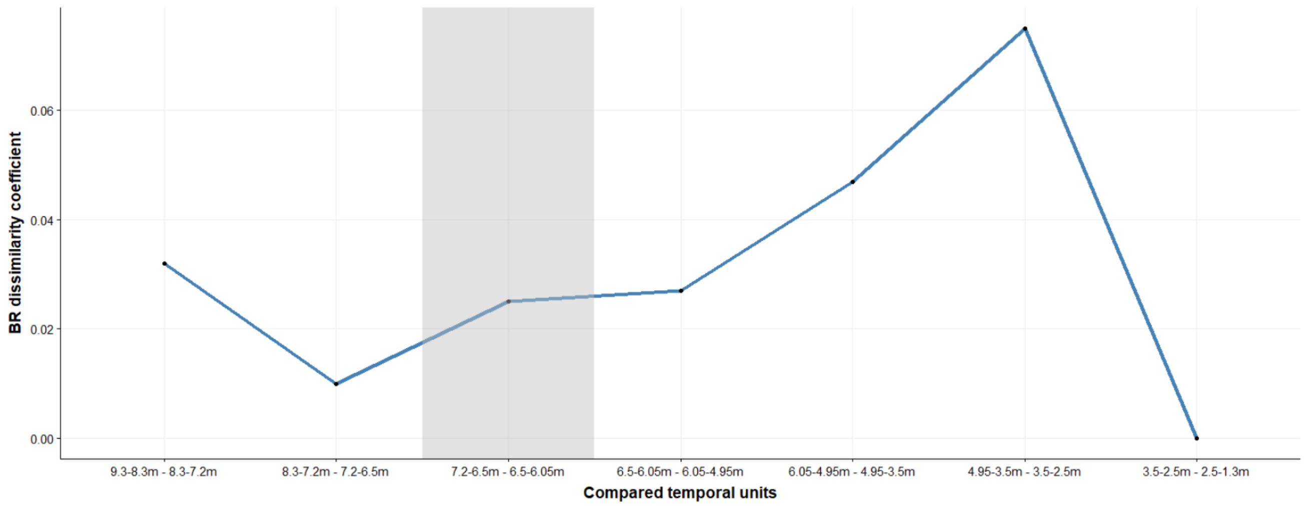


Figure 7.59. Magnitudes of diachronic changes in proportions of different arm positions of figurines, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Head shape

Creating the typology of figurine heads was a difficult task, as it was necessary to discretize many complex shapes of figurine heads (**Appendix 2**). Thus, the head shape typology presented here should be considered very rough and more sophisticated methods such as geometric morphometrics should be used in the future. The GMM analysis was not applied to figurine heads as: there are no sets of corresponding points on figurine head for the landmark analysis; the overall geometry of figurine heads cannot be appropriately normalized due to absence of a common geometric axis for all outlines, impeding the application of the EFA. The application of bootstrapping has shown good estimates of population richness for most samples, although the youngest two temporal units would probably increase in richness with larger samples. The battleship plot in **Figure 7.60** shows continuous distributions for the majority of head shape types and mostly gradual changes in their frequencies (for the classification of head shape modalities see **Appendix 2**). The first seven head shape modalities in the battleship plot have distributions often described as battleship curves, i.e. unimodal distributions often explained in terms of the popularity principle, while some types have only a few occurrences. The circular/oval, triangular/ogival, and trapezoidal heads are the most common modalities in the early phases, and they very gradually decrease in proportion in the later phases, before disappearing in the two youngest temporal units. The rectangular heads are present from the earliest temporal unit, gradually increasing in proportion and then having fairly stable proportions in the middle part of the sequence, before more markedly increasing in TU 3.5-2.5m and then decreasing in the latest temporal unit. The pentagonal faces occur in the middle part of the sequence, but also in the latest temporal unit, despite „disappearing“ in the previous TU. Head with pronounced zygomatics, reverse triangle/trapezoid, and rectangular with ’ears’ appear in the middle part of the sequence, but then increase in frequency and are characteristic of the youngest temporal units. The differences in distributions of head shape types in different temporal units are statistically significant (n = 389, χ^2 = 173.3, df = 70, p < 0.01) with a moderate effect size (Cramer’s V = 0.25).

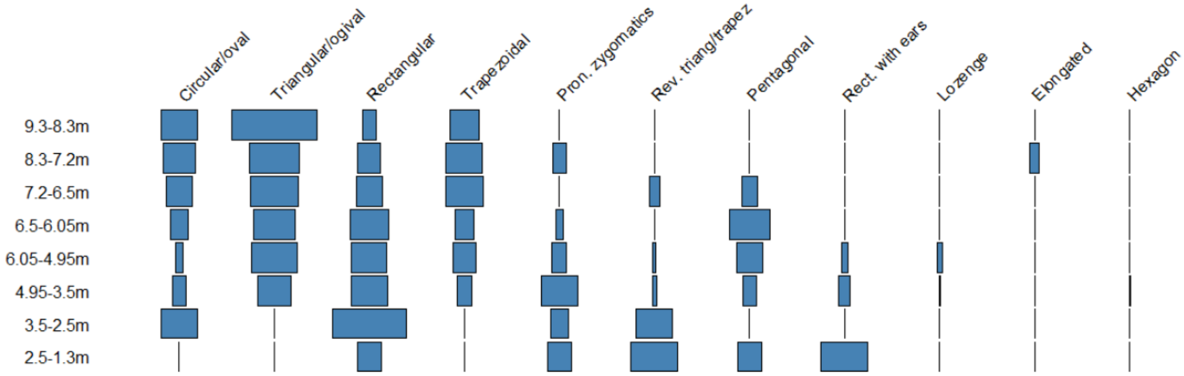


Figure 7.60. The battleship plot showing the proportion of figurines with different head shape types according to temporal units.

The magnitude of changes is roughly between 0.2 and 0.3 for all transitions in the early and middle part of the sequence, and then notably increases for the transitions to the two youngest temporal units where the values of BR coefficients are 0.52 and 0.56 (**Figure 7.61**).

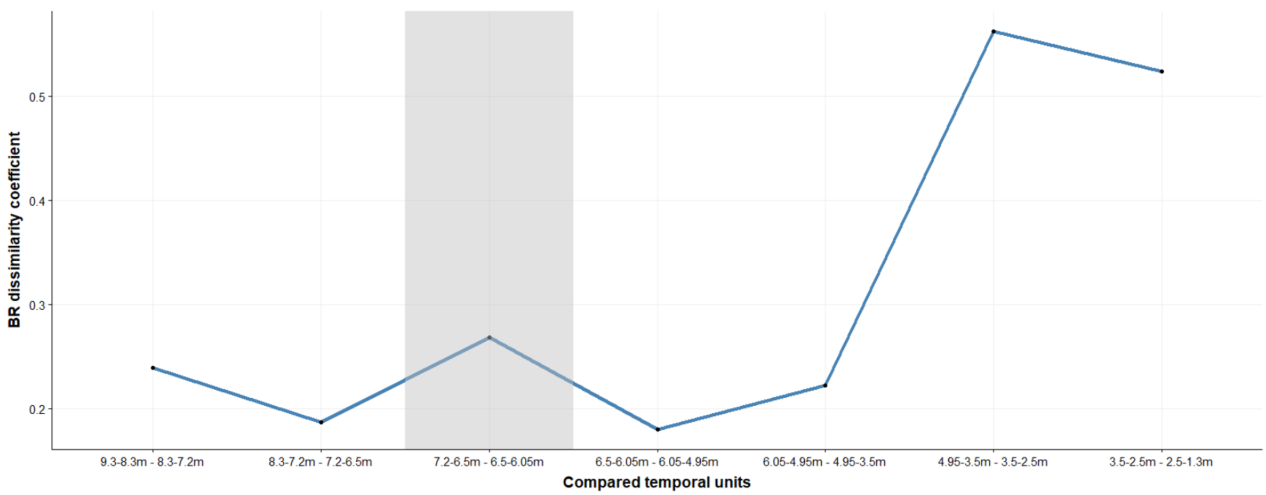


Figure 7.61. Magnitudes of diachronic changes in proportions of different head types of figurines, calculated using the Brainerd-Robinson dissimilarity coefficient.

Eye shape

In this study, 17 modalities of eye shape were defined (**Appendix 2**). The bootstrapping has shown that the estimates of richness for the latest two temporal units might be poor. The battleship plot that the figurines without eyes are the most frequent in the majority of temporal units, i.e. after the first two temporal units, and their percentage increases in the latest two temporal units (**Figure 7.62**). The linear and angular eyes are typical for the earlier intervals, although they do appear in low frequencies in the middle and even late part of the sequence. Triangular eyes appear during the TU 8.3-7.2m, slightly increase and then decrease in popularity, disappearing after the end of TU 4.95-3.5m. Eyes in the shape of a segment also appear during the TU 8.3-7.2m and are continuously present until the end of the Late Neolithic on Belo brdo. Other eye shapes are less frequent and are largely limited to the middle part of the sequence. It should be noted that many types do not have a completely continuous distribution, but due to the low percentages of most eye types, a possible explanation could be a sampling effect. The Chi-Square test indicates statistically significant differences in the structure of frequencies of various eye shapes between the temporal units (n = 368, $\chi^2 = 311.52$, df = 112, $p < 0.01$), with a moderate effect size (Cramer's V = 0.34).

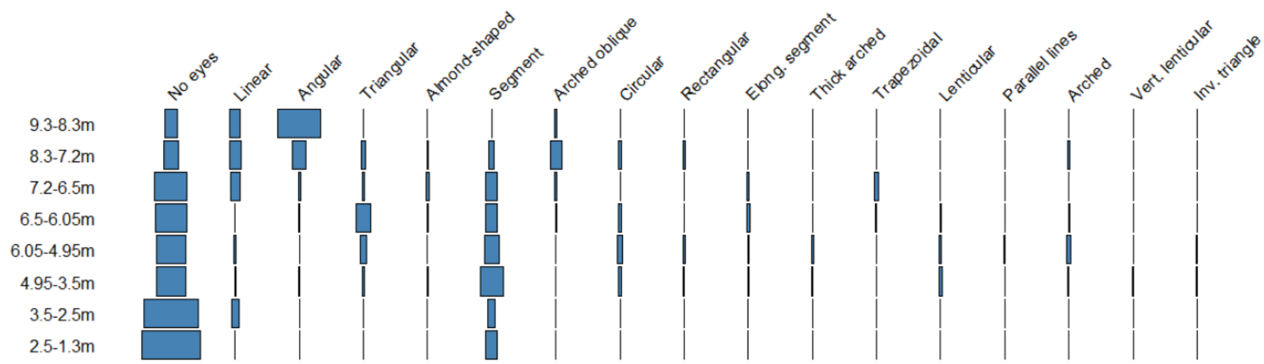


Figure 7.62. The battleship plot showing the proportion of figurines with different eye shapes according to temporal units.

The BR coefficient, which measures the magnitude of differences, is around 0.43 for the transitions to TU 8.3-7.2m and TU 7.2-6.5 m (**Figure 7.63**). It decreases for the subsequent transitions, before increasing again to the value of 0.44 for the transition to the TU 3.5-2.5m. The transition to TU 2.5-1.3m has the lowest value of BR (0.11), indicating the highest similarity between these two temporal units regarding the proportions of eye shapes.

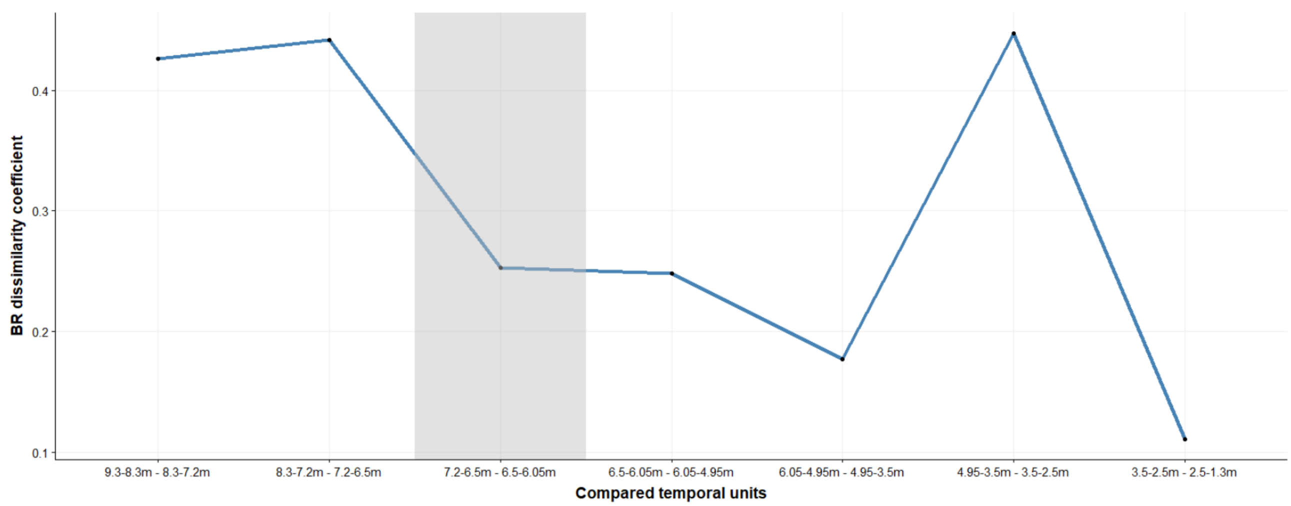


Figure 7.63. Magnitudes of diachronic changes in proportions of different eye types of figurines, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Skirt/lower body ornaments

The skirts/lower body ornaments are not present in the earliest temporal unit of the site, they appear in the following TU 8.3-7.2m. These ornaments were divided into two main groups of patterns/motifs, large patterns (LP, 12 modalities) and small patterns (SP, 4 modalities; see **Appendix 2**). Only the temporal units in the middle part of the sequence (TU 6.05-4.95m, 4.95-3.5m, 3.5-2.5m) have a richness that stabilizes with the given sample size, while all other temporal units might suffer from lower richness due to sampling effects (especially TU 8.3-7.2m and TU 2.5-1.3m that each have only one observation[17]). Several large motifs show continuous distributions and resemble battleship curves

[17] Note that the ornament on this figurine is very crude and irregular, but it resembles a maze-like motif.

(**Figure 7.64**). Large patterns of vertical and horizontal lines are present in almost all temporal units, while the belts are more restricted to the middle part of the sequence. The maze-like motifs (meanders) are characteristic of the earlier temporal units, nets are present in the middle part of the sequence, while the zig-zags are distributed in the later intervals. Other large motifs and all small motifs are much less frequent and occur primarily in the middle part of the sequence. The differences between the groups are not statistically significant as indicated by the Fisher's exact test (n = 136, simulated p = 0.12), but the effect size is moderate (Cramer's V = 0.31).

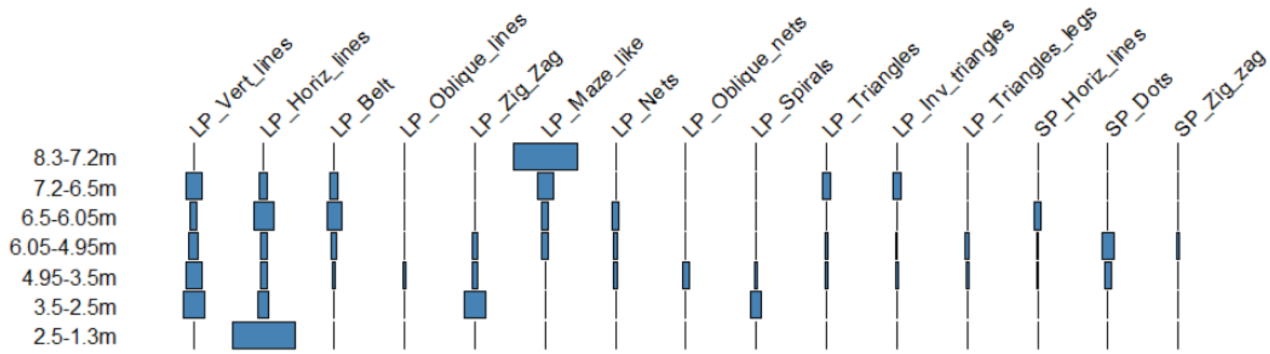


Figure 7.64. The battleship plot showing the proportion of different motifs on the lower body, according to temporal units.

A line plot in **Figure 7.65** shows the magnitudes of changes for different transitions within the sequence. The largest changes occur with the transition to TU 8.3-7.2m when the skirts/lower body ornaments appear, but they could not have been quantified. Among other changes on the site, the transitions to TU 7.2-6.5m and 2.5-1.3m have the highest values of BR dissimilarity coefficient. The BR coefficient shows a general temporal trend of larger differences between temporal units in the early and late part of the sequence, and smaller differences in its middle part.

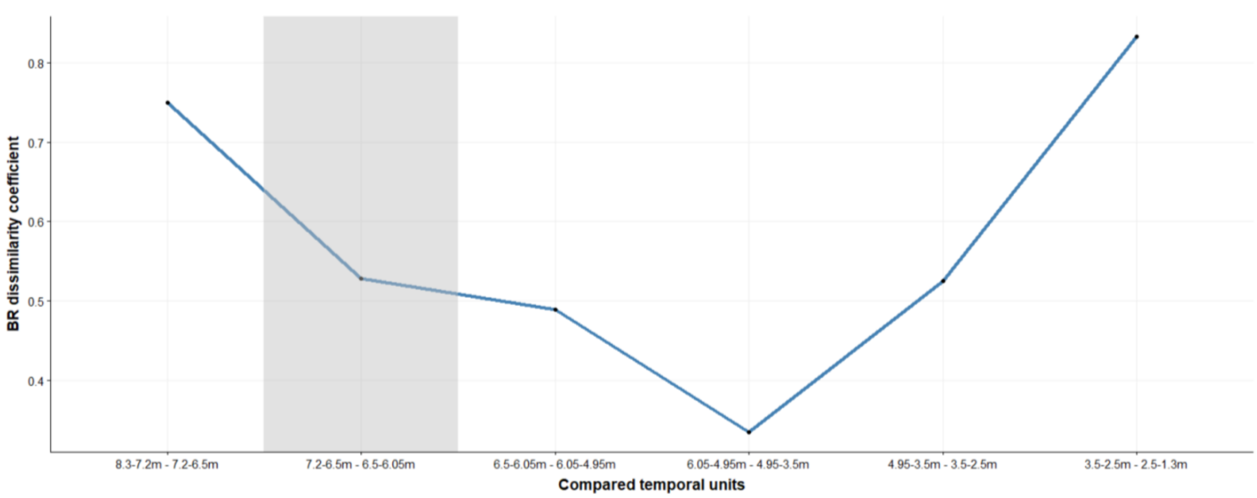


Figure 7.65. Magnitudes of diachronic changes in proportions of different motifs on the lower body, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

Summary of the diachronic changes in figurine attributes

As in the case of prismatic blades, the most pronounced changes in figurine attributes occur at different parts of the sequence for different attributes (**Table 7.17**). However, in the case of figurines, the largest changes most commonly occur for the transitions to the latest temporal units (TU 3.5-2.5m and TU2.5-1.3m). Interestingly, the transition to the Gradac phase is the only transition that does not exhibit the largest changes in some of the attributes and has the lowest mean z-score, so these results do not support research hypothesis 1. However, as in the case of prismatic blades, this approach only tends to roughly summarize the changes in different aspects of figurines, and some caution is needed when interpreting these results.

Table 7.17. Summary of the diachronic changes in figurine attributes.

Compared temporal units	Mean z-score	Number of largest changes
9.3-8.3m - 8.3-7.2m	0.09	1
8.3-7.2m - 7.2-6.5m	-0.22	1
7.2-6.5m - 6.5-6.05m	-0.51	0
6.5-6.05m - 6.05-4.95m	-0.33	1
6.05-4.95m - 4.95-3.5m	0.12	2
4.95-3.5m - 3.5-2.5m	0.49	4
3.5-2.5m - 2.5-1.3m	0.34	3

7.3.2. Diachronic changes in paradigmatic types of figurines

The paradigmatic classification was done to group figurines that share common features – e.g. same body and arm positions. As in the case of prismatic blades, figurine attributes commonly exhibit continuous variation, and creating typologies involves a certain degree of arbitrariness, especially in the case of quantitative variables. Thus, the paradigmatic classifications in this research are just arbitrary choices among many possibilities of combining qualitative and arbitrarily discretized qualitative attributes. However, their goal is to get some general insights into temporal changes when observing multiple attributes simultaneously.

Firstly, the paradigmatic classification was done on the whole figurines, using the following attributes and modalities: body position (1 – standing, 3 – kneeling), arm position (1 – spread towards sides, 3 – on the torso, 12 – holding a baby), head shape (1 – circular/oval, 2 – triangular/ogival, 3 – rectangular, 4 – trapezoidal, 5 – pronounced zygomatics, 6 – reverse triangle/trapezoid, 7 – pentagonal, 8 – rectangular with 'ears', 9 – lozenge), height (1 – below 50 mm, 2 – above 50 mm). The total number of combinations of attribute modalities (types) with at least one figurine is 18. Note that there are no whole figurines in TU 8.3-7.2m (**Figure 7.66**). Besides this gap in the sequence, the types show more or less continuous temporal distribution. Almost all the types are standing figurines with arms spread towards the sides, with the exception of two figurines – a figurine in a sitting position with the arms on the torso (type 3.3.4.2) and a standing figurine holding a baby (type 1.12.5.2). The standing figurines with spread arms differ in other two attributes – head shape and height (from top to bottom). The most common types of standing figurines with spread arms are those with triangular/ogival or rectangular head shapes. There are certain temporal trends of change where different types increase and decrease in popularity, but the Fisher's exact test does not indicate significant differences between the temporal units ($n = 55$, simulated $p = 0.72$).

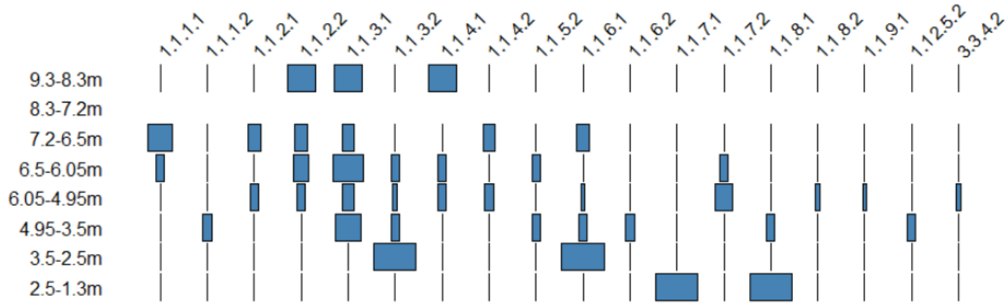


Figure 7.66. The battleship plot showing the proportion of different paradigmatic types of the whole figurines according to temporal units.

The BR dissimilarity coefficient indicates that the magnitude of changes is highest for the transition to TU 2.5-1.3m (**Figure 7.67**). It was not possible to calculate the BR coefficient for the transitions to temporal units 8.3-7.2m and 7.2-6.5m as there are no whole figurines in TU 8.3-7.2m.

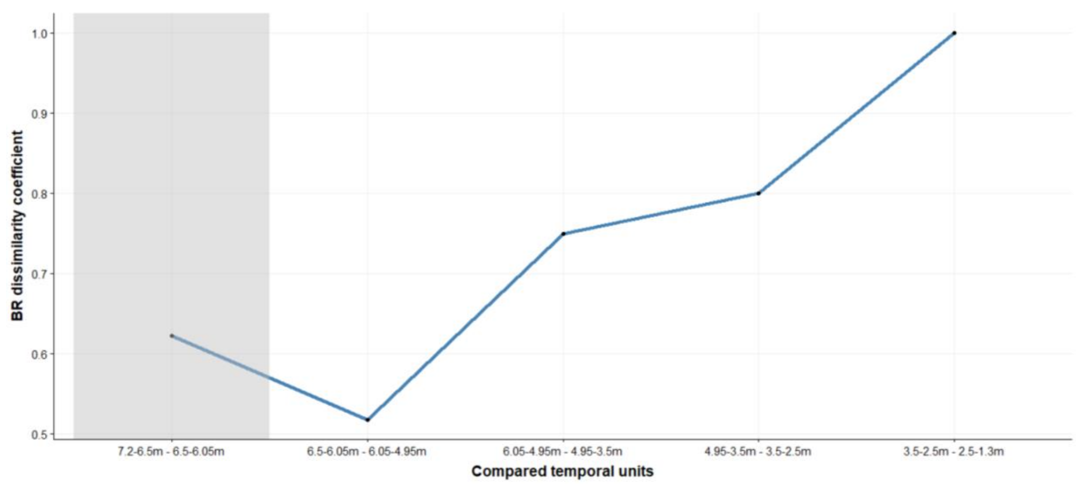


Figure 7.67. Magnitudes of diachronic changes in proportions of different paradigmatic types of whole figurines, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

To reduce the sampling effects and to incorporate other attributes in the exploration of general changes in figurines appearance, the paradigmatic classification was also done separately on figurine heads. After attempting several combinations of attributes, only two commonly discussed attributes were used for paradigmatic classification – head shape (1 – circular/oval; 2 – triangular/ogival; 3 – rectangular; 4 – trapezoidal; 5 – pronounced zygomatics; 6 – reverse trapezoid; 7 – pentagonal; 8 – type 8; 9 – lozenge) and eye shape (0 – no eyes; 1 – linear; 2 – angular; 3 – triangular; 4 – almond-shaped; 5 – segment; 6 – arched oblique; 7 - circular; 10 – rectangular; 11 – elongated segment; 12 – thick arched; 15 – trapezoidal; 17 – lenticular; 18 – parallel lines; 19 – arched; 22 – vertical lenticular; 25 – inverse triangles) – as the inclusion of additional attributes lead to incomprehensible results due to a very large number of types with low frequencies. As there are numerous modalities of these two attributes, there are a large number of 74 figurine types that are not empty, i.e. there is at least one figurine with that combination of attributes. The battleship plot in **Figure 7.68** shows that the majority of paradigmatic types of figurines have very low frequencies and proportions, indicating high variability in the appearance of figurine heads. Nevertheless, there are several types with continuous distributions and certain temporal trends in the presence of types. Some of the common types are those with circular/oval heads and no eyes, triangular/ogival heads and no eyes, triangular/ogival heads and angular eyes, heads with pronounced zygomatics with the eyes in the shape of segments. The differences between the groups, in terms of proportions of different eye shapes, are statistically significant (n = 280, simulated p < 0.01) with a strong effect size (Cramer's V = 0.57). The most common head types in the early part of the sequence are those with the triangular/ogival head shapes and angular eyes, and those with trapezoidal heads and angular eyes. The figurines with triangular/ogival or rectangular heads without eyes are characteristic of the middle part of the sequence. Finally, pronounced zygomatics, reverse triangle/trapezoid, and rectangular with 'ears' heads with no eyes are typical for the latest temporal units. However, there are many other types with low frequencies throughout the sequence, especially in its middle part.

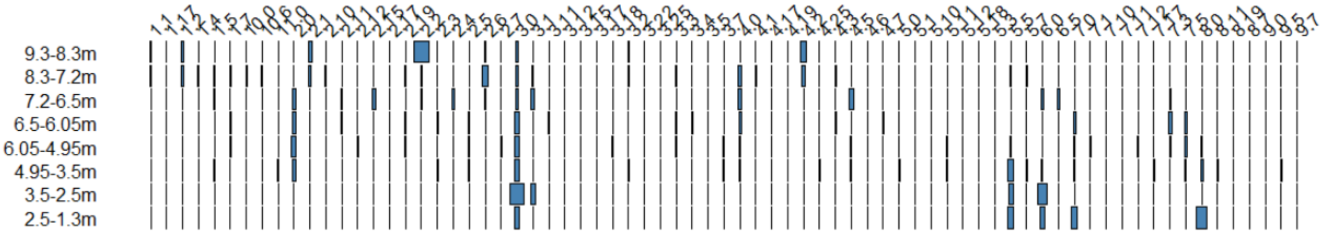


Figure 7.68. The battleship plot showing the proportion of paradigmatic types of the figurines heads according to temporal units.

The BR dissimilarity coefficient is generally high (~0.4~0.8) and shows a certain temporal trend – it is higher for the transitions to early and late temporal units than for the transitions in the middle part of the sequence (**Figure 7.69**). The largest changes in the proportion of different head types occur at the transition to TU 7.2-6.5m.

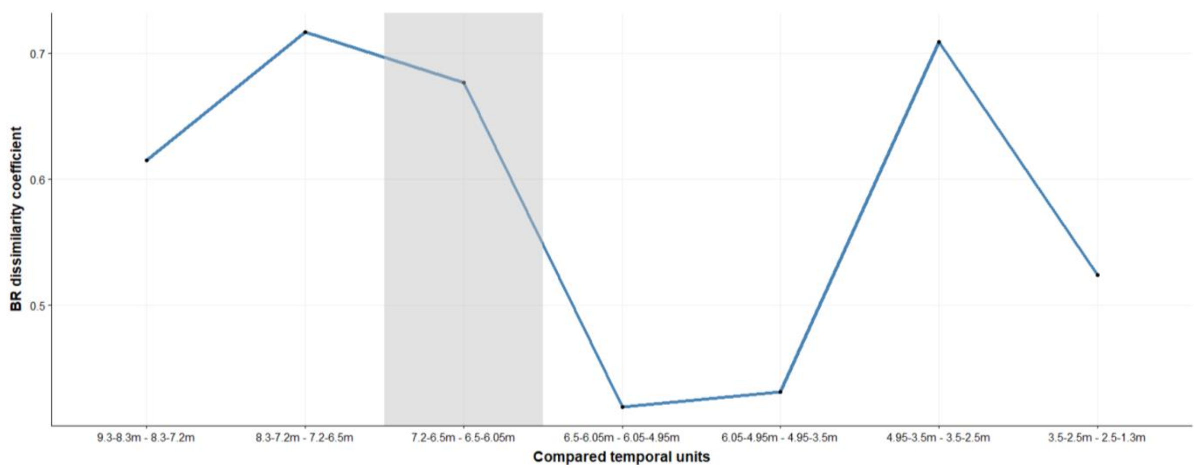


Figure 7.69. Magnitudes of diachronic changes in proportions of different paradigmatic types of figurine heads, calculated using the Brainerd-Robinson dissimilarity coefficient. The transition to the Gradac phase is shaded in grey.

7.3.3. Diachronic changes in the outline shape of figurines

The geometric morphometric analysis is a suitable tool for quantitatively exploring the morphology of objects. However, one of the primary assumptions is to have certain correspondence between the studied objects. In the case of outline shape, the comparability of the overall shapes is expected. In order to avoid the incomparability of figurine outlines, the Elliptic Fourier Analysis was conducted on the figurines with the most common body and arm positions – standing figurines with spread arms. After excluding figurines with other body and arm positions and those missing one arm, a small number of 32 figurines were analyzed using the EFA for exploring patterns of their morphological variation. Due to a small sample, only a visual assessment of the figurine outline shape was made.

The first three principal components describe 82.4% of figurine outline variability (PC1 – 55.7%, PC2 – 14.4%, PC3 – 12.3%). The first principal component is related to a combination of the stockiness of figurines and the relative arm length, where figurines with a more elongated body and short arms relative to the body have negative PC1 values, while the figurines with positive PC1 values have stocky bodies and arms that are longer in relation to the body (**Figure 7.70**). The PC2 seems to be related primarily to the position of arms in relation to the vertical axis of the body, but also to the shape and possibly size of arms. The PC3 is related to the stockiness of the figurines, primarily concerning their lower body, i.e. how bulky they are beneath the arms.

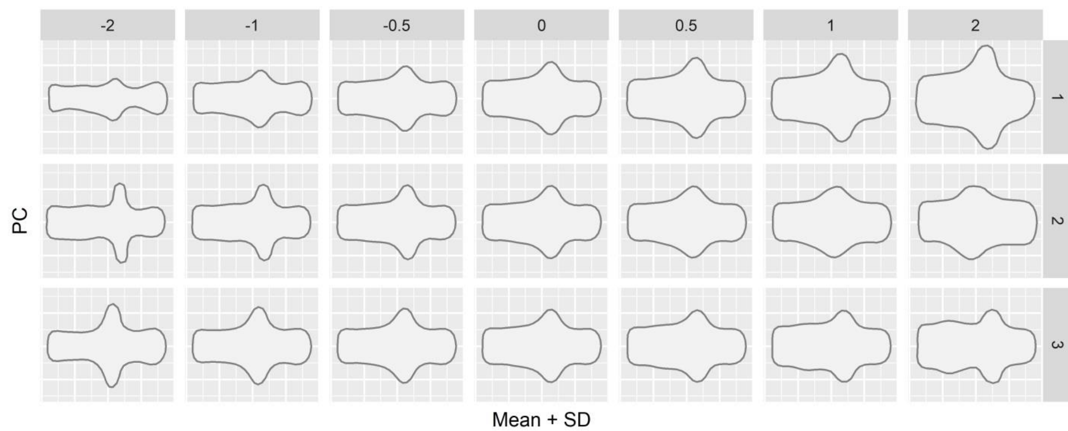


Figure 7.70. The morphospace of the first three principal components of figurine outline shape variability.

The PCA plots show that there is high morphological variability within the figurines with the same body and arm position (**Figure 7.71**). There is a possible clustering of certain figurine shapes, even though these possible clusters consist of figurines from different periods. However, these small samples do not allow any firmer conclusions. Although there are certain differences between figurines from different temporal units, there are no clear patterns of diachronic change. The figurines from the earliest temporal unit are generally somewhat more elongated and have shorter arms in relation to the body compared to later figurines, as indicated by their position on the PC1. Concerning the PC2, figurines from the earliest and the latest two temporal units have similar values, differing from figurines from all other temporal groups in this regard. The PC3 values indicate a very coarse trend of the bulkier lower part of figurines in the earlier temporal units, but the figurines from the Gradac phase deviate from this trend.

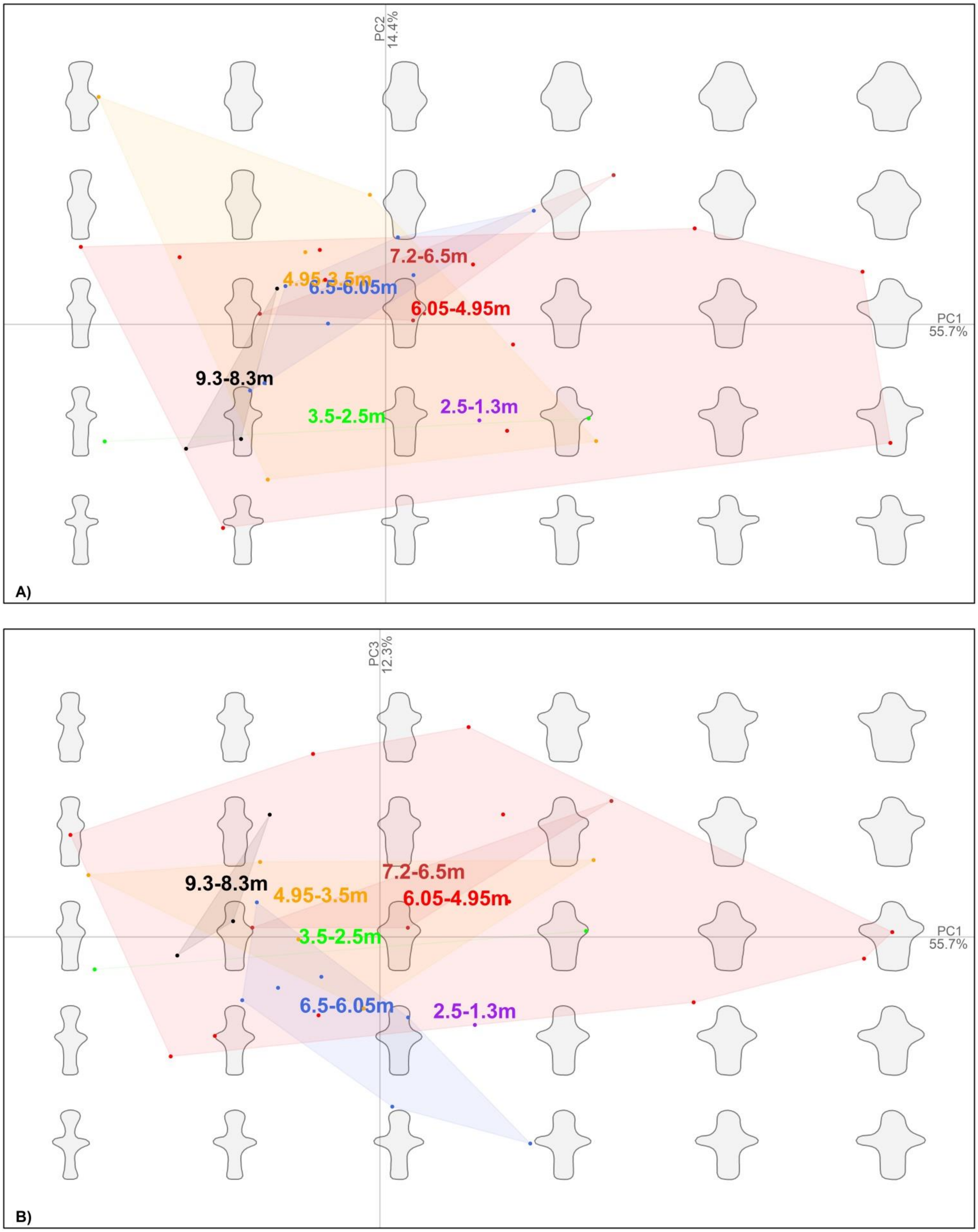


Figure 7.71. Scatter plots of PC1 and PC2 (A) and PC1 and PC3 (B) showing the main shape differences between the figurines from different temporal units, with visualization of the shape space. Convex hulls and group centroids are shown for each temporal unit.

8. Demography and cultural diversity of prismatic blades and anthropomorphic figurines

In this chapter, it will be explored if there is a relationship between population dynamics and cultural diversity. A correlation between these two variables is expected based on theoretical and empirical research (see Chapter 4). In the case of the Late Neolithic of the Central Balkans, two strands of evidence have suggested that the population size increases after the initial Late Neolithic and then decreases in the latest phase (Porčić 2020; Porčić et al. 2016; Ристић-Опачић 2005). Although these studies were focused on regional population dynamics, rather than local dynamics on Belo brdo, the possible effect of demographic factors on the cultural diversity at the studied site will be explored here.

8.1. Inferential methods

To assess the relationship between demography and cultural diversity in the case of lithics and anthropomorphic figurines, the diversity of these two artifact classes was quantified for each temporal unit and it was explored if it broadly correlates with the reconstructed population dynamics. To reduce the sampling effects and make a more general assessment of temporal changes in diversity, the material was aggregated into four 200-year-long temporal units. Although the four-fold division of temporal variation used here broadly resembles the commonly used Milojčić's periodization, it has slightly different boundaries of temporal units (**Table 8.1**).

Table 8.1. Temporal units for assessing the relationship between demography and cultural diversity, and age estimates for their boundaries (after Tasić et al. 2015b).

Temporal unit	Start (Highest Posterior Density interval, 95% probability)	End (Highest Posterior Density interval, 95% probability)
9.3-7.2m	5305-5255 cal BC	5135-5060 cal BC
7.2-6.05m	5135-5060 cal BC	4940-4855 cal BC
6.05-3.5m	4940-4855 cal BC	4730-4640 cal BC
3.5-1.3m	4730-4640 cal BC	4570-4460 cal BC

Diversity is a measure of variation within a particular collection. In the case of qualitative variables, it depends on the number of different types or attribute modalities and their frequency. The existence of a large number of types that are equally represented is an example of pronounced diversity (heterogeneity), while an example of low diversity (homogeneity) is a collection with a small number of groups where one has a considerably higher frequency than the others. The diversity of material cultures can be quantified in different ways and some researchers suggest that it is desirable to use different diversity indices in research (e.g. Morris et al. 2014). Three diversity measures for exploring the cultural diversity of qualitative features: Shannon's H (Shannon 1948), Simpson's D (Simpson 1949), and the Neiman's t_F (Neiman 1995). The Shannon index (H) is one of the most commonly used diversity indices, which takes into account the number of classes of an entity (e.g. different types of vessels) and the frequency distribution by class (e.g. 10 amphorae, 17 bowls). It is calculated according to the following formula:

$$H = - \sum_{i=1}^{k} p_i \, log(p_i)$$

where k represents a number of categories, while p_i represents a proportion of an element (e.g. a particular eye shape) in relation to the total number of studied entities. Simpson's diversity index (D) is calculated using the same parameters (number of categories and their frequencies), but using a different formula:

$$D = \sum_{i=1}^{k} p_i^2$$

Finally, Neiman's index of diversity (t_F) is calculated using the same parameters and the following formula:

$$t_F = \frac{1}{\sum_{i=1}^{k} p_i^2} - 1$$

It should be noted that despite the usage of these formal measures of diversity, the cultural diversity of qualitative data at least partially depends on the systematics, i.e. on our typologies and classifications. However, an effort was made here to define attribute modalities and types that have a low intra-group and a high inter-group variation, and should provide robust analytical units for the investigation of cultural diversity and dynamics.

The diversity of univariate quantitative data, primarily linear measurements, was quantified by using the coefficient of variation (CV) (e.g. Eerkens, Bettinger 2001). This commonly used measure is calculated by dividing the standard deviation of the sample by the sample mean. The minimal theoretical value of CV is 0 when all the observations have identical values, while the maximal value can be larger than one, indicating a high variance. The coefficient of variation is usually multiplied by 100 and expressed in percentages and is a useful measure for comparing the variability of different artifact classes (Eerkens, Bettinger 2001) as it eliminates the effect of scale. To quantify the diversity of multivariate data from the GMM analysis, the multivariate Euclidean distance (MED) was used (e.g. Herzlinger et al. 2018). The MED measures the multivariate deviations of each observation from the group centroid (mean shape). Unlike the coefficient of variation which eliminates the effect of scale, values of this measurement denote absolute deviations and cannot be compared for different artifact classes.

The diversity of different aspects of prismatic blades and figurines, quantified using the described measures, will be compared with the reconstructed demographic curve (Porčić et al. 2016; Porčić 2020). As there are no precise estimates of absolute population dynamics for the site of Vinča-Belo brdo, the correlation between population size and cultural diversity will only be explored visually, without using any statistical tests. It is expected that the cultural diversity will increase shortly after the beginning of the initial Late Neolithic (~5200 BC) and decrease near the end of the sequence (~4500 BC). In other words, the cultural diversity should be higher in the early and especially middle part of the sequence (TU 7.2-6.05m and TU 6.05-3.5m) than in the youngest temporal unit.

8.2. Demography and diversity of prismatic blades

Even though the temporal units of a longer duration and consequently a larger number of finds (**Figure 8.1**) were used for evaluating the research hypothesis 2, the bootstrapping has shown that the sample statistics (standard deviation, richness) for the whole unretouched blades from the youngest temporal interval (TU 3.5-1.3m; n = 9) do not completely stabilize, but that they are sufficient for making some general conclusions. For other temporal units and for the attributes that were observed on both whole and fragmented blades, the bootstrapping has shown that the sample statistics that are relevant for the study of diversity provide good estimates of the population parameters.

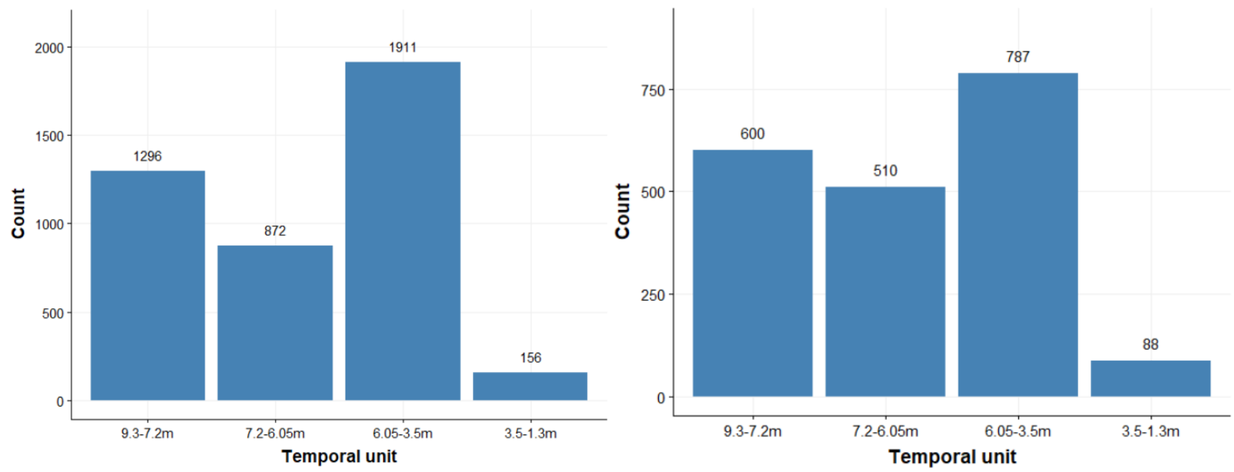


Figure 8.1. Frequencies of all chert finds (A) and prismatic blades (B) in 200-year-long temporal units.

Demography and diversity of quantitative attributes of prismatic blades

The temporal changes in coefficients of variation for each quantitative attribute of prismatic blades are shown in **Table 8.2** and **Figure 8.2.** The CV values for the length, elongation index, medial width, and the number of dorsal negatives range between 20 and 30%. The value of CV for medial thickness, platform area, and especially the mass of prismatic blades are higher, indicating a higher variability in these attributes. High coefficients of variation are generally expected in the case of reductive, less controllable technologies like knapping (Eerkens, Bettinger 2001; Schillinger et al. 2014). Concerning the temporal trends of the coefficients of variation for attributes of prismatic blades, three out of six quantitative attributes of prismatic blades – platform area, medial thickness, and medial width – show a general trend of decrease in cultural diversity from the initial to the final temporal unit. The coefficient of variation for the mass of the whole blades also decreases in temporal units 7.2-6.05m and 6.05-3.5m, but it then increases in the youngest temporal unit. The coefficient of variation for the length of the whole blades oscillates with a slight general trend of increase. The CV of elongation index increases in the TU 7.2-6.05m and 6.05-3.5m, and decreases in the youngest temporal unit, as expected if there is a correlation between demography and diversity of prismatic blades. However, the CV in the latest temporal unit is still higher than during the TU 7.2-6.05m, contrary to the expectations of this research hypothesis. Generally, the temporal trajectories of coefficients of variation are not in line with research hypothesis 2, except for the three attributes that show reduced diversity in the final temporal unit, as expected.

Table 8.2. Coefficient of variation for quantitative attributes of prismatic blades.

	CV (%)						
Temporal unit	**Length**	**Medial width**	**Medial thickness**	**Mass**	**Platform area**	**Elongation index**	**Number of dorsal negatives**
9.3-7.2m	26.1	31.8	54.6	104.9	68.7	26.9	25.0
7.2-6.05m	29.1	30.4	40.4	92.9	63.8	29.2	24.0
6.05-3.4m	26.2	28.2	38.2	64.5	55.7	31.0	26.0
3.5-1.3m	30.5	24.9	38.5	82.5	52.9	30.0	27.78

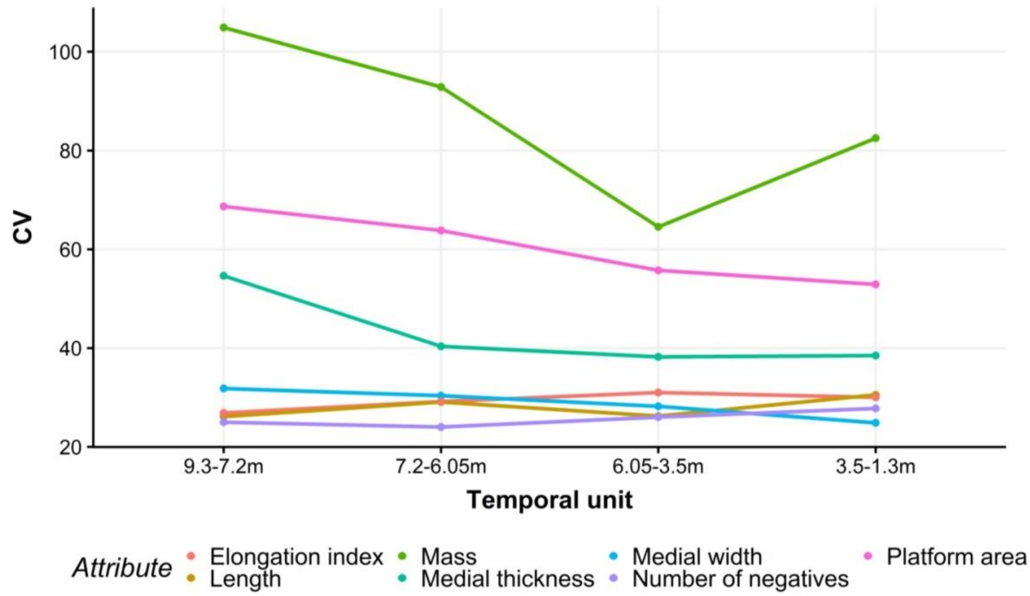


Figure 8.2. The diachronic changes of the coefficients of variation for prismatic blades from Vinča-Belo brdo.

Demography and diversity of qualitative attributes of prismatic blades

Qualitative attributes of prismatic blades that are related to bulb and lip that with a small number of modalities, as well as retouch distribution where the observations are not independent, were excluded from the analysis of cultural diversity. As all three diversity indices (Shannon's H, Simpson's D, Neiman's t_F) all show almost identical temporal trends, indicating that they probably all provide robust measures of diversity, only Shannon's index of diversity will be presented in this case. The coefficients of variation for four qualitative attributes of prismatic blades – directionality of removals, distal end termination, platform type, and debitage profile type – show different temporal trajectories (**Table 8.3**, **Figure 8.3**). The diversity of platform types increases from the beginning of the sequence until its end. Distal end type and debitage profile type have very similar trajectories of Shannon's index – it decreases slightly in the second temporal unit (TU 7.2-6.05m), increases in the TU 6.05-3.5m, before a more pronounced decrease in diversity in the final temporal unit. The diversity of the directionality of removals reduces from the initial temporal unit throughout the entire sequence, especially in the final temporal unit. The qualitative attributes show a partial agreement with research hypothesis 2, as a notable decrease in diversity in the final temporal unit is expected in the case of correlation between demography and cultural diversity.

Table 8.3. Values of Shannon's index of diversity for qualitative attributes in different temporal units.

	Shannon's index (H)			
Temporal unit	**Directionality**	**Profile type**	**Distal end**	**Platform type**
9.3-7.2m	0.40	0.85	0.50	1.03
7.2-6.05m	0.36	0.79	0.40	1.08
6.05-3.5m	0.26	0.91	0.56	1.20
3.5-1.3m	0.00	0.67	0.29	1.32

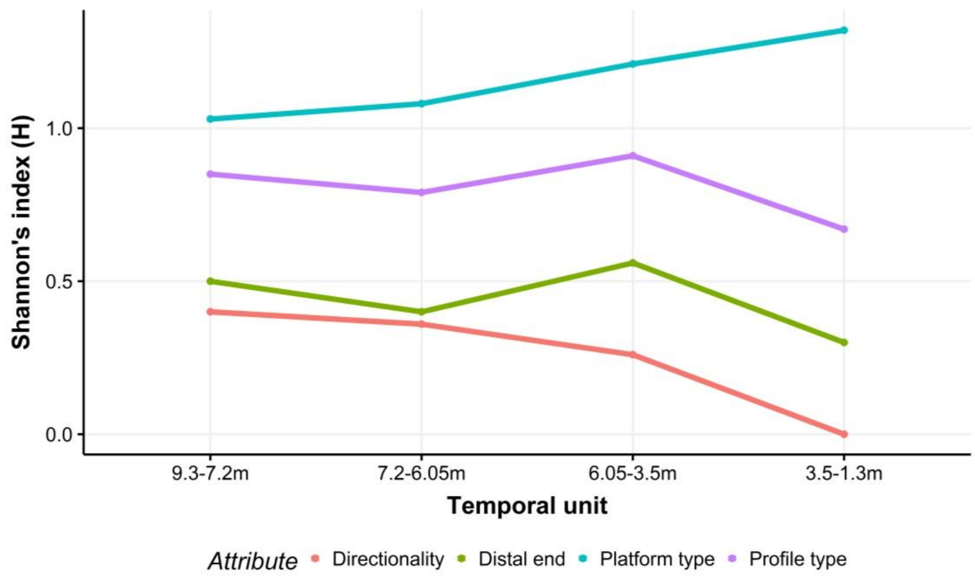


Figure 8.3. The diachronic changes in the diversity of different qualitative attributes of prismatic blades, quantified using Shannon's index.

Demography and diversity of paradigmatic types of prismatic blades

Paradigmatic types defined in Section 7.2.2 relied on the arbitrary discretization of continuous attributes and represent one of many possible attribute combinations. Nevertheless, they should be suitable for assessing the relative changes in the diversity of prismatic blades. **Table 8.4** and **Figure 8.4** indicate a general agreement between all measures of diversity – the diversity decreases gradually from the beginning until the end of the sequence. A reduction in diversity for the Simpson's D is not evident from the figure, however, as the values of this index are generally lower and show a more subtle decrease in values. Like in the case of qualitative attributes of prismatic blades, these temporal trends in diversity of prismatic blades only partially match the expectation of research hypothesis 2 – diversity decreases in the final temporal unit, as predicted.

Table 8.4. Values of diversity for paradigmatic types of prismatic blades in different temporal units.

Temporal unit	Shannon's H	Simpson's D	Neiman's t_F
9.3-7.2m	2.31	0.84	5.44
7.2-6.05m	2.18	0.84	5.32
6.05-3.5m	2.12	0.82	4.64
3.5-1.3m	1.83	0.81	4.40

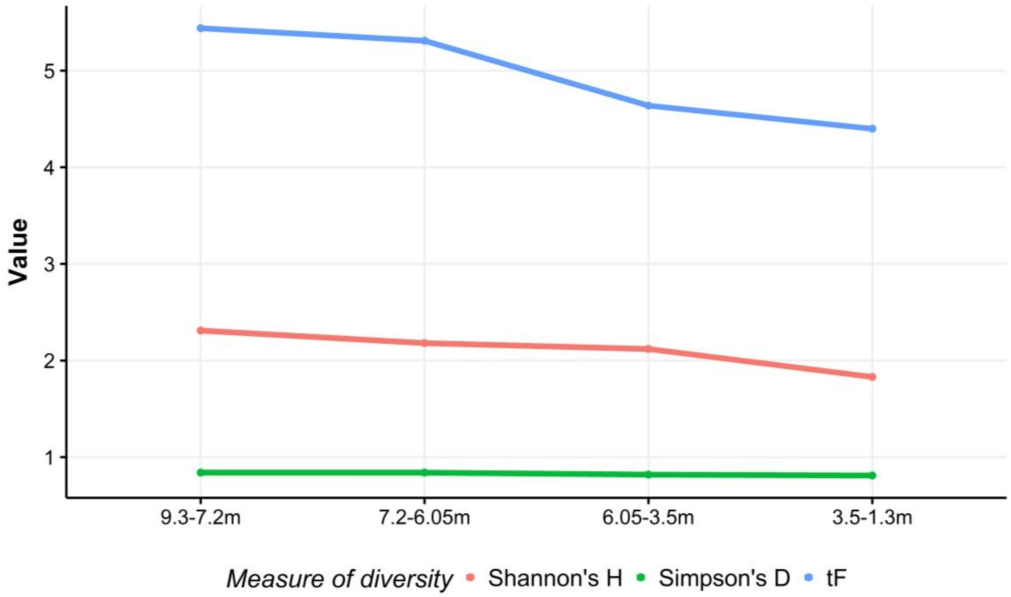


Figure 8.4. The diachronic changes in the diversity of paradigmatic types of prismatic blades, quantified using different measures of diversity.

Demography and diversity of outline shapes of prismatic blades

For the blade outline shape, the diversity was assessed by observing how much individual blades deviate from the mean shape of their group. These deviations measured using the multivariate Euclidean distances are shown in **Figure 8.5**. They are quite similar for the two oldest and the latest temporal unit, and markedly higher for the TU 6.05-3.5m. These results are not completely consistent with research hypothesis 2.

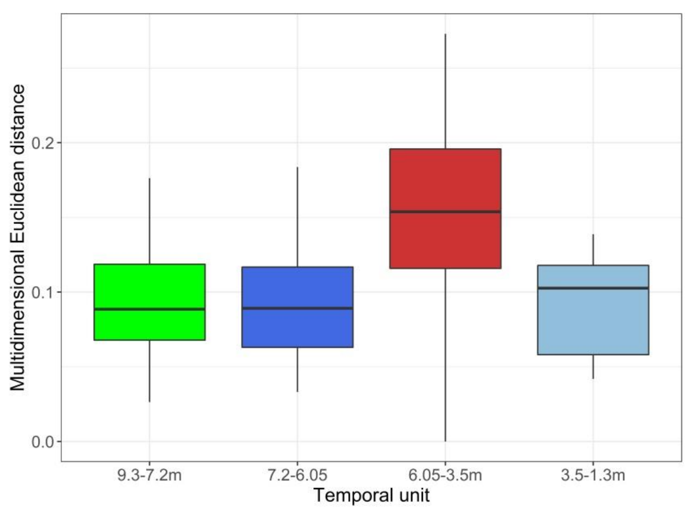


Figure 8.5. The box plot comparing the diversity in outline shapes of prismatic blades from different temporal units, calculated using the multivariate Euclidean distance.

The coefficients of variation for the bilateral symmetry of prismatic blades show the opposite trend from the one that is expected if the cultural diversity follows the hypothesized population dynamics (**Figure 8.6**). The CV decreases in the middle part of the sequence and increases in the latest temporal unit.

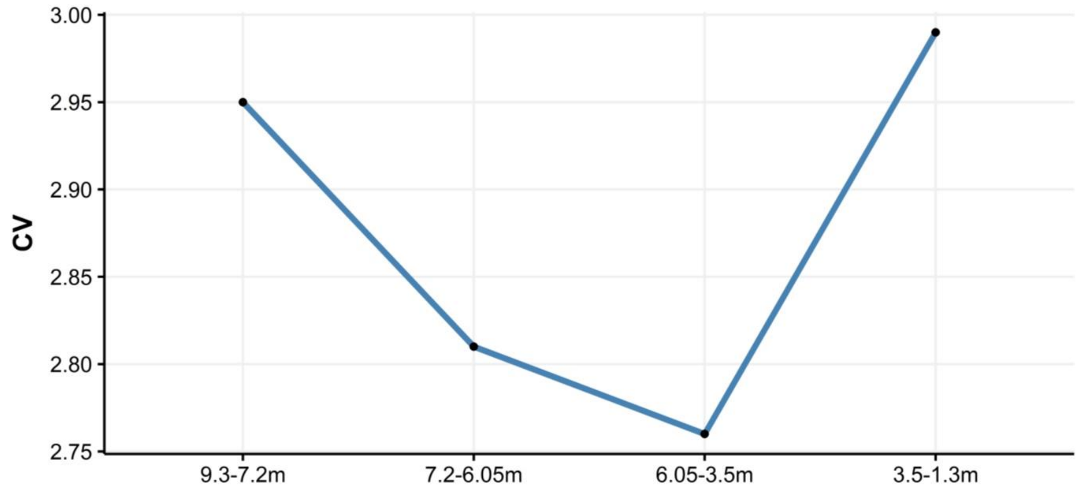


Figure 8.6. The temporal change of the coefficient of variation for the symmetry of prismatic blades.

8.3. Demography and diversity of anthropomorphic figurines

The number of figurines in each 200-year-long temporal unit is shown in **Figure 8.7**. The bootstrapping has shown that the samples from the first three temporal units are sufficient and provide good estimates of the population parameters, but that the sample statistics (standard deviation, richness) for the latest temporal unit should be treated with some caution.

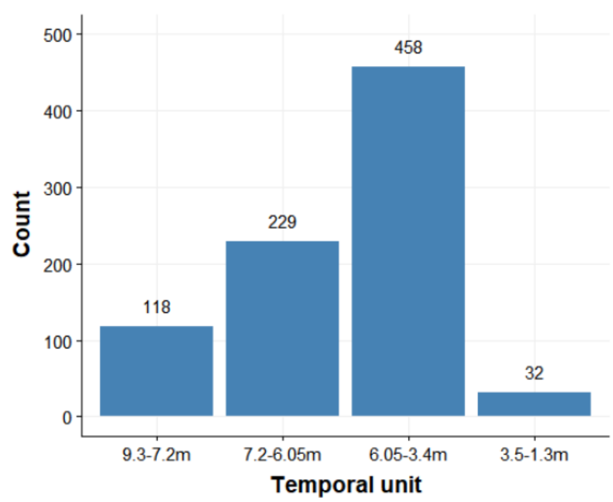


Figure 8.7. The number of figurines in each 200-year-long temporal unit.

Demography and diversity of quantitative attributes of anthropomorphic figurines

The coefficients of variation for the quantitative attributes of figurines show different temporal trajectories (**Table 8.5, Figure 8.8**). The CV for figurine measurements and indices generally ranges between 20 and 40%, indicating non-standardized, but also not extremely variable production (Eerkens, Bettinger 2001), as in the case of prismatic blades. The temporal trends of diversity of the arm length and possibly waist thickness match the expectations of research hypothesis 2. The CVs of the relative width of the lowest part and the height of figurines, on the other hand, correlates with assumed population dynamics only for the latest temporal unit, as their values decrease as predicted. The remaining two attributes, the head height and the head height/width ratio, do not support the hypothesis regarding the relationship between population dynamics and cultural diversity.

Table 8.5. Coefficients of variation for different quantitative attributes of anthropomorphic figurines, calculated separately for each temporal unit.

	CV (%)					
Temporal unit	Height	Head height	Head height/ width	Waist thickness	Arm length	Relative width of the lowest part
9.3-7.2m	48.4	39.4	28.8	30.5	36.6	34.6
7.2-6.05m	28.9	44.3	15.3	31.0	45.1	35.4
6.05-3.4m	42.5	44.3	19.4	30.9	54.1	18.9
3.5-1.3m	28.6	62.7	23.8	23.1	33.8	9.4

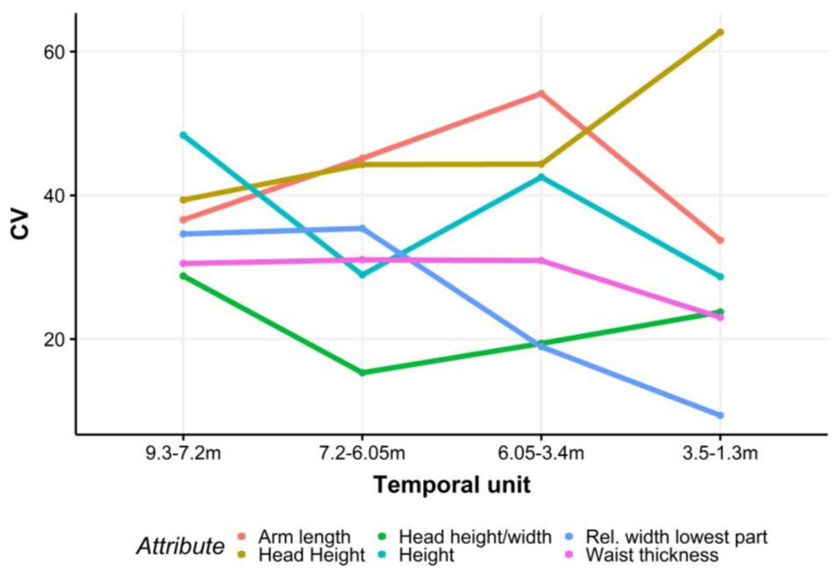


Figure 8.8. Diachronic changes in the diversity of quantitative attributes of figurines, measured using the coefficient of variation.

Demography and diversity of qualitative attributes of anthropomorphic figurines

The three indices that were used for measuring the diversity of qualitative attributes – Shannon's H, Simpson's D, and Neiman's t_F – have shown generally similar, but also slightly different trends of temporal changes in the diversity of qualitative attributes, so all three indices are presented here (**Table 8.6, Figure 8.9**). The diversity of arm position, head shape, and skirt/lower body ornaments matches the expectations of research hypothesis 2, as it increases in the middle of the sequence and decreases in its latest part. Temporal changes in the diversity of eye shapes also show some agreement with the research hypothesis 2, as the diversity is fairly constant in the first three units and then it sharply decreases in the latest temporal unit. In the case of body position and lower body type, the temporal trend of diversity does not fulfill the expectation of research hypothesis 2.

Table 8.6. Diversity indices for qualitative attributes of anthropomorphic figurines, calculated separately for each TU.

Attribute	Temporal unit	Shannon's H	Simpson's D	Neiman's t_F
Body position	9.3-7.2m	0.23	0.11	0.13
	7.2-6.05m	0.12	0.05	0.05
	6.05-3.4m	0.45	0.22	0.29
	3.5-1.3m	0.32	0.18	0.22
Lower body type	9.3-7.2m	1.05	0.63	1.74
	7.2-6.05m	0.99	0.60	1.48
	6.05-3.4m	1.07	0.65	1.83
	3.5-1.3m	0.99	0.59	1.47
Arm position	9.3-7.2m	0.10	0.04	0.04
	7.2-6.05m	0.16	0.06	0.07
	6.05-3.4m	0.32	0.13	0.15
	3.5-1.3m	0.00	0.00	0.00
Head shape	9.3-7.2m	1.53	0.75	2.96
	7.2-6.05m	1.73	0.81	4.18
	6.05-3.4m	1.97	0.84	5.17
	3.5-1.3m	1.66	0.79	3.744
Eye shape	9.3-7.2m	1.79	0.78	3.58
	7.2-6.05m	1.75	0.73	2.77
	6.05-3.4m	1.76	0.73	2.72
	3.5-1.3m	0.63	0.34	0.51
Skirt	9.3-7.2m	2.73	0.91	10.08
	7.2-6.05m	2.92	0.93	13.32
	6.05-3.4m	3.25	0.94	14.69
	3.5-1.3m	1.56	0.78	3.54

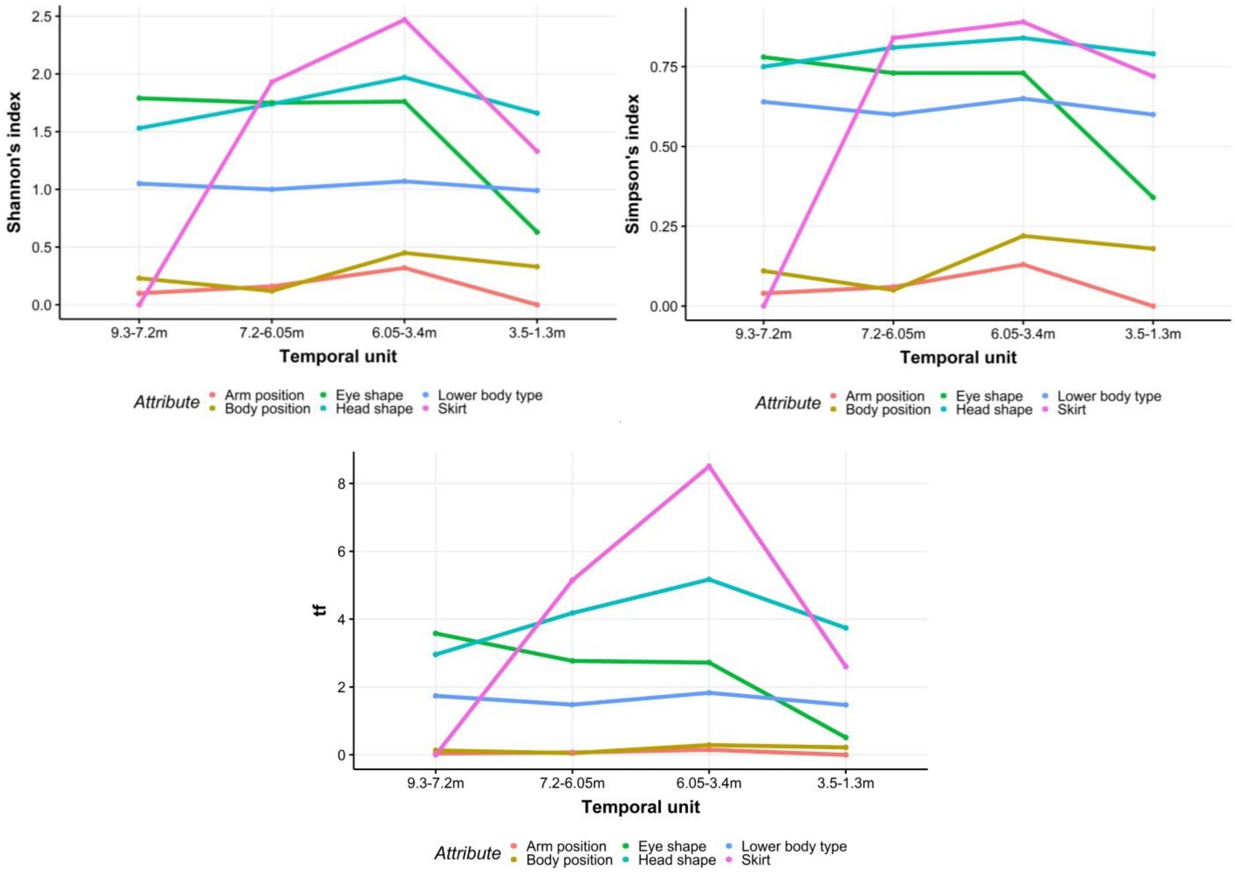


Figure 8.9. The diachronic changes in the diversity of different qualitative attributes of anthropomorphic figurines, measured using the a) Shannon's H; b) Simpson's D; c) Neiman's t_F.

Demography and diversity of paradigmatic types of anthropomorphic figurines

Paradigmatic classification of the whole figurines, described in Section 7.3.2, was used here as an analytical tool for exploring the temporal trends of diversity. It should be highlighted here that this typology relies on a fairly arbitrary discretization and combination of attributes, but its advantage is that it allows us to compare the diversity of the whole objects, not only its preserved parts. The temporal trajectories of diversity indices differ only in magnitudes of values, but they all show evidence of the same temporal trend (**Table 8.7, Figure 8.10**). The diversity of paradigmatic types of whole figurines increases in the middle part of the sequence, and decreases in the final temporal unit, as expected in the case of a correlation between demography and cultural diversity, but the sample size issues should be taken into account.

Table 8.7. Diversity indices for paradigmatic types of whole anthropomorphic figurines, calculated separately for each temporal unit.

Temporal unit	Shannon's H	Simpson's D	Neiman's tf
9.3-7.2m	1.10	0.67	2.00
7.2-6.05m	2.08	0.85	5.48
6.05-3.4m	2.58	0.91	9.71
3.5-1.3m	1.39	0.75	3.00

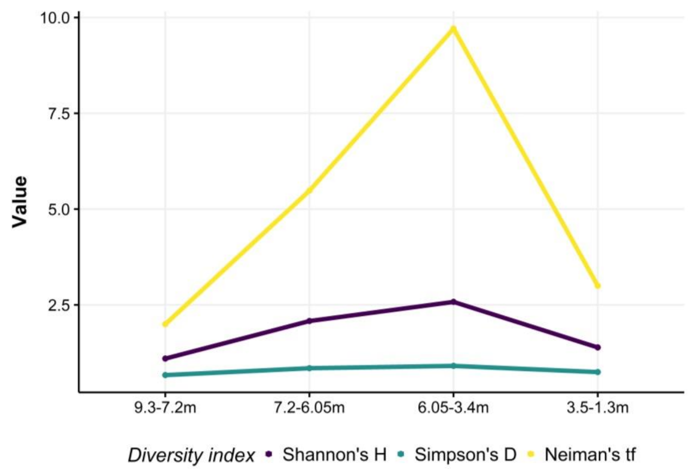


Figure 8.10. The diachronic changes in the diversity of paradigmatic types of whole anthropomorphic figurines, measured using Shannon's H, Simpson's D, and Neiman's t_F.

As presented in Section 7.3.2, the paradigmatic types of figurines heads were obtained by combining different modalities of head and eye shape. The diachronic changes of the paradigmatic types of figurines show the same trend as types of whole figurines, i.e. their diversity increases in temporal units 7.2-6.5m and 6.05-3.5m and decreases in the latest temporal unit (**Table 8.8, Figure 8.11**), mirroring the assumed changes in population size.

Table 8.8. Diversity indices for paradigmatic types of figurine heads, calculated separately for each temporal unit.

Temporal unit	Shannon's H	Simpson's D	Neiman's t_F
9.3-7.2m	2.73	0.91	10.08
7.2-6.05m	2.92	0.93	13.32
6.05-3.4m	3.25	0.94	14.69
3.5-1.3m	1.56	0.78	3.55

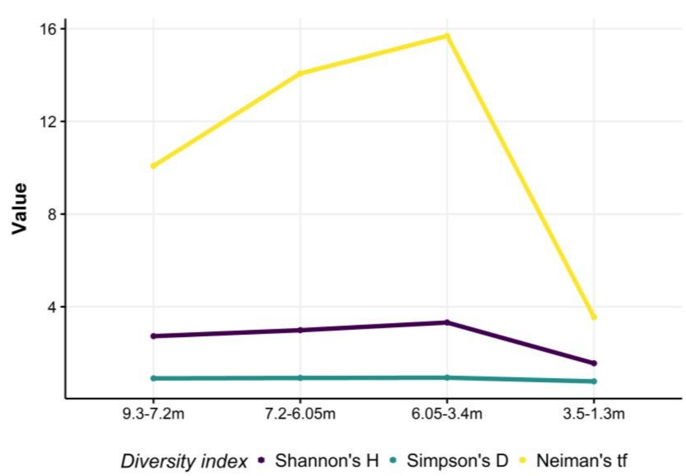


Figure 8.11. The diachronic changes in the diversity of paradigmatic types of heads of anthropomorphic figurines, measured using Shannon's H, Simpson's D, and Neiman's t_F.

The number of whole figurines analyzed using the geometric morphometrics is too low for any meaningful assessment of the changes in their diversity.

9. Reconstructing the models of cultural transmission on Vinča-Belo brdo

9.1. Inferential methods

What socio-cultural scenarios stand behind the observed patterns of variability of figurines and prismatic blades that were described in Chapter 7? This "inverse problem" (Shennan 2011) can be tackled by using the agent-based computer simulations to "re-create possible pasts" and the inferential frameworks to assess which of them most closely resemble the patterns that we see in the archaeological record. In this research, the approach developed by Crema et al. (2016) was used for inferring the models of cultural transmission, i.e. the scenarios of information-flowing within the Belo brdo community. This approach enables a simulation of different scenarios of the past that can incorporate relevant information about the studied communities (e.g. innovation rate, population size and dynamics, production rate) and sampling effects into the models, while a formal inferential framework based on Bayesian inference allows selecting a range of hypotheses that best fit the observed data. It takes into account the issue of equifinality (e.g. Kandler et al. 2017), i.e. the fact that different social scenarios can produce similar patterns of material culture variability. Thus, rather than inferring a single most likely social scenario, the goal of this inferential framework, named approximate Bayesian computation (ABC) is to narrow down the possible historical scenarios (e.g. Crema et al. 2016) by excluding the unlikely ones (Kandler et al. 2017).

In the ABC framework, a range of hypotheses that could explain the observed data are generated based on our previous knowledge on the studied phenomenon (prior parameters). Subsequently, it is evaluated which hypotheses and their corresponding combinations of parameters best fit the observed data. The parameters that provide the best fit for the observed data are named posterior parameters. For example, to investigate the population size and dynamics during the Mesolithic-Neolithic transitional phase at Lepenski Vir settlement in the Danube Gorges, Porčić and Nikolić (2016) used all available knowledge about relevant aspects (prior parameters) – e.g. duration of occupation of the site based on radiocarbon dates, the average use-life of houses, average house floor area, estimates of household size based on floor area, population dynamics – which were the defined as prior parameters and combined for generating a range of hypotheses. The outcomes of these various hypotheses were explored using the computer simulations, where *virtual* populations would behave according to defined prior parameters and produce a sufficient number of houses for accommodating a population of a certain size. In the final step, Porčić and Nikolić evaluate which of the simulated hypotheses produce the number of houses which is most similar to the number of houses in the archaeological record at Lepenski Vir. The posterior parameters of these best-fitting hypotheses have most likely produced the observed data in the archaeological record. As they were interested in population size and dynamics, they explore the range of posterior values for them to provide estimates for demographic aspects of Lepenski Vir.

In this research, it was investigated which scenarios of transmission of knowledge about knapped stone tools and anthropomorphic figurines best fit the observed patterns of cultural stability and change. Vinča-Belo brdo is adequate for such an approach due to the abundance of finds, firmly established chronology, and continuity of occupation (Tasić et al. 2015a; 2015b; 2016). The variable population-transmission model was chosen for simulating a range of different scenarios of cultural transmission, as it allows the changes in different parameters of transmission (e.g. transmission models, innovation rate) rather than keeping them constant throughout the entire period. A limitation of this approach is that it incorporates only the three commonly discussed models – a continuum between a neutral (unbiased) model and frequency-dependent biases, i.e. conformism and anti-conformism (**Figure 9.1**) – but more comprehensive frameworks are yet to be developed.

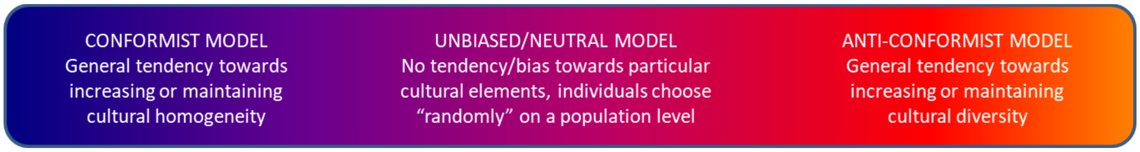


Figure 9.1. A continuum between conformist, unbiased, and anti-conformist transmission.

A general description of the variable population-transmission model will be presented here in simple terms in the context of this case study, but the reader should refer to the original publication for a more detailed overview (Crema et al. 2016). The variable population-transmission model simulates the transmission and modification of cultural knowledge through time, as well as the processes of sampling and time-averaging that characterize the archaeological data. It is developed for simulating the transmission of qualitative traits (e.g. ornament variants, ceramic types) that can be expressed in frequencies. As mentioned in Chapter 3, the cultural dynamics can be described as the changes in frequencies of cultural modalities (types or attribute modalities). Starting from the structure of frequencies of cultural modalities in the initial temporal unit ('initial sampling pool', Crema et al. 2016), which is inferred from the archaeological record, a range of possible scenarios is simulated and the trajectories of changes in the frequencies of cultural modalities in these theoretical models are compared with the trajectories of change in the archaeological record. Theoretical models that demonstrate changes in frequencies that are most similar to those that are empirically observed are preserved as plausible models of the past, while the other models are excluded as unlikely.

Starting with the initial frequencies of cultural modalities (sample from the oldest temporal unit), the Dirichlet distribution is used to generate a possible (probable) population from which this sample was drawn, while the simulations aim to re-create the process of transmission and modification of knowledge in the subsequent generations. In each temporal unit, agents ('individuals') produce artifacts at a certain rate by copying them from a particular model or creating a new cultural element by innovation. All these parameters – number of temporal units and their duration, population size, production rate, model of transmission, innovation rate – need to be defined. Parameters related to the chronology are known and they remain constant in all the simulations. In the case of Vinča-Belo brdo, the 800 years of occupation of the site were divided into four 200-year-long units (see Chapter 8), in order to have sufficient sample sizes. Other parameters, such as the production rate, models of transmission, and population size, are informed by our knowledge about the studied community or estimated from other sources (e.g. ethnographical data). However, rather than having a single value for each of these parameters, ranges of their possible values are defined by the researchers based on the available data. The ranges of values for relevant parameters that were used for simulating the cultural dynamics on Belo brdo are shown in **Table 9.1**. The effective population size, i.e. a total number of producers in each temporal unit, was defined indirectly by Crema et al. (2016), as a combination of a number of households (H) and a number of producers in each household (ρ). Concerning the Vasić's excavations at Belo brdo, B. Stalio conducted a detailed analysis of the building horizons of the site from the available documentation (Сталио 1968). An approximate number of households in each 200-year-long temporal interval was calculated from Stalio's report, but this number was increased by 50% as the new excavations indicate a certain number of unburned houses in addition to the burned houses that were documented during the Vasić's excavations (e.g. Tasić et al. 2016). The number of producers in each household was estimated to a range between 1 and 5, as the previous researchers have indicated that these households could accommodate nuclear or extended family, or other small groups that were related in some other way (Глишић 1968; Трипковић 2013). The recovery rate (r) is another parameter that is used for estimating the population size, which indicates the estimate of the size of the observed archaeological sample in comparison to the underlying population. Based on the small surface area covered by Vasić's excavations (e.g. ~350 m^2 in 1929-1934; Chapter 5) in comparison to the total area of the site (~10 ha; Tasić et al. 2015b), it could be said that 1/300 of the site has been excavated, but this estimate seems somewhat unrealistic. Thus, the *r* was estimated in another way, based on the estimates about a length of occupation of the site (Tasić et al. 2015a; 2015b; 2016), duration of houses (Tasić et al. 2016), a total number of houses (Сталио 1968, see above), and a population size (Porčić 2019). By solving the Schiffer's (1976) equation with a total duration of the site of 800 years, use-life of houses of around 30 years, and an estimate of 65 houses in all levels from Vasić's excavations – it was estimated that around 3 houses were on average contemporaneously used at each moment at the excavated area. By assuming that there was on average 5 inhabitants in each house, it can be estimated that around 15 inhabitants were living on the excavated area at every moment. By assuming that the average population size at the site was around 500 to 1000 inhabitants, this would mean that around 1/30 to 1/60 of the site was excavated during the 1929-1934 excavations, respectively. This estimate is very crude, but it seems somewhat more realistic, so the *r* values that correspond to this estimate were used. The production rate (w_i) was set to values between 1 and 20 for prismatic blades, meaning that on average 1 to 20 blades were produced a year by each producer. This estimate was based on the insight of Bogosavljević Petrović (2016) that sickles could last for more than a season, but no information was found on the needs for blades for other tasks. A somewhat wider range was defined for figurines as they are less abundant, so it was assumed that they were produced from 5 a year at most to once in around 30 years (~one per generation, w_i = 0.03). The values of innovation rate (*v*) range between 0.001 and 0.01, similarly to other studies of cultural transmission studies (e.g. Crema et al. 2014; 2016). Finally, the strength and direction of the frequency-dependent bias (*b*) was set to a broad range between -0.5 and 0.5 at 0.05 increments, covering a large part of the continuum between conformism and anti-conformism. The value of 0 indicates no frequency-dependent bias, i.e. the unbiased/neutral model of transmission, while departures from the 0 in terms of positive and negative values indicate anti-conformist and conformist models, respectively. The further the b values are from 0 the stronger the frequency-dependent bias, where the value of -1/1 are maximal theoretical (unrealistic) values.

Table 9.1. The prior parameters for the agent-based simulations of cultural transmission.

Parameter	Description	Values
H	Number of households in each temporal unit	Constant – 15, 22, 18, 10
P	Number of producers in each household	1, 3, 5
w_i	Production rate (yearly)	Lithics: 1, 10, 20 Figurines: 0.03, 0.1, 1, 5
R	Recovery rate	1/0.017, 1/0.03
N	Innovation rate	0.001, 0.005, 0.01
B	Strength and direction of frequency-dependent bias	Between -0.5 and 0.5, at 0.05 increments

For each simulation that was performed for each cultural element (e.g. head shape, see below), the parameters with non-constant values in **Table 9.1** were randomly sampled from the defined range, generating a large number of combinations of parameters, i.e. a large number of possible scenarios of the past. As mentioned, rather than keeping the parameters constant throughout the entire Late Neolithic, they were allowed to vary through time, i.e. in each temporal unit. A total number of 30 000 simulations was done for all studied units of cultural transmission, i.e. attributes and paradigmatic types.

Finally, to simulate the creation of archaeological assemblages, time-averaged samples (assemblages) are drawn from the simulated populations. In other words, while the described models simulate continuously occurring transmission and deposition events, the 'cultural remains' from simulations were sampled and grouped into temporal units, i.e. into cumulative units such as those that we use for describing, analyzing, and interpreting the archaeological record (e.g. horizons, layers, phases). In this way, the outcomes of simulations are sequences of temporal units with different frequencies of cultural modalities, comparable to the ones from the archaeological record. To assess which simulated assemblages have the most (dis)similar patterns of diachronic changes to the archaeological ones, i.e. which ones best fit the empirical data, the distance between simulated and empirical (archaeological) temporal trajectories is calculated using the Euclidean distance (ε) for each simulation. The Euclidean distance is used to measure the dissimilarity between archaeological and simulated data in proportions of attribute modalities and types. To exclude the unlikely scenarios, only the 10% of simulated assemblages that are most similar to the archaeological ones are retained as a range of scenarios that could have happened in the past. Subsequently, the parameters of those retained simulated scenarios are examined to see what aspects of transmission characterize these models and consequently to determine what range of parameters (posterior distribution) of transmission might have produced the patterns of change in the archaeological record. Among the parameters, it was shown that *b*, the parameter related to direction and magnitude of frequency-dependent bias, has the largest influence on cultural trajectories (Crema et al. 2016; Kandler, Crema 2019). Thus, the goal of applying the described framework was to infer the values of *b* and consequently to evaluate which models of transmission best fit the observed patterns of variability of prismatic blades and anthropomorphic figurines.

9.2. Cultural transmission of knowledge about prismatic blades

Learned choices are not always clearly reflected in the attributes of prismatic blades, as there is a complex interplay of factors that influence them. Thus, it is difficult to define blade attributes that are good proxies for the transmission of knowledge about their production. For example, while the choice of a knapping technique of percussion influences certain attributes of prismatic blades, there is no one-to-one correspondence between the two, as similar stigmata can be produced by different knapping techniques (e.g. Damlien 2015; Magnani et al. 2014). Thus, the inferences about the cultural transmission are based only on one attribute that may more directly reflect the learned choices – type of the striking platform – but the results should be nevertheless considered with some caution.

Type of striking platform

The platform type depends on the pattern of removals before the detachment of the blade. The box plot of this attribute has shown certain diachronic changes in this attribute (**Figure 7.27**). Based on the inferential framework by Crema et al. (2016), it was determined that the 95% HDPI cannot distinguish between the three competing models of transmission (anti-conformist, unbiased, conformist) for TU 7.2-6.05m and TU 6.05-3.5m, although a weak conformist bias seems most likely based on the 50% HDPI (**Figure 9.2**). In the final temporal unit, the most likely scenario is anti-conformist transmission, although the 90% HDPI suggests that the neutral model and a weak conformist bias can also explain the observed data.

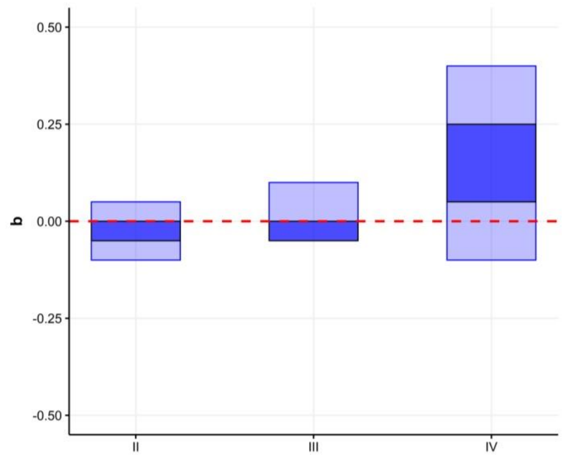


Figure 9.2. Marginal posterior distributions for the variable population-transmission model for striking platform type of prismatic blades (blue – 50% HDPI, light blue – 90% HDPI).

9.3. Cultural transmission of knowledge about anthropomorphic figurines

In the case of anthropomorphic figurines, it is easier to define distinct features that reflect the (learned) choices of their makers. The models of cultural transmission were reconstructed for four attributes of figurines – body position, arm position, head shape, and eye shape – which are commonly discussed and represent clearly definable and recognizable visual features of the figurines. In order to assess the transmission of knowledge about the production of figurines regarding multiple features, the inference about the models of transmission was also made for the paradigmatic types of figurine heads, which have sufficient sample sizes for the quantitative models that were used here.

Body position

The figurines from all temporal units of Vinča-Belo brdo most commonly have a standing body position, with a much lower number of figurines with a kneeling or sitting position (**Figure 7.54**). The posterior distributions of *b* values indicate that the most likely model in all three temporal units (7.2-6.05m; 6.05-3.5m; 3.5-1.3m) is a conformist bias, although there is a shift from a strong conformist bias in TU 7.2-6.5m towards a weaker form of this bias in later temporal units where the neutral model is another possible scenario, or even a weak anti-conformism in the latest temporal unit (**Figure 9.3**).

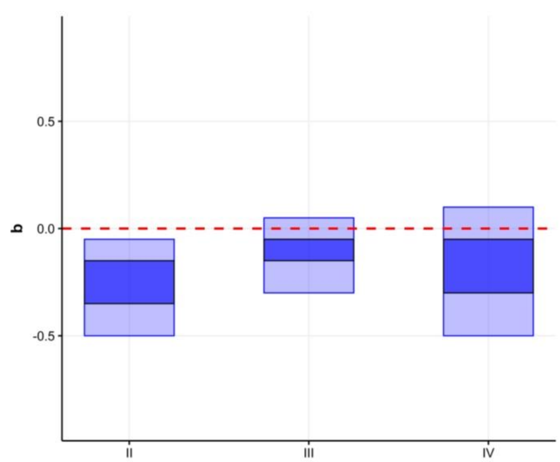


Figure 9.3. Marginal posterior distributions for the variable population-transmission model for the body position of anthropomorphic figurines (blue – 50% HDPI, light blue – 90% HDPI).

Arm position

The arms of the figurines from Vinča-Belo brdo are spread towards the sides in most cases, while the other arm positions are rarer and appear primarily in the middle part of the sequence (**Figure 7.58**). The application of the inferential framework described above gave the following results – both 50% and 90% HDPI indicate that a conformist transmission is the most likely scenario for the entire sequence, although for TU 6.05-4.95m a neutral model is another possibility (**Figure 9.4**).

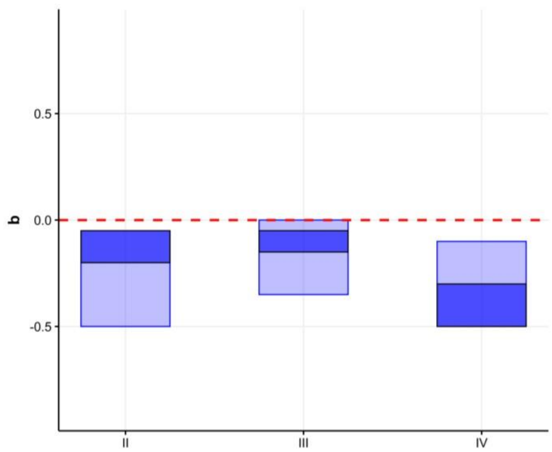


Figure 9.4. Marginal posterior distributions for the variable population-transmission model for the arm position of anthropomorphic figurines (blue – 50% HDPI, light blue – 90% HDPI).

Head shape

The head shape of figurines shows high variability and certain changes in frequencies that resemble the battleship curves (**Figure 7.60**). From a total of 1000 simulated scenarios of transmission of head shapes through generations, the ones that produce the outcomes that are most similar to the observed data generally have positive *b* values or values around 0, suggesting the anti-conformist bias predominates for the transmission of head shape, although the neutral model is another possibility for TU 7.2-6.05m and TU 6.05-3.5m (**Figure 9.5**). For the final temporal unit, both the 50% and 95% HDPI indicate the anti-conformist bias as the most likely explanation.

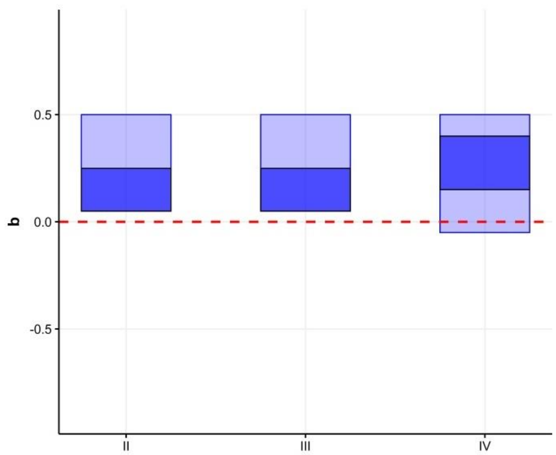


Figure 9.5. Marginal posterior distributions for the variable population-transmission model for the head shape of anthropomorphic figurines (blue – 50% HDPI, light blue – 95% HDPI).

Eye shape

There are numerous varieties of eye shapes, and their frequency distributions display certain temporal patterns (**Figure 7.62**). The *b* values for the simulated scenarios that best fit the observed (archaeological) data are shown in **Figure 9.6.** For TU 7.2-6.05m and 6.05-3.5m, it is not possible to distinguish between the competing models, although the largest number of best-fitting models points to the anti-conformist bias. In the final temporal unit, there is a shift towards a strong conformist model as the most likely scenario of cultural transmission.

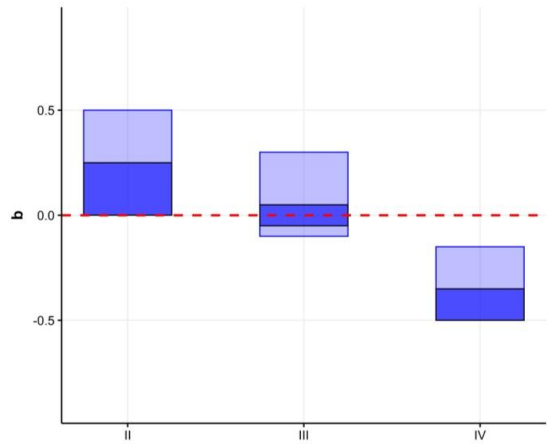


Figure 9.6. Marginal posterior distributions for the variable population-transmission model for the eye shape of anthropomorphic figurines (blue – 50% HDPI, light blue – 90% HDPI).

Skirt/lower body ornaments

There is a fairly high diversity of the skirt/lower body decoration motifs, and similarly as the eye shape, some motifs show the characteristics temporal patterns, the battleship curves (**Figure 7.64**). The earliest temporal unit was excluded from the analysis as there is only one sample in this time unit, so the models of transmission were reconstructed only for the latest two temporal units. The application of the ABC framework indicates a shift from the anti-conformist model to a model which is closer to unbiased transmission, although the HDPI ranges for *b* values are quite wide and unable to distinguish between the three broad models (**Figure 9.7**). There is a possible sampling effect for the latest temporal unit which produces such wide range of *b* values.

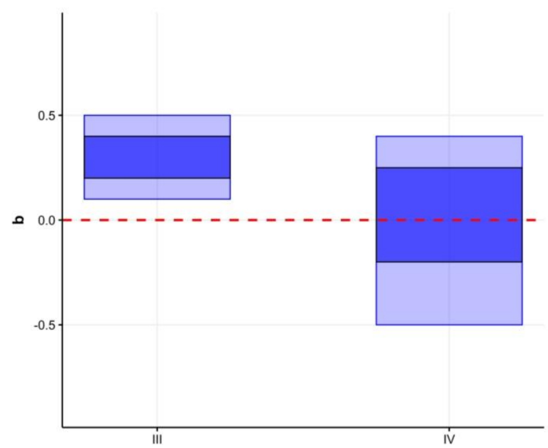


Figure 9.7. Marginal posterior distributions for the variable population-transmission model for the skirt/lower body ornaments (blue – 50% HDPI, light blue – 90% HDPI).

Paradigmatic types of figurine heads

Finally, it was explored what are the likely models of cultural transmission of ideas about the general appearance of the figurine heads. Based on the posterior distribution of *b* values, it can be concluded that the best-fitting models are anti-conformist transmission, although the neutral and even the conformist model are also possibilities (**Figure 9.8**). These very broad ranges are probably a consequence of uncertainties related to very low frequencies of a very high number of paradigmatic types of figurine heads. There is a possible shift in the posterior distributions of *b* values within the Belo brdo sequence, from a strong anti-conformist bias towards somewhat lower values of *b* on average, but the ranges are too large for creating any sound conclusions.

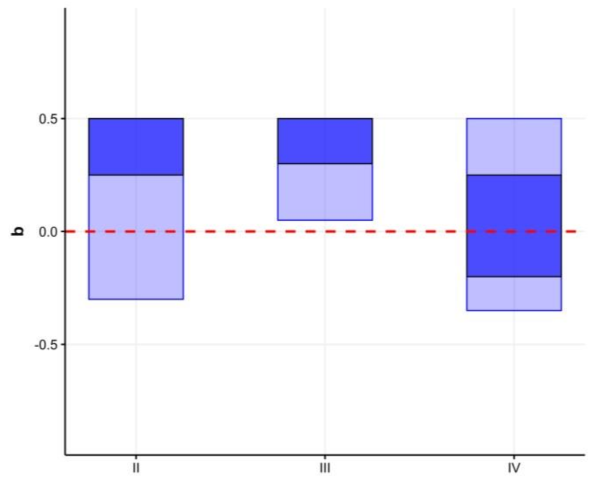


Figure 9.8. Marginal posterior distributions for the variable population-transmission model for the paradigmatic types of figurine heads (blue – 50% HDPI, light blue – 90% HDPI).

10. Discussion

The foundations of knowledge about the Late Neolithic of the Central Balkans were laid within the framework of traditional culture-historical archaeology, and many ideas and concepts made within this framework are still used today. The site of Vinča-Belo brdo has a particularly important place in the history of research of the Late Neolithic communities in the Central Balkans, as its long and continuous sequence has been a model for creating narratives about the Late Neolithic of the whole region. Based on the evidence from Vasić's excavations, different efforts were made in exploring and explaining the temporal variability of the material culture during this period (e.g. Garašanin 1979; Трифуновић 1968). The questions about the long-term cultural dynamics were assessed by making subjective insights about the variation of material culture and usually explained in terms of commonsensical and simplistic concepts, such as social norms, external stimuli, and the flourishing and decline of the archaeological cultures. Some core assumptions of the culture-historical approach were heavily criticized during the 60s and 70s (e.g. Johnson 2020), but many conclusions about the long-term cultural dynamics on Belo brdo that were made within this framework still lure within the current research.

The three main goals of this research were to: explore the character of cultural changes on the site, explore the potential relationship between demography and cultural diversity, and reconstruct the models of cultural transmission. By synthesizing the answers to these questions, a more general goal was to make novel insights into the social organization of the Late Neolithic community that lived on Belo brdo for around 800 years (~40 generations) and the social dynamics during this long period. In the following text, the results of this study will be discussed in the context of the research aims of this work.

10.1. Character of cultural changes on Belo brdo

As mentioned, there are different opinions about the character of cultural changes on Belo brdo. Certain researchers were more inclined towards seeing continuities, while other pointed to changes, indicating that some of them are significant and possibly related to the influences of external factors like migration or diffusion. Based on the results of this study, it is evident that there are both stability and changes in the variability of prismatic blades and anthropomorphic figurines. For example, while the figurine arms (**Figure 7.58**) and blade outline shapes (**Figure 7.35**) exhibit only slight changes in 800 years, other attributes such as figurine eye or head shape change continuously. However, there can be a range of scenarios between continuities and changes (e.g. Zvelebil 2001), so the goal of this study was to narrow down the range of possible explanations of long-term cultural dynamics. Are some of these changes significant/disruptive and indicative of some notable social dynamics (e.g. migrations, social disintegration)?

The character of cultural changes was explored in two ways – by visually exploring the continuities and changes in the features of artifacts, and by quantitatively examining if the certain transitions (e.g. to the Gradac phase) evidence more pronounced changes in the artifact variability than other transitions within the sequence. To assess the question of the character of cultural changes with sufficient resolution and using more theoretically meaningful intervals of comparable duration (Porčić 2015; Premo 2014), the sequence was divided into eight approximately 100-year long temporal units. The insights about the character of cultural changes will be firstly discussed for prismatic blades, then for figurines, and finally, a more general discussion of cultural changes will be presented which will take into account other relevant data about the site.

Prismatic blades

The basic premise for the visual exploration of artifact variability was that all the changes should be gradual rather than sudden if there was a continuous transmission of knowledge about these two artifact classes. In the case of prismatic blades, the majority of qualitative and quantitative features exhibit stability or fairly gradual changes in the frequency or central tendency/dispersion on the appropriate graphical representations. Quantitative attributes of prismatic blades regarding the size (length, medial width, medial thickness, mass, platform size, number of dorsal negatives) and shape (elongation index), all show either stability or gradual changes in values with only slight oscillations. The only exceptions are the latest temporal units (TU 3.5-2.5m and 2.5-1.3m) where the changes seem to be somewhat more pronounced. However, the very low sample size for these temporal units, especially for the attributes that were analyzed only on the whole blades, precludes any firmer conclusions. The possible sampling effects are supported by the fact that the blades from this temporal unit do not show visually apparent differences in terms of quantitative attributes when both whole and fragmented blades are observed.

In order to supplement the visual insights with a more formal approach, the character of cultural changes on the site was also examined quantitatively – by conducting general statistical tests to explore the differences and using different indices to assess the magnitude of changes for each transition. The statistical tests confirm the general absence of pronounced differences in quantitative traits, as despite the long period of 800 years of blade production the only significant differences are those related to a very rough measure of platform area, with a small effect size ($r = 0.1$), while the blade size, elongation, and the number of removals generally exhibit only slight variations. Similar conclusions can be made by observing the effect sizes for the differences, as the *r*-value for the pairwise comparisons generally indicates no effect, or weak/weak to moderate effect only for a small number of changes in quantitative attributes. The stability in blade size (length, medial width and thickness, mass) possibly reflects the transmission of ideas about appropriate blade size (although this should be explored by agent-based simulations), but it might be also linked to functional or raw material constraints.

The qualitative attributes of prismatic blades also show stability or gradual changes. Directionality of removals is most commonly parallel, and this feature does not change much throughout the entire period. The changes in the type of platform type, bulb type, debitage profile of whole and fragmented blades, distal end termination, and retouch distribution are mainly gradual and expected if the knowledge is passed through generations. On the other hand, certain features do show changes that seem more discontinuous and sudden. The changes in the proportions of blades with a lip, debitage profile type of whole blades, and the change in the proportion of blades with retouch on both distal end ventral parts in the Gradac phase, are more pronounced than other changes in qualitative features of blades. What could be the reasons for such changes? One possibility is that the sudden changes in the frequencies of lip and profile types reflect some notable shifts in the technology of production, such as the changes in the applied knapping technique(s). However, this explanation does not seem likely in the light of more general insights about the laminar technology on Belo brdo (see below), except for the changes in the presence of blades with a lip that might be related to the changes in the types of indentors used. In the case of retouch distribution, I am not aware of a functional explanation for such changes, so there might be some notable changes in the tradition of blade shaping and/or re-sharpening. Some of these sudden changes might also be at least partially a consequence of sampling effects, imperfections of Vasić's evidence (Palavestra 2020), or certain differences related to specific contexts, but the contextual information for this material is largely lost. However, these explanations should not be restricted only to certain attributes. Finally, another possibility is that some of these attributes might be poor proxies for cultural transmission of knowledge about blade production and are influenced by other factors, but this should be confirmed by the knapping experiments. While it is difficult to distinguish between different possibilities for these seemingly sudden changes, in the context of the continuity and transmission of knowledge it is important to underline that all these features which experience notable changes are present more or less throughout the entire sequence, which indicates no shifts in the corpus of knowledge within the community that would be expected in the case of cultural discontinuities.

The statistical tests support the general stability of lithic technology, as from a total of 7 qualitative attributes only the temporal distributions of debitage profile types and the presence/absence of lip show statistically significant differences (but note that no statistical test was done for the retouch distribution). Although the Brainerd-Robinson dissimilarity coefficient cannot be interpreted in a similar way as the effect size (e.g. no effect, weak effect), it should be noted that the values are generally low (< 0.1). To repeat, the values of the rescaled BR coefficient range from 0 (maximal similarity) to 1 (maximal dissimilarity).

Paradigmatic types were created by combining several features of prismatic blades. Despite their arbitrary nature, they present a very useful tool for exploring the general patterns of blade variability. Although many paradigmatic types have low frequencies due to many combinations of attribute modalities, **Figure 7.33** shows that that are several more frequent types that are present in almost all temporal units and exhibit very gradual changes in proportions, confirming the general stability of the observed features. These are types 11201 and 11211, short (<50 mm) and narrow (< 15 mm) blades with curved profiles and a bulb of percussion which differ only in the presence of a lip, as well as 21211 and 22211 which have the same characteristics besides being longer (> 50 mm) and wider in the case of type 22211. The paradigmatic classification confirms that the proportion of blades with a lip increases with time, but these changes are gradual when observed in the context of paradigmatic classification. The quantitative assessment for the differences in proportions of paradigmatic types, using the BR coefficient, indicates that the only notable change happens in the latest temporal unit, where the sampling effects cannot be excluded.

Although the technological analysis offers a deeper understanding of the production process, the geometric morphometric analysis seems like a suitable complementary tool for analyzing blades and visualizing similarities and differences, as it most clearly demonstrates the stability of blade production on the site – both shape and symmetry of blades from different temporal units greatly overlap. Based on the study that I. Kajtez and I conducted (Radinović, Kajtez 2021), certain changes in blade outline shape and regularity should be expected if there are changes in production technology, or more specifically in the choice of the knapping techniques. The mean blade shape of all groups is very similar and there seem to be no diachronic changes in the blade shape (**Figure 7.35**), as confirmed by the PERMANOVA test. Although the symmetry of blades from the latest temporal units is somewhat higher than for the blades from the preceding levels (**Figure 7.38**), there are no statistically significant differences between the values of groups. These results suggest that there are no notable changes in the blade production technology. The *r*-values for the differences in blade outline shape (**Figure 7.37**) and symmetry (**Figure 7.39**) show the largest differences for the transitions to the Gradac phase and TU 3.5-2.5m, respectively.

These insights into patterns of variability of prismatic blades should be contextualized in terms of anthropological implications related to lithic production. All three analytical approaches - attribute analysis, paradigmatic classification, and geometric morphometrics – indicated stability in most aspects of prismatic blade variation, which indicates the robustness of this conclusion. From a technological point of view, the production of blades seems to stay unchanged during the whole sequence of the site, as previously suggested (Bogosaljević-Petrović 2015; Radovanović et al. 1984). Prismatic blades of fairly equal dimensions were produced most commonly from the single-platform, unidirectional cores, as evidenced both by cores (**Figure 10.1**) and directionality of removals on blades, indicating the same method of production. Concerning the knapping techniques, certain blade features suggest that the characteristics of pressure debitage are absent – e.g. very regular blades (e.g. Pelegrin 2006; **Figure 10.2**), a predominance of blades with straight and 'light' profiles (e.g. Pelegrin 2006), and lens-shaped butts (n = 4) (e.g. Sørensen 2006) – even though the production of obsidian blades from the site possibly involved pressure debitage (Milić 2016; Radinović, in preparation). Although the differentiation between direct and indirect percussion blades can be difficult (e.g. Inizian et al. 1999), a low number (n = 12) of mesial bellies that are typical for indirect percussion (e.g. Pelegrin 2006), as well as a comparison of blade outline shapes from Vinča with the experimentally produced blades (**Figure 10.2**), indicate that the chert blades were most likely produced using direct percussion (cf. Bogosaljević-Petrović 2015; 2018) based on their outline shape and regularity. Despite the rare occurrences of features usually associated with indirect percussion and pressure debitage, the recognition of knapping techniques should be done on the assemblage level (e.g. Damlien 2015) and the direct percussion seems to predominate in all temporal units. However, the changes in the proportions of bulb and lip seem to indicate shifts in the use of different percussors, probably antler and soft stone percussors, where the latter becomes more common in the younger levels. It should be noted that there are no indications of blade production using copper tools (cf. Bogosavljević-Petrović 2015).

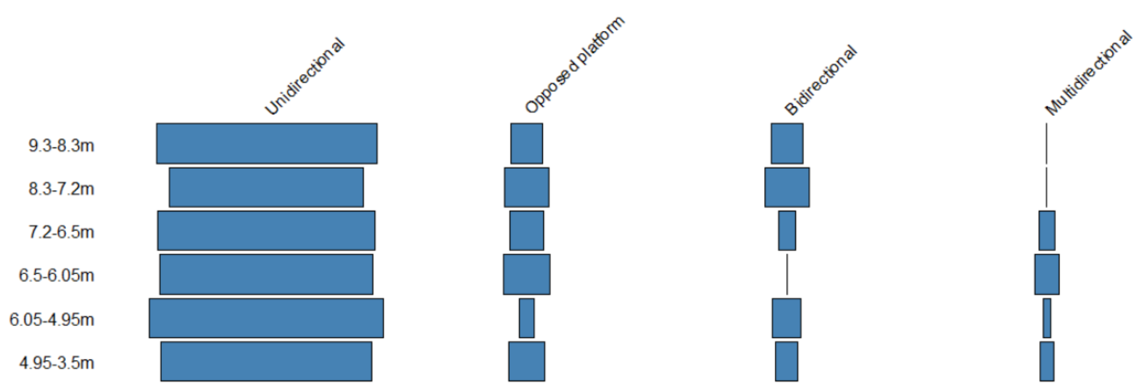


Figure 10.1. The patterns of removals on chert laminar cores from Belo brdo in different temporal units. The latest two temporal units are not displayed as they have no laminar cores.

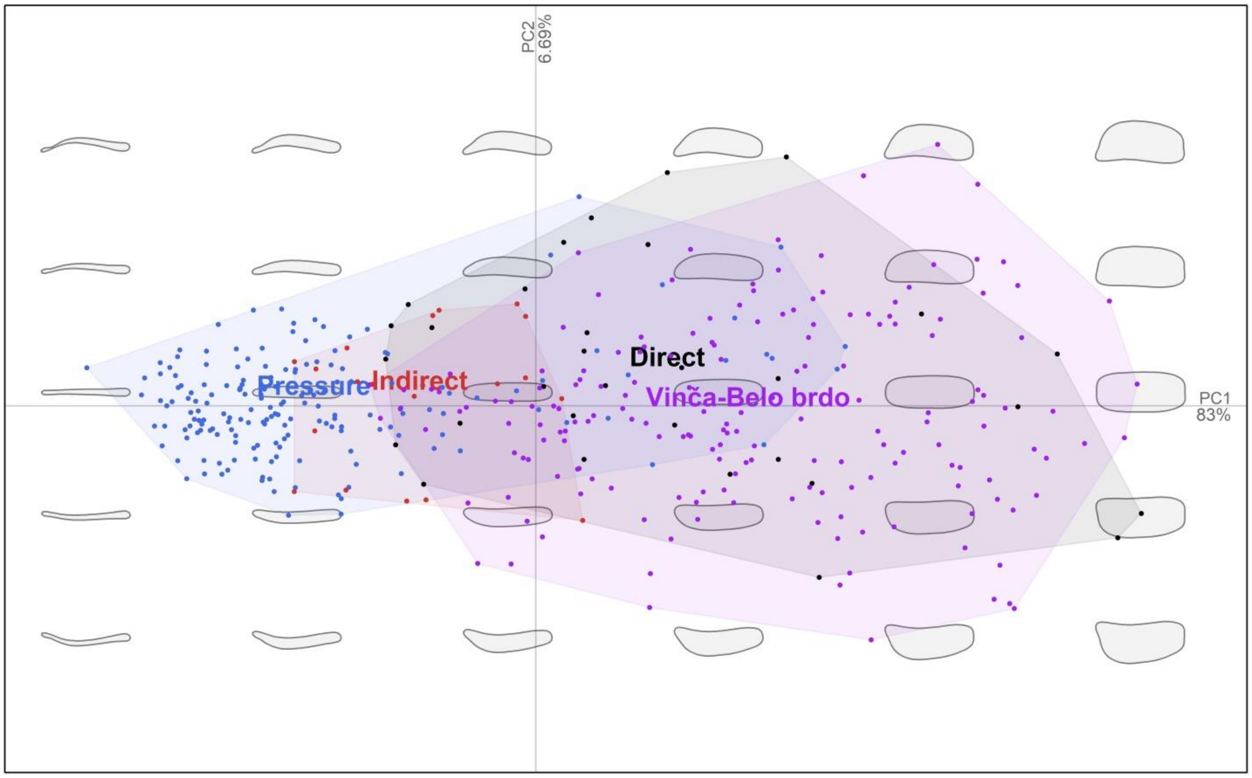


Figure 10.2. Scatter plot of PC1 and PC2 showing the main shape differences between the prismatic blades from Vinča-Belo brdo and blades that were experimentally produced using different knapping techniques (Lengyel and Chu, 2016; Muller et al., 2017; Pelegrin, 2012; 2006; Sørensen, 2006; see Radinović, Kajtez 2021), with visualization of the shape space. Convex hulls and group centroids are shown for each temporal unit – direct percussion (black), indirect percussion (red), pressure debitage (blue); blades from Vinča-Belo brdo (purple).

Besides this stability in the production method and technique, there are also certain changes in the manufacture and maintenance of blades. Concerning the striking platform types, there is an increase in the proportion of prepared, facetted platforms in relation to plain ones. Although there are no conclusive explanations for these changes, there was possibly a technological reason for such shifts, e.g. to avoid knapping errors. However, this may be a feature where the constraints on production were not so large, so there are other possible reasons for the observed shifts – e.g. idiosyncratic reasons or different transmission model(s) for this feature (see below). Another qualitative attribute that exhibits some obvious changes throughout the sequence is the retouch distribution. Again, knowledge about the retouching of blades might have been passed by different models of cultural transmission (Tostevin 2012), or there are some other reasons for the observed changes (e.g. functional, idiosyncratic).

Although the largest changes (highest *r*-values and BR coefficients) happened at different depths for different features of blades (**Table 7.10, Figs. 7.34, 7.37**), indicating that there were no large, disruptive changes on the site that simultaneously affected multiple blade features, they often appear at the beginning of the Gradac phase or in the latest temporal units (**Table 7.10**). How to interpret these results? While for the latest two temporal units the small sample sizes probably affect the magnitudes of changes (larger effects of stochasticity), the high magnitudes of changes at the onset of Gradac phase are more difficult to explain in terms of technological, social, and other factors. It should be repeated that the corpus of knowledge about blade technology does not change and that the effect sizes indicate no practical importance of the observed differences, so some disruptive scenarios might be excluded, but there are still many possible explanations – e.g. sampling, excavations procedures, functional reasons, demography, and cultural transmission.

To conclude, based on the exploration of variability of blades (attributes, types, outline morphology and symmetry) and the assessment of the magnitudes of differences, it can be concluded that there are continuities and gradual changes in blade production on Belo brdo, as expected if there is a continuous transmission of knowledge related to blade production through generations. Even with the sampling and other (e.g. Palavestra 2020) issues that impede proper comparisons, the majority of blade features show either continuity or gradual changes, as evidenced by both visual exploration and quantitative assessments. There seem to be no notable changes in the corpus of knowledge about the production and maintenance of blades, i.e. there is generally strong stability of lithic technology (e.g. Hashemi et al. 2021; Okumura, Araujo 2014). Contrary to the expectation of research hypothesis 1, for most attributes there seem to be no significant changes in the production of prismatic blades at the beginning of the Gradac phase or in other units. However, some of the seemingly more sudden changes in certain blade features (e.g. retouch distribution) are yet to be explained, as well as the reasons why the largest changes most commonly occur with the transition to phase Gradac phase and the latest two temporal units.

Anthropomorphic figurines

While some of the figurine attributes also show general stability or gradual changes, others exhibit numerous changes within the sequence, where new cultural modalities continually appear. Among the quantitative attributes, the changes seem gradual in most cases, and this is confirmed by the Kruskal-Wallis H test which shows statistically significant differences between the groups only for the arm length, and marginally significant differences for the head height. Although figurine height covers a large range from 2.8 to 16.6 cm, their mean height remains quite similar throughout the entire sequence with a general trend of gradual decrease (from 5.9 to 4.4 cm), although the figurines from the earliest temporal unit are somewhat larger with a mean of 8.8 cm. However, it should be noted that there are certain outliers regarding the height of figurines. Although the height slightly (non-significantly) decreases, the values of arm length and waist thickness remain similar throughout the sequence, indicating that the relative size of these two body features increases. More generally, several figurine characteristics – head height/width ratio (**Figure 7.45**), relative lowest part width (**Figure 7.52**), and the outline analysis using EFA (**Figure 7.71**) – indicate that the figurines gradually become bulkier in younger levels, and have longer arms in relation to the body (**Figure 7.50**). Based on the visual assessment of the variability of these metric traits, it seems that there are no discontinuous diachronic changes in the size and certain aspects of the shape of anthropomorphic figurines from Vinča-Belo brdo, but only some gradual, directional changes throughout the sequence. This is confirmed by the observation of r-values for the magnitudes of the diachronic changes that indicate no effect ($r < 0.1$) in most cases or more rarely a weak effect ($0.1 < r < 0.3$).

Certain qualitative attributes also indicate the general stability of figurine production. The standing body position is dominant in all temporal units, as already noted (e.g. Лазић 2008; 2015). The rare kneeling figurines are only present in the middle part of the sequence, while the sitting figurines gradually increase in proportion before suddenly disappearing in the youngest temporal unit. This sudden disappearance seems discontinuous, but the small sample of figurines from this temporal unit might not be representative. A very similar temporal trend is seen in the variability of figurine arm positions (see also Лазић 2015). The arms are spread towards the sides for the majority of figurines, while the other arm positions – on the torso, facing upwards, on the face, holding a baby – are mainly distributed in the middle part of the sequence. The arms on the torso and facing upwards continuously appear in several units before disappearing, showing no evidence of sudden changes, and the same is true for the figurine with arms towards the sides. Figurine with arms on a face and holding a baby both appear in single temporal units. These insights about the general stability of body and arm positions are supported by the non-significant Chi-Square tests and possibly low values of BR dissimilarity coefficients (< 0.1), except for the final temporal unit where the higher value (0.2) is probably caused by the sudden disappearance of figurines in the sitting position. Based on the presented evidence, there generally seems to be a continuous transmission of knowledge (e.g. by teaching or copying) about the figurine body and arm positions, or a strong selective factor related to the figurine function which remains elusive.

There are several features of figurines that, despite generally exhibiting continuity, also show numerous changes in the form of appearances and disappearances of different variants. Head shape is one of the attributes that exhibit a large diversity, and it should be repeated that the head typology used in this work is only one possibility of dividing the complex variation of head shapes. The majority of head shape modalities show a largely continuous distribution within the sequence. Although there are some seemingly sudden changes – e.g. head with pronounced zygomatics disappears in TU 7.2-6.5m and then reappears, rectangular head with 'ears' disappears in TU 3.4-2.5m and reappears in the final TU – the majority of types are continuously distributed in many temporal units, gradually increasing or decreasing in frequency in the form of unimodal distribution, i.e. the battleship curves (**Figure 7.60**). It should be noted that, while this research supports the insights of many researchers (Garašanin 1979; Letica 1964; Васић 1936b; Срејовић 1968; Тасић 2008) about the overall changes from triangular/ogival heads to pentagonal, and finally "bird-heads", many head types coexist in different temporal units and exhibit gradual changes in proportions. Several head shapes appear in five or more temporal units, existing for 500 years or more, so they should not be used as clear markers of relative chronology. More generally, there seem to be no discontinuous transitions, where many new variants would appear and/or disappear simultaneously, although 3 less common varieties of head shapes appear in TU 6.05-4.95 and TU 4.95-3.4m, possibly indicating more frequent innovations in these intervals (either internal or external), while certain head shapes disappear during the latest two temporal units. Due to the numerous changes in the proportions of head shapes, the Chi-Square test indicates the statistically significant differences, while the magnitudes of differences are highest for the transitions to youngest temporal units (TU 3.5-2.5m and TU 2.5-1.3m). Despite these higher magnitudes of differences, the latest temporal units show a general continuity with the preceding levels, as many head shapes from the preceding intervals are still present.

As in the case of head shapes, there are numerous changes in both presence/absence and the frequencies of different variants of eye types (**Figure 7.62**). Figurines without eyes are the only variant that is present along the entire sequence, and it gradually increases in frequency. While the more frequent eye shapes are fairly continuously distributed throughout the sequence, the uncommon types show certain discontinuities, but this might be due to sampling effects as they are present in very low frequencies. An exception among the common types is the linear eye shape, which has fairly low but stable proportions in the early phases, disappears in the Gradac phase, and appears again in the subsequent temporal unit. Angular, triangular, and eyes in the shape of the segment have unimodal, battleship-curve distributions. Other types are much rarer, more or less continuous, and largely limited to the middle part of the sequence. These appearances in the middle part of the sequence are not sudden, but possibly suggest some kind of 'innovation horizon' (e.g. Schier 2000) or increased population size. The diachronic changes in the eye shape distribution are statistically significant, while the highest magnitudes of changes are for the transitions to the early and late part of the sequence. Even for these largest changes, there is a general continuity in eye shapes, although many variants disappear in the last two phases. Like in the case of head shapes, the previously described diachronic changes were related only to the most common types (Garašanin 1979; Letica 1964; Васић 1936b; Срејовић 1968; Тасић 2008), but the more detailed assessment shows the coexistence of many types and their long duration, where all changes are largely gradual.

Based on the visual assessment of the box plot (**Figure 7.64**), the skirt/lower body ornaments also exhibit high diversity and numerous changes throughout the sequence. However, there are no lower body ornaments in the earliest temporal unit, and only one figurine with the lower body ornament in the subsequent TU 8.3-7.2m, as well as in the latest temporal unit. These temporal units show the most sudden changes, but their very low sample sizes are not representative. In other temporal units, from 7.2 to 2.5m of relative depth, there is a generally continuous distribution of different variants and gradual changes in their proportions. However, two variants that have very low frequencies (triangles and inverted triangles) disappear during the Gradac phase and then appear again. Rather than representing evidence for discontinuity, sampling effects, disturbances, or some other explanations seem more likely in this case. Like in the case of head and eye shapes, the skirt/lower body ornaments are more variable in the middle part of the sequence than in the other parts. As they have shorter temporal distributions, they might be better chronological markers than head and eye shapes. The Cramer's V indicates a moderate effect for the differences in the proportions of skirt/lower body ornaments in different temporal units.

The lower body type was classified into three variants: cylindrical lower body, a distinct lower body without legs, and a distinct lower body with legs. The proportions of these three lower body variants show sudden and discontinuous changes in several parts of the sequence, and the Chi-Square test confirmed the statistically significant differences between the groups. Although the reasons for such large changes are puzzling and should be further investigated, these changes do not seem to reflect certain discontinuities, as the range of variants of the lower body type does not change.

The paradigmatic types of whole figurines were created by combining four attributes – body position, arm position, head shape, and height. The majority of a total of 18 types have fairly continuous distributions, except in TU 8.3-7.2m where there are no whole figurines. Concerning the paradigmatic classification for the figurine heads, although only two qualitative attributes were used – head and eye shape – the number of types is very high and most of them have very low frequencies. This indicates that there is a low number of figurines with the same combinations of features (e.g. triangular head shape and linear eye shape), so it seems that the figurines were quite free to vary in these aspects – individual features were copied rather than the appearance of the entire head. Nevertheless, there are several paradigmatic types of heads with somewhat higher proportions, and they generally show continuous distributions along the sequence. It should be noted that the paradigmatic classification has shown that the anthropomorphic figurines from Belo brdo are very diverse objects and that there is a very small number of figurines that have the same combinations of features.

The geometric morphometric analysis of figurine outlines using the EFA was applied only to a small sample of 32 entirely preserved standing figurines with spread arms. Although this small sample was not sufficient for making more general conclusions, the analysis has shown that there is a large variability of shape even within this one type. The EFA is particularly suitable for visualizing the similarities and differences in figurine shape and it could be a useful tool for making large-scale comparisons.

When the magnitudes of changes for the quantitative and qualitative attributes are summarized (**Table 7.17**), as well as for the paradigmatic types of whole figurines (**Figure 7.67**) and figurine heads (**Figure 7.69**), it is evident that the largest changes happen at different transitions for different attributes. However, it is clear that the largest changes most often happen in the latest two temporal units, where the sampling effects cannot be excluded. Interestingly, the changes with the Gradac phase are the lowest when the parameters in **Table 7.17** are observed – none of the largest changes occur at this transition, and the mean z-scores are the lowest for the transition to the Gradac phase. These results do not support the expectations of research hypothesis 1.

In conclusion, both for attributes that do not show pronounced changes (quantitative attributes, body and arm position), as well as for those that exhibit a large number of changes (head and eye shape, skirt/lower body ornaments), there is an overall continuity in the distributions of their modalities through time, indicating an uninterrupted transmission of knowledge from generation to generation during the 800 years of Late Neolithic occupation. The hypothesis of sudden changes with the Gradac phase is not supported by the analysis of figurine variability.

Continuities and discontinuities on Belo brdo – summarizing the evidence

From the presented evidence, it can be concluded that the knowledge about the production of chert prismatic blades and anthropomorphic figurines was generally continuously transmitted within the community for 800 years. There is no evidence for sudden, discontinuous changes with the transition to the Gradac phase (at 6.5m) or any other temporal unit. The majority of features of these two artifact classes show either stability or gradual diachronic changes in their variability. More rarely, there are more notable changes, where features with relatively high proportions suddenly disappear, but the sampling effects cannot be excluded in many such situations, or some other factors (e.g. poor proxies for cultural transmission).

What about other classes of material culture, are there discontinuities in their temporal distributions? As mentioned in the introductory chapter, W. Schier (1996; 2000) conducted a detailed analysis of the morphology and ornamentation of ceramics vessels. Figure 3 (battleship plot) from Schier's (2000) article shows the distribution of ceramic type proportions according to their relative depth, i.e. Vasić's 10 cm spits. Like the features of prismatic blades and anthropomorphic figurines, the Schier's ceramic types have largely continuous distribution along the sequence, even though the sampling effects should be large in such fine-grained units. The changes in terms of shifts in the proportion of types, their appearances and disappearances, occur continually along the sequence. Continuous distribution of types with gradual changes in their proportions is more clearly evident in Figs. 5-8 of his earlier (1996) article, where the changes in proportions ceramic types are shown according to his periodization. Figure 3 from Schier's (2000) article is interesting for another reason – although the relative depths on the figure are somewhat blurry, it is evident that there is a gap/hiatus in the distribution of many ceramic types at one relative depth between 7.0 and 6.5 m (6.7 m?). As almost all the ceramic types continue their distributions after this depth, this gap is possible evidence for some kind of 'disturbances' – e.g. 'destruction and leveling horizon' (Schier 2000: 196), various taphonomic factors (e.g. Borić 2009), or shortcomings of Vasić's evidence (Palavestra 2020). This possible gap in the sequence might have some influence on the assessments of the cultural continuity on Vinča-Belo brdo, where the changes after the gap seem more sudden in the case of lithics (Chapter 7) and ceramics (Schier 1996). It should be also mentioned that there are no building horizons at Belo brdo between 6.5 (end of Horizon IIIc after Stalio) and 6.2 m of relative depth (start of Stalio's Horizon IV), possibly indicating some kind of gap (Tasić et al. 2015b: 41). In my opinion, there is another possible reason that instigated the previous researchers tor commonly state that the largest changes happen during the Gradac phase. Before the more detailed assessments of the absolute chronology of the site (Tasić et al. 2015a; 2015b; 2016), it was not known (and today it is rarely acknowledged) that the Gradac phase, which covers only 0.5 m of the Belo brdo sequence (from 6.5 to 6 m of relative depth), represents a 100-year-long interval (see **Table 7.1**). Thus, in the case of the Gradac phase, the 100 years of changes are 'packed' into a short interval of relative depths, while other 100-year-long intervals cover longer sections (~1 m) of the Belo brdo sequence and thus seem to be more gradual. This shorter sequence could be the consequence of a slower accumulation rate of sediments or some disturbances (anthropogenic or environmental).

Regarding the other evidence for sudden changes, a frequently quoted sudden change is related to the appearance of copper – for example, Garašanin (1979: 162) argued that the copper pearls appear at 6.6 m of relative depth. However, it was suggested that the malachite appeared in the earlier levels of the site (see Borić 2009) and that the copper metallurgy appears in the Central Balkans around 5200 BC (Radivojević et al. 2010), which corresponds to ~8.3 m of relative depth at Belo brdo. In contrast, the evidence for a sharp decrease in obsidian (Radovanović et al. 1984; Srejović, Jovanović 1957) was also used to support the notion of significant changes in the middle part of the sequence. However, the evidence from new excavations suggests that obsidian does not disappear during Vinča D (Chapter 5; K. Penezić, personal communication), so the obsidian collection might be biased in some way regarding the temporal distribution of finds.

Thus, it seems that the vast majority of evidence indicates cultural continuity at Vinča-Belo brdo, where the internal changes were the most important mechanism of change (see also Chapman 1981; Глишић 1968; Грбић 1968; Јовановић 1968; Kaczanowska, Kozlowski 1990; Milojčić 1949b, cited in Tasić et al. 2015b). This does not mean that certain ideas and knowledge were not acquired by interactions with surrounding communities[18], which is evidenced most strongly by the trade of different goods (e.g. Dimitrijević, Tripković 2002; Tripković 2006; Tripković, Milić 2008), but it seems that there are no disruptive scenarios at Belo brdo, and some scenarios of more notable demic and cultural diffusion (sensu Zvelebil 2001) can probably be excluded. The boundaries between the phases do not seem like 'turning points' of this community, but rather arbitrary discretizations of continually occurring changes in the choices and preferences of Vinča-group inhabitants. As stated by Glišić (Глишић 1968: 30): "the entire evolution of the Vinča group leaves the impression of an ongoing process of the shifts in generations and their tastes", where the "changes did not occur abruptly, suddenly and without the possibility of foreshadowing through previous developments, so that even from the aspect of formal typology they could not be reduced to frequently applied schemes of ethnic movements".

Although he made these statements more than a half-century ago based on subjective insights, the formal examinations of diachronic changes in ceramics (Schier 1996), lithics, and anthropomorphic figurines (Chapter 7) fully support the conclusions of Glišić. However, it seems that his work was less frequently cited when the long-term cultural dynamics are discussed than the works of Srejović and especially Garašanin (1979) who argued that the sudden changes might better explain the archaeological record. Although Garašanin and Srejović were balancing between continuities and discontinuities, migration and diffusion, their work and terminology largely influenced the field, and the notion of larger changes is still persistent in the archaeological literature (e.g. Bogosavljević Petrović 2015; Tasić et al. 2015b), and occasionally related to migrations (e.g. Ристић-Опачић 2005).

If there are no discontinuities on Vinča-Belo brdo, and the periodizations are completely arbitrary divisions of continuous temporal variation, what is the reason for arguing about larger changes at the transition to the Gradac phase and other phases, and to repeat similar boundaries for these changes? Remarkably, it was already Vasić who divided Belo brdo figurines into four (temporal?) groups by their position within the sequence (Васић 1932b), with boundaries at 8, 6, and 4 m. Later researchers

[18] Moreover, some regional similarities in figurine eye shapes and other features are quite evident and probably indicate certain interactions (although other possible scenarios should be excluded – e.g. common ancestry, cultural convergence), but the study of diffusion of innovations requires high resolution of absolute chronology on a regional level rather than the study of on-site cultural transmission.

were possibly somewhat biased towards the boundaries for periodizations that were already established by their predecessors (possibly Vasić, but certainly Childe and Milojčić; see Whittle et al. 2016 for the overview of periodizations). But apart from the history of research, there is another possible reason for making similar periodizations and arguing about sudden changes. Without capturing the variability of the entire collections of finds, they were forced into creating very general descriptions, where only the most common, typical variants ('mode', Eerkens, Lipo 2007) for each period were usually described. In such a framework, the transitions from one common type to another were the only way to divide the sequence into meaningful groups, and these most common types important chronological markers (the so-called 'index fossils', e.g. O'Brien, Lyman 2002), especially for the research at the regional level. By combining the changes in different artifact classes – ceramics, figurines, stone tools (primarily obsidian), and copper finds – they created analytical units for exploring the temporal variability of material culture.

But these analytical units were often also interpretational. The boundaries between the phases were often ascribed to some significant shifts in multiple cultural aspects, probably because the reasons for seemingly notable changes in style and other aspects were puzzling in terms of social dynamics and were easier to explain by such concepts. Even though they did not deny the existence of internal changes, it was commonly assumed that the changes are some general, community-level processes. An example of considering phases as some discrete entities is provided by Garašanin who, puzzled by the appearance of types that are characteristic of one phase in another phase, wondered if that might be evidence for the disturbances of Belo brdo layers (e.g. Garašanin 1979: 180).

Today, we know that "the phases themselves might be simply arbitrary spatial and temporal slices of an interacting population" (Lipo et al. 1997: 322). One of the best confirmations of the arbitrariness of the commonly used phases was either directly or indirectly given by their creators, as many researchers noticed that the changes in different artifact classes did not fit perfectly into their periodizations and interpretations of sudden changes. For example, while noting the important changes in the material culture with the Gradac phase, Garašanin repeatedly noted that this phase cannot be clearly distinguished on Belo brdo and that it is better to observe it on the site of Gradac near Zlokućane (e.g. Garašanin 1979: 152, 174). Also, for many changes with the Gradac phase, he argued that they started a little bit above 6.5 m (e.g. Garašanin 1979: 174-175). The arbitrariness of the Gradac phase is also indicated by its subdivision into Gradac I, II, and III (Jovanović 1994). More generally, a large number of proposed periodizations with slightly different boundaries of phases also indicate the arbitrariness of phases. Thus, the phases do not seem to reflect certain social realities in the past in this case, in the form of certain periods of "stagnation" or gradual change, interrupted by the transitions where there are sudden and significant socio-cultural changes.

In summary, it seems that the proposed "sudden changes" in material culture are arbitrary and the artifacts of different factors: the lack of appropriate methodological tools for a detailed study of the changes in material culture, where it was necessary to discretize the gradual variation and waxing and waning of types and discuss only the most common ones for each phase; a limited spectrum of theoretical mechanisms for explaining the cultural changes, where the changes were commonly related to some broad-scale, community- or regional-level, significant social dynamics; history of research; and other factors, such as a possible preservation bias in the case of obsidian or sampling effects.

In conclusion, although some other cultural aspects should be more formally investigated to complement the current knowledge (e.g. altars, lids; Tasić et al. 2015b), based on the reviewed evidence there seem to be no sudden changes in the long-term cultural dynamics at Vinča-Belo brdo, and that internal factors were most important mechanisms for change. After discussing the arguments for the continuous, predominantly internally-driven long-term cultural dynamics, I now try to explain the reasons for the observed stabilities and changes in the material culture. Thus, after establishing the cultural continuity during the 800 years of Belo brdo, how to explain the evident patterns in material culture – e.g. the presence/absence of certain elements, or shifts in their proportions, distributions, and diversity – in terms of social dynamics, i.e. the behavior of individuals? In the following text, the influence of two factors – demography and models of cultural transmission – on the long-term cultural dynamics on Belo brdo will be evaluated.

10.2. Demography

There are two strands of evidence that indicate changes in the population size during the Late Neolithic of the Central Balkans (Porčić et al. 2016; Porčić 2020; Ристић-Опачић 2005) – it increases shortly after the beginning of the Late Neolithic, remains constant during several centuries, and then decreases in the final part of this period. Based on the previous studies (e.g. Derex et al. 2014; Henrich 2004; Neiman 1995), a correlation between the reconstructed population dynamics and the cultural diversity of the studied artifacts from Belo brdo was expected. A possible relationship between the two was suggested by certain researchers, who saw the "flourishing" and increased diversity of knapped stone tools (e.g. Bogosavljević Petrović 2015; Garašanin 1979; Radovanović et al. 1984: 14; Srejović, Jovanović 1957) and figurines (Срејовић 1968) starting from the middle part of the sequence, and the decline or "degeneracy" in lithic (Bogosavljević Petrović 2015; Radovanović et al. 1984: 14; Srejović, Jovanović 1957) and figurine production (Borić 2015; Васић 1936b: 82; Лазић 2015, Графикон 1) in the final part.

By quantifying the diversity of various features of prismatic blades and anthropomorphic figurines, it was explored if the temporal changes in their diversity show a similar trend as the population dynamics, which would indicate a possible relationship between the two. To reduce the sampling effects, the sequence of Belo brdo was divided into four 200-year-long temporal units for exploring the effects of demography and models of cultural transmission.

The results of this study generally do not support the hypothesis about the correlation between the diversity of material culture and the reconstructed demographic curve, as the expected temporal trend of cultural diversity is evidenced only for several cultural elements or only for certain parts of the sequence. A correlation between the two is inferred for certain features of figurines – arm position, head shape, skirt/lower body ornaments, arm length, and waist thickness – which show higher diversity of variants in the middle part of the sequence. The correlation between the diversity of possibly stylistic features is particularly interesting, as Neiman's (1995) prediction research predicted such a relationship. Although there is a correlation between sample size and the cultural diversity of possibly stylistic elements (Spearman's $\rho = 0.54$; **Figure 10.4**), the bootstrapping generally shows the stabilization of diversity for samples from all but the last temporal unit, so they might be suitable for making robust conclusions about the possible effects of demographic factors. A higher diversity of these elements in the middle part of the sequence might be related to: 1) increase in population size at Belo brdo; 2) increased connectivity with the neighboring communities; 3) the shifts in the models of cultural transmission – higher diversity is expected with anti-conformist than with conformist model. Thus, although there is a possible relationship between the demography and cultural diversity of stylistic elements, the results should be taken with some caution as the reconstructed population dynamics refer to regional, rather than a local level.

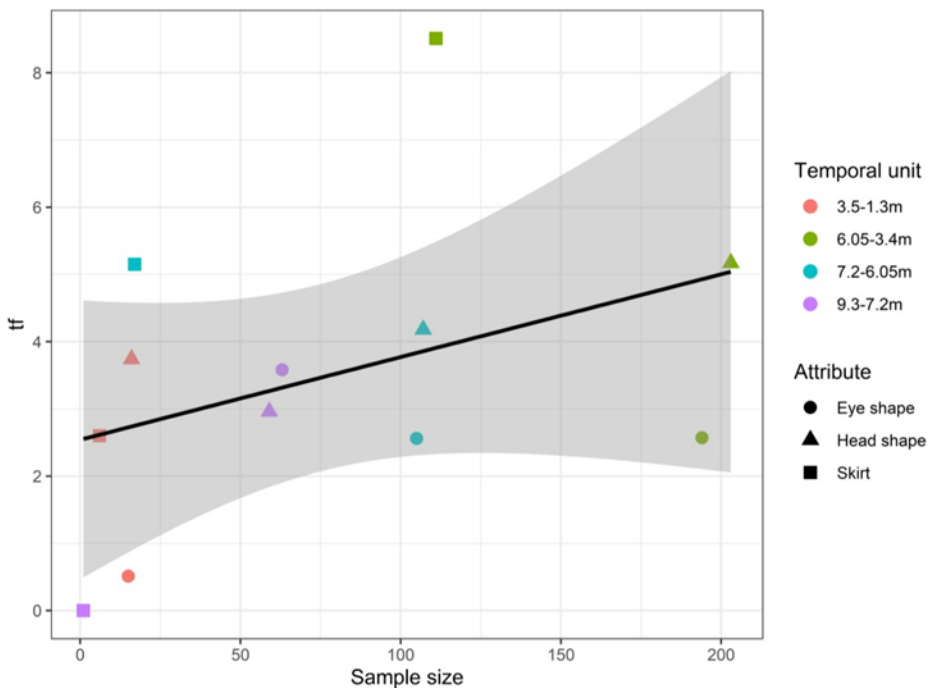


Figure 10.4. Scatter plot showing the relationship between sample size and the diversity of possibly stylistic elements.

A partial correlation in terms of a decrease in artifact diversity in the latest phase has been observed for a larger number of artifact features. There might be a possibility that the 'sampling effects' and losses of certain cultural variants, that were observed here for many cultural elements from the latest part of the sequence (3.5 – 1.3 m), might be the consequences of a real decrease in the population size and consequently production (**Figs. 8.1, 8.7**). Despite showing continuities with the preceding traditions, many cultural elements seem to be lost in these temporal units. In this case, the so-called sampling effects can be indications of a population bottleneck, where some aspects of cultural knowledge might have been lost due to a smaller population size where it was not possible to maintain all the previously accumulated knowledge (the so-called cultural drift) (e.g. Henrich 2004; Shennan 2000). However, there are other possible explanations for the diachronic changes in cultural diversity, such as standardization/specialization (e.g. Bogosavljević Petrović 2015: 212, Kaczanowska, Kozlowski 1990; Vuković 2011), sample size, preservations biases, or the intensity of cultural interactions (e.g. Whittle et al. 2016).

It can be concluded that, although the demographic factors might have influenced the diversity of some aspects of lithic and figurine production from Belo brdo, the relationship between the two cannot be clearly established for most cultural elements. Nevertheless, demography should be considered as another factor that is relevant in explaining the variability of material culture, i.e. it should be taken into account when discussing the possible social scenarios during the Late Neolithic on Belo brdo and other sites. There is a possibility that the vague terms of 'flourishing' and 'decline' of archeological cultures, frequently used by the culture-historians, can be related to the population dynamics (Shennan 2000; 2013).

10.3. Social learning strategies

After inferring that there is generally a continuous transmission of knowledge about the production of figurines and stone tools through generations, the question is how to explain the observed stabilities and changes in terms of the behavior of individuals? How do prismatic blades stay relatively unchanged for around 30 generations, while figurine head types exhibit continuous changes during this period? During this long period of 800 years, possibly tens of thousands of people were living in this settlement, and it is equally difficult to explain the stability of technology as it is to explain the changes, as even small changes (e.g. copying errors) can lead to large changes if accumulated over generations (see Schillinger et al. 2016 for an unrealistic but illustrative example). In this research, the concepts and tools of cultural transmission theory were applied to relate the large-scale cultural patterns with the scenarios of behaviors of individuals. The inferential framework created by Crema et al. (2016) was utilized to reconstruct the models of cultural transmission for certain qualitative attributes and narrow down the range of plausible scenarios of the past that could have produced the observed patterns of material culture.

In the case of stone tools, there are no suitable discrete proxies of cultural transmission. Although a general stability of lithic production is clearly observable in the case of prismatic blades, no individual analytical unit analyzed in this research (e.g. debitage profile type, bulb of percussion) reflects well the technological choices that individuals made during the production process. The variability of knapped stone tools is a consequence of multiple factors – knapper's choices of methods and techniques, raw material properties and constraints, gesture, angle of a blow, properties of percussor, etc. As these factors interact in complex ways in the reductive knapping technology, it is difficult to find elements of complete correspondence between the choices and the formal attributes. However, it is clear that the general idea about laminar technology – methods, techniques, suitable dimensions of blades – was faithfully transmitted through generations. While the stability of functional cultural elements such as prismatic blades is largely expected, the underlying social dynamics that produce such stability are an interesting topic for discussion.

It was suggested that such maintenance of technological knowledge could be related to the conformist transmission (e.g. Okamura, Araujo 2014), although there are other models of transmission that can produce or maintain cultural homogeneity (**Figure 10.5**) – e.g. oblique transmission, specialization, strong cultural (or even natural?) selection, or possibly prestige bias, and even a high-fidelity vertical transmission. The contextual data can advance our efforts in reconstructing the aspects of cultural transmission (as suggested by Eerkens, Lipo 2007), by further narrowing down the possible historical scenarios that produced the material culture. The contextual data from the new excavations of Vinča-Belo brdo (Bogosavljević Petrović 2015: 363-380) possibly support the idea about the community-level sharing of knowledge about the laminar technology in a form of conformist bias, oblique transmission, or less likely prestige bias, as the knapping activities were performed in many areas of the site and most often outside of houses in the open spaces, where other (older and younger) members of the community were able to observe the production process, acquire knowledge from the more experienced knappers and possibly participate in the knapping activities. Thus, the individual would acquire knowledge from one (prestige bias) or multiple individuals (oblique and conformist transmission). Some examples of knapping in a social context can be found in the ethnographical record (e.g. Stout 2002; Stout 2005; Toth et al. 1992), and indicate that the knapping is often a social, rather than a private activity. Specialization does not seem likely for several reasons - the contextual data from new excavations indicate production in multiple areas of the site (see Chapter 5; Bogosavljević Petrović 2015: 363-380); it is commonly assumed that the households had self-sufficient production (e.g. Greeenfield 1991); the more complex modes of pressure debitage technique in the case of chert production, which are often regarded as specialized activities (e.g. Pelegrin 2012), are absent. If the knapping was indeed a social activity that included many community members, other social learning strategies might have been present at Belo brdo besides the commonly assumed vertical transmission (from parents to children) in the pre-industrial societies, but more research is needed to reach such a conclusion. Thus, while the exact scenarios of transmissions are still elusive, it was shown here how the existence of social norms (e.g. Vuković 2021b: 66) is not the only possible scenario where the technological knowledge remains stable during long time periods, nor the vertical transmission (e.g. Amicone et al. 2020).

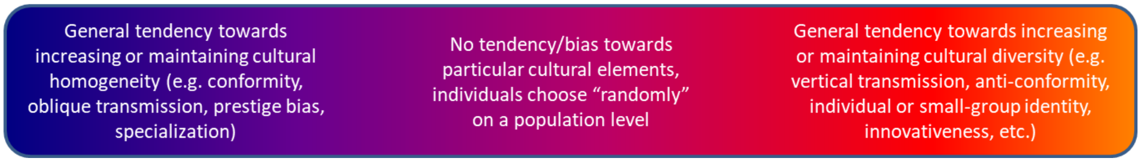


Figure 10.5. A very general division of cultural transmission models by the population-level cultural patterns that they tend to produce. Compare this figure with **Figure 9.1**.

Besides the inferred stability for the majority of features of prismatic blades, some attributes show diachronic changes. Among them, the platform type is possibly a feature that is suitable for assessing the transmission of knowledge. The ABC framework has shown that the likely models for the transmission of platform type are neutral or even anti-conformist. Although these results should be taken with some caution, they possibly indicate that some features of blades were transmitted under different models of transmission (see Tostevin 2012), and changed in a fashion-like manner like stylistic features.

The anthropomorphic figurines seem to be more suitable for modeling the cultural transmission, as there are some distinct features of their appearance that could be directly related to the choices of their makers. In this research, five distinct features of figurines were modeled using the ABC framework to assess the most likely scenarios of knowledge-sharing among the three broad transmission models (anti-conformist, neutral, and conformist). The results have shown that different figurine attributes were transmitted by different models of transmission. The strong traditions in the choice of figurine body and arm position (Лазић 2008; 2015) were probably acquired by a fairly strong conformist transmission, where the knowledge was generally shared at the community-level. Thus, the figurines probably had the same meaning or role for the community through the entire period (Лазић 2008), as the "Repetitions of design and production (including symbols) illustrate a collective communication system" (Biehl 2006: 203, cited in Bailey 2017) or even symbolize the "stability in societal order" (Hansen 2007). Altenatively, the figurine body and arm position were constrained by their function.

The head shape and the paradigmatic head types were possibly transmitted by the opposite frequency-dependent bias, the anti-conformist model, where there was a tendency towards new variants. Between these two models, the eye shape (and possibly skirt/lower body ornaments) exhibits a shift from the anti-conformist in TU 7.2-6.05m to a neutral model in TU 6.03-3.5m, and finally a conformist model in the latest temporal unit. Although the figurine eye shapes change in a fashion-like way (the popularity principle) as confirmed by the battleship curves (**Figure 7.62**), the reconstructed models of transmission show changes from an anti-conformist to a conformist bias, and not the neutral model as it would be expected. What are the reasons for the shifts in the models of transmission for figurine eye shapes over time? One possibility is that there are shifts in the role or meaning of the figurine eyes during the course of time – the individuals are generally biased towards novel shapes as they want to be distinct from others in depicting this attribute; in the subsequent TU there is a random choice of eye shape on a population-level, as individuals choose the eye shape for many different reasons; in the final TU, individuals generally choose the eye shape by conformity, by copying the most common type. Another possibility is that there is another model of cultural transmission besides the neutral model that can produce the patterns recognized as the principle of popularity (O'Brien, Lyman 2002). After the predominance of a certain cultural variant (conformity), there would be a tendency towards novel, rare cultural variants (anti-conformity). Among those rare variants, one of them would increase until becoming the most common, where it is transmitted by a conformist model, and this oscillation between the conformist and the anti-conformist model would repeat over time. Similar shifts between the anti-conformist, neutral, and anti-conformist models for stylistic elements (decorative motifs) can be seen in Figure 2 from Crema et al. (2016). It is possible that the previous inferential frameworks were not able to capture this trend as there was no possibility of changing the *b* values (i.e. the direction and strength of frequency-dependent bias) through time like in the variable population-transmission model (Crema et al. 2016) used here. However, more research needs to be done to fully address this issue.

Returning to the anthropomorphic figurines, the reconstruction of the models of cultural transmission might bring us closer to the understanding of their role within the Vinča-Belo brdo community and possibly the wider region. As "figurines tend to differ, even within the strict canon" (Tasić 2011:8), i.e. they exhibit a high conformism in the transmission of certain attributes (body and arm position, possibly size), and "artistic freedom" (individual expression) in the depiction of others (head and eye shape, skirt) (see also Лазић 2008), it seems that they had (at least) a dual nature or role for their makers and owners. On one hand, they had a community-level meaning and significance, as it seems that the knowledge about the appropriate body and arm position was shared by the entire community. On the other hand, it seems that other features – head and eye shapes, skirt/lower body ornaments – were modeled freely, but largely relying on the previously made figurines as a source of inspiration, where the ideas about modeling these features could have been acquired by any member of the community. In other words, it seems that there were no incentives from the community to maintain a tradition for these attributes, and probably neither from other individuals within the households (vertical transmission). Thus, the figurines cannot be fully explained as solely community-level symbols, nor as products of a purely creative process. Both of these have to be taken into account, as figurines were probably both collective and individual – objects between a community symbol and idiosyncratic representation, tradition and fashion, conservatism and freedom of expression, public and private, and possibly style and function (cohesive role in rituals?; e.g. Borić 2015).

Based on the presented results, it seems that both prismatic blades and anthropomorphic figurines overcome the common dichotomy between style and function (e.g. Dunnell 1978). They show how different features of objects can have different temporal trajectories, which are reflections of different social dynamics that influence them. Furthermore, the models of cultural transmission have shown how the changes can occur solely by internal processes and behaviors of individuals, rather than being caused solely by some abstract population-level notions frequently suggested by the culture-historians (e.g. ethnicity, migrations).

11. Conclusions

The rich stratigraphy of the Vinča-Belo brdo site has a central place in the studies of the Late Neolithic of the Central Balkans, as its continuous occupation during the entire period and the abundance of recovered material remains often served for making general conclusions about the Late Neolithic of the whole region. The investigations of the temporal variability in material culture from Belo brdo were particularly important as they served for reconstructing the social dynamics during this period and establishing the regional relative chronologies. During the long history of research of Vinča-Belo brdo, the descriptions and explanations of the long-term cultural dynamics that were made by culture-historians had laid some foundations of knowledge about the social dynamics during the Late Neolithic of the Central Balkans, which still influence the current research. However, their interpretations were largely based on subjective, very general insights into the diachronic changes in material culture, and on simplistic, general concepts for creating the narratives, which were criticized by later researchers. The main goal of this research was to re-examine some of these interpretations and concepts regarding the long-term cultural dynamics on Vinča-Belo brdo and offer new explanations, using contemporary, empirically grounded methods and theories. By analyzing the long-term cultural dynamics based on the detailed assessment of variability of chert prismatic blades and anthropomorphic figurines, and interpreting the observed patterns of variability in the light of cultural transmission theory, it was shown how the contemporary methodological and theoretical frameworks release us from some legacies of the past research (e.g. phases, types, migrations, etc.) and change our view of the past. Rather than proposing a single scenario of the past, the goal of this study was to narrow down the range of possible scenarios that best fit the observed data, and exclude the unlikely ones.

In this research, the inferences about the socio-cultural dynamics were based on the detailed descriptions of the variability of lithics and anthropomorphic figurines, as different aspects of artifact variability were used as proxies for social learning in the past. The clearly defined features of each artifact were recorded, while the subsequent quantitative tools served for describing the patterns of variability of these two artifact classes. This is in sharp contrast with some of the previous insights on long-term cultural dynamics, where conclusions were often based only on typical, representative finds, or on the presence/absence of different cultural elements. For recording the variability of artifacts, three different analytical approaches were used – attribute analysis, paradigmatic classification, and geometric morphometrics. While the attribute analysis was previously applied to explore the long-term changes in lithics (Radovanović et al. 1984) and certain attributes of figurines (Лазић 2008; 2015) from Belo brdo, paradigmatic classification and geometric morphometrics provided a different perspective on the variability of the studied classes of artifacts. Although similar general conclusions were reached by all three approaches (particularly in the case of prismatic blades), paradigmatic classification and geometrics morphometrics can be used as valuable complementary tools for exploring and explaining the variability of material culture. In the case of figurines, this is one of the first systematic and quantitative studies of the figurine variability from the entire sequence of Belo brdo which assessed multiple attributes of these objects.

I am fully aware that the "'raw data' do not exist in any unproblematic or unbiased way" (Johnson 2020: 259), especially as some of the qualitative data in this research involves a certain degree of arbitrariness and is susceptible to inter- and intra-analyst variation (e.g. Ruck et al., 2020). Moreover, there is much more work to be done to fully understand different aspects of variability and complex relationships between different features of these two artifact classes, especially in the case of figurines, where the effects of skill should be further investigated. However, the application of clearly defined analytical procedures and the quantification of different traits provide at the very least a fertile ground for discussions about the variability of material culture and transmission of ideas, especially as commonsensical units of transmission of ideas are often used (e.g. meander motifs) without any critical reflection on such units (e.g. 'parallels'). As the aspects of variability that were described in this work are based on the relevant previous research and using a systematic, clearly defined methodology, they should represent a sound basis for making general inferences about socio-cultural dynamics on Belo brdo, and tackling the research aims of this work.

Based on the results of this research about the diachronic changes in the production of blades and figurines, as well as on the results of the ceramic analysis of W. Schier (1996; 2000), it can be concluded that there is a clear cultural continuity on the site during the entire Late Neolithic (Chapman 1981; Глишић 1968; Грбић 1968; Јовановић 1968; Kaczanowska, Kozlowski 1990; Milojčić 1949b, cited in Tasić et al. 2015b), where all stabilities and changes in the production of chert blades and figurines can be explained by continuous, uninterrupted transmission of knowledge about artifact production through social learning. There is no evidence of sudden, larger changes in the material culture (e.g. Bogosavljević Petrović 2015; Garašanin 1979; Radovanović et al. 1984; Tasić et al. 2015b; Ристић-Опачић 2005; Срејовић 1968) at the transition to the Gradac phase or other temporal units that would be expected in the case of some notable, more disruptive socio-cultural dynamics such as notable external influences (see Zvelebil 2001) or social disintegration. All the stabilities and changes in the variability of prismatic blades and figurines can be explained by the internal mechanisms, where the behaviors of Belo brdo inhabitants were the main drivers of the cultural dynamics. To cite Glišić once more, the diachronic changes in artifacts leave "the impression of an ongoing process of the shifts in generations and their tastes" (Глишић 1968: 30).

In such a social context, where the internal interactions of Vinča inhabitants were the main drivers of cultural stabilities and changes, some of the main factors that influenced the long-term cultural dynamics can be demography and the models of cultural transmission. Although a population decrease might be a plausible explanation for the reduction in the production of material culture in the latest part of the sequence, while the population increase might explain the increased diversity of stylistic elements in the middle part of the sequence, the effects of reconstructed (regional) demographic fluctuations (Porčić et al. 2016; Porčić 2020; Ристић-Опачић 2005) on certain aspects of artifact variability cannot be clearly established, as there are other possible explanations of such patterns (e.g. regional connectivity, standardization/specialization). The existence of all three evaluated models of cultural transmission on Vinča-Belo brdo has been inferred – conformist, neutral, and anti-conformist model – which can explain the observed "balance between continuity and change" (Tasić et al. 2015b: 58) in the material culture, and also indicate some information about the social organization of this community. Based on the inferences using the ABC framework, some scenarios of knowledge sharing can be excluded as unlikely, although more comprehensive frameworks should be developed for incorporating other scenarios of cultural transmission (e.g. Rendel et al. 2011), as well as for inferring the models of transmission for the quantitative traits. In this study, it was also shown how the contextual data can assist our efforts in reconstructing different aspects of social learning in the past (Eerkens, Lipo 2007: 252), i.e. to strengthen or weaken conclusions based on the cultural transmission modeling by evaluating if they seem plausible. The knowledge about certain aspects of the production of lithics and anthropomorphic figurines was partly collective, shared on the level of community, and partly individual, where a person could acquire it from any member of the community or engage in a creative process of innovation. Generally, the production of both stone tools and figurines were social activities, where the individuals largely relied on the knowledge of their predecessors. It seems that this Late Neolithic community was neither 'traditional', conservative concerning the sharing of knowledge, nor predominantly oriented towards displaying individuality or other small-scale identities. However, more research is needed to further narrow down the range of possible scenarios of transmission of cultural elements. Based on the current results, there are no changes in the social learning strategies that would indicate some notable social dynamics, either internal or external.

The inferred hypothetical scenarios of socio-cultural dynamics have a wider impact on the research of the Late Neolithic of the Central Balkans, as they question some of the core assumptions and interpretations of the cultural-historical school which largely affect the current research, and show that other factors should be taken into account when exploring the past dynamics. There is no need to explain the stability and change only by simplistic, population-level scenarios – e.g. social norms, conservatism, external influences, and ethnicity – as this research has shown how the internal dynamics can produce both stability and change in the material culture. Thus, certain interpretations of the past that were made using the commonsensical and simplistic theoretical concepts should be re-examined. Additionally, some analytical (but often also interpretational) concepts that are still used in the current research, such as archaeological culture, phases, or types, should be critically evaluated and their largely arbitrary nature should be acknowledged.

The results of this study have shown that the periodizations of the Vinča culture based on Belo brdo stratigraphy are largely arbitrary divisions of the continually occuring cultural changes within the sequence, rather than 'turning points' or reflections of some notable social dynamics. However, I do not claim that the proposed periodizations are useless and that they should be abandoned. For investigating or even imagining the great complexity of events that could have happened in 800 years, phases and other temporal divisions are useful as analytical tools for simplifying and comprehending the complex nature of the archaeological record, and exploration and understanding of past events. However, it should be acknowledged that these arbitrary constructs are often based on the fraction of the material culture of the site, that most probably do not reflect any notable changes in the Belo brdo society, so we should constantly question their usefulness for our research aims and the legacies behind them (e.g. external influences, the notion of the rise and fall of archaeological cultures). Moreover, the temporal units of more balanced duration, like the ones used in this research, might be more theoretically grounded for studying many anthropological questions. The historically used phases are maybe most useful for the regional relative chronologies, especially as the number of radiocarbon dates for the Late Neolithic of the Central Balkans is not sufficient for many research projects. However, even in this case one should be careful as the duration of some figurine features, which were used for creating periodizations (e.g. Garašanin 1979) is hundreds of years, so some estimates of relative chronologies might be very imprecise and unfounded. This is partially confirmed by Whittle et al. (2016; Fig.37), where the absolute dates for material attributed to different phases greatly overlap. However, another possibility could be a spatial variation in the temporal appearances of these elements.

Although I do not consider that the narratives based on the site of Vinča-Belo brdo can be easily transferred to other sites in the region, as that would imply "an oversimplified picture of closely synchronized unilinear evolution of material culture over a broad front" (Chapman 1981: 16), they might be used for excluding some unlikely regional scenarios or suggesting some future areas of research. Based on the evidence from the cultural transmission of knowledge about knapped stone tools and figurines, there is no evidence for large-scale migrations during the Late Neolithic that would bring multiple cultural changes (see Zvelebil 2001), so these scenarios might be excluded as unlikely for the neighboring areas. Furthermore, the narratives related to the social disintegration in the final phase of the Late Neolithic communities of the Central Balkans, often related to the depletion of resources, might be questioned by this research. However, we should expect a high diversity in the tempo of resource overload for such local and particular processes, so this hypothesis should probably be tested on a case-by-case basis.

A possibly important outcome of this research is the contribution to the understanding of the role of figurines in the Late Neolithic communities, as it was shown that they were important on both collective and individual levels, as objects that were both public and private, containing elements of both conservative tradition and changing fashion. In other words, their role was both cohesive on the level of community (rituals?) and important on an individual level where everyone could decorate it as desired, but largely acquiring ideas from other members of the community. In the case of knapped stone tools, an important contribution is the reconstruction of the utilized knapping techniques, which is important for studies of craft specialization (e.g. Pelegrin 2012; Perlès 2001), as well as the insight that certain aspects of production might be transmitted under different models of transmission (see Tostevin 2012).

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Appendix 1. Protocol for recording the variability in lithics

Basic info

1. **ID number**. Unique ID number given to each specimen.
2. **Inventory number**. Inventory number previously assigned to a find by the previous researchers.
3. **Bag/case number**. Number of a bag or case where the find is stored.
4. **Box number**. Number of a box where the bag/case is stored.
5. **Year excavated**. Calendar year when a find was excavated (recorded as e.g. G33 in Vasić's excavations).
6. **Relative depth**. Relative depth of a find, as documented during the excavations.
7. **Image name(s)**.
8. **Raw material type**. Macroscopic determination of rock type: chert, obsidian, quartz, miscellaneous sedimentary, undeterminable. Add/adjust categories if needed.
9. **Raw material subtype**. Frequently exploited varieties of chert: chert, flint, radioliarite, jasper, chalcedony, opal. Frequently exploited varieties of quartz: milky quartz, rock crystal. Add/adjust categories if needed.
10. **Raw material color**. Subjectively determined color of the raw material. Observed under constant source of light (a lamp), on opaque part of the find, if present.
11. **Raw material texture**. Macroscopically observed texture, classified as: 1 - coarse, 2 – medium, 3 – fine.
12. **Type of a product:**
    - Raw material nodule – coded as "nodule", unworked piece of knappable raw material
    - Tried nodule
    - Core
    - Flake
    - Undeterminable/waste – pieces with the greatest dimension smaller than 10 mm or with no diagnostic features of flakes
    - Cobble/pebble
    - Percussor
    - Polished stone
13. **Blank type**. Flake category: core, flake, blade, undeterminable
14. **Flake type:**
    - Striking platform rejuvenation
    - Debitage surface rejuvenation
    - Crested blade

- Unretouched flake
- Unretouched blade
- Retouched blade
- Endscraper
- Sidescraper
- Double scraper (retouch on two edges)
- Denticulated tool
- Notched tool
- Trapeze
- Truncation
- Perforator
- Burin
- Point
- Composite tool
- Secondary modification flake
- Undeterminable

15. **Fragmented**. If a find is fragmented enter 1, if not 0.

16. **Sickles gloss**. If macroscopically visible sickle gloss is present enter 1, if not 0.

**Further information is collected only for blades*

Taphonomy

17. **Fragmentation**. 1 - whole blade, 2 - almost whole blade (outlines can be approximately reconstructed), 3 - proximal fragment, 4 - medial fragment, 5 - distal fragment, 6 - longitudinal/Siret fracture, 7 – whole blade with edge damage.

18. **Post-depositional surface modifications (PDSM)**. If there are visible post-depositional traces (striations, concussions, etc.) on the surface of a blade enter 1, if not 0.

19. **Pseudo-retouch**. If present enter 1, if absent 0.

20. **Perpendicular breakage**. For blades where the broken surface of blade is perpendicular in relation to the long axis of blade, enter 1, if not 0.

Metric attributes

21. **Mass (g)**. Measured to the nearest gram.

22. **Maximal length (mm)**. Measured as a maximal distance from the proximal to the distal end along the debitage axis (box method). If a blade is fragmented, measure the preserved length of a fragment.

23. **Width of the striking platform (mm)**. Maximal length from one to another lateral side of the striking platform.

24. **Width of the medial part (mm)**. Measured perpendicularly to the axis of flake propagation.

25. **Width of the distal part (mm)**. Measured perpendicularly to the axis of flake propagation.

26. **Width of the preserved part (mm)**. If a proximal fragment of a blade is preserved, but not distal, it is impossible to measure width of the medial and distal part. In this case, the width of the preserved part is the width of the most distal end of a blade. Similarly, if the distal fragment of a blade is present, the width of the preserved part is the width of the most proximal part of a blade. For medial fragments, the width of the preserved part is calculated as a mean width of the two fragmented parts.

27. **Thickness of the striking platform (mm)**. Maximal distance from ventral to dorsal side of the striking platform, measured perpendicularly to the axis of flake propagation.

28. **Thickness of the medial part (mm)**. Thickness of a blade in the medial part of the flake.

29. **Thickness of the distal part (mm)**. Thickness of a blade in the distal part of the flake.

30. **Thickness of the preserved part (mm)**. If proximal part of a blade is preserved, but not distal, it is impossible to measure thickness of the medial and distal part. In this case, the thickness of the preserved part is the thickness of the most distal end of a blade. Similarly, if the distal fragment of a blade is present, the thickness of the preserved part is the thickness of the most proximal part of a blade. For medial fragments, the thickness of the preserved part is calculated as a mean thickness of the two fragmented parts.

31. **Elongation index (mm)**. Ratio of maximal length and maximal width of a blade, calculated only for whole and almost whole blades.

32. **Vertical convexity (volumetric index)**. Ratio of width of the medial part and medial thickness of a blade, calculated only for whole and almost whole blades.

General morphology

33. **Presence of cortex**. If present enter 1, if not 0.

34. **Back**. If a blade is absent enter 0, if it is natural enter 1, and if retouched 2.

35. **Directionality of removals**. Directionality of dorsal scars on the blade in relation to debitage axis: 1 - parallel, 2 - converging, 3 - orthogonal, 4 – multidirectional, 5 – diverging.

36. **Number of dorsal negatives**. The number of negatives on dorsal side of the blade.

37. **Debitage profile type**. Shape of the blade profile: 1 - straight, 2 - slightly curved (curved roughly in the distal part), 3 - curved (curved roughly in the medial part), 4 - twisted.

38. **Distal end**. Approximate shape of the distal end of a blade: 1 - pointed, 2 – blunt, 3 – stepped/broken, 4 - hinged, 5 - overshot, 6 – undeterminable, 7 – intentionally broken, 8 secondary modification, 9 – retouched.

39. **Blade regularity**. Subjective assessment of regularity of edges and ridges of a blade: 1 – irregular, 2 – moderately regular and parallel, 3 - very regular and parallel.

Detachment features

40. Shape of the striking platform:

- Lenticular – 1

- Triangular – 2
- Trapezoidal – 3
- Polygonal – 4
- Punctiform – small-sized platform, less than 2mm in any dimension – 5
- Linear – narrow platform, with thickness of no more than 2 mm – 6
- Irregular – 7
- Removed by subsequent flaking – 8
- Damaged/indeterminable - 9
- Rectangular – 10
- 'Chapeau *de gendarme*' - 11

41. Striking platform type:
- Cortical – platform is completely or almost completely covered with cortex – 1
- Smooth (plain) – no platform preparation – 2
- Dihedral – two negatives were used as a striking platform – 3
- Facetted – platform that has two or more regular removals – 4
- Scarred – three or more irregular removals – 5
- Punctiform – small-sized platform, less than 2mm in any dimension – 6
- Linear – narrow platform, with thickness of no more than 2 mm – 7
- Removed – platform is removed by subsequent removals – 8
- Damaged/undeterminable - 9

42. Abraded platform. If the platform is abraded, enter 1, if not 0.

43. Crushed platform. If the platform is crushed enter 1, if not 0.

44. Circular crack. If circular crack from the copper pressure flaker is present enter 1, if not 0.

45. Lip. To assess if there is a lip between the striking platform and ventral side of a blade, finger was run across the ventral face, towards the striking platform (e.g. Buchanan et al. 2016). If present enter 1, if not 0.

46. Bulb type. 1 – no bulb; 2 – concentrated; 3 – diffuse.

47. Bulbar scar. If there is a bulbar scar (eraillure scar) on the ventral side enter 1, if not 0.

48. Ripples. If ripples are clearly visible on ventral side of a blade enter 1, if not enter 0.

49. Mesial belly. If mesial belly is clearly visible or it can be felt under the finger enter 1, if not enter 0.

Retouch

50. Retouch scar morphology. 1 – scaled, 2 – stepped, 3 – sub-parallel, 4 – parallel, 5 – irregular.

51. Retouch distribution. Both ventral and dorsal sides are divided in squares (left dorsal proximal, left dorsal distal, left ventral proximal, left ventral distal, right dorsal proximal, right dorsal distal, right ventral proximal, right ventral distal), and for each square it is noted if the retouch is present or absent.

52. Clarkson's index of invasiveness. See Clarkson (2002).

53. **Comments**. Write everything that does not fit into this research protocol, all the notes, uncertainties, and similar.

Cores

1. **Mass (g)**. Weight of the core in grams.
2. **Dimensions (mm)**. Approximate dimensions of the core: length of the debitage surface, length of the striking surface, width of the striking surface.
3. **Core type**. Cores are classified into three broad core types: 1 – flake cores, 2 – blade cores, 3 – bipolar cores.
4. **Pattern of removals**. Determined by orientation of removals on a core: 1 – unidirectional, 2 – opposed platform, 3 – bidirectional, 4 – multidirectional. Add/adjust categories if needed.
5. **Core morphology**. 1 – conical/pyramidal, 2 – prismatic/cylindrical, 3 – tabular, 4 – bullet-shaped, 5 – discoid, 6 – polyhedral, 7 – cortical (cortex covers roughly half or more than half of the surface), 8 – irregular, 9 – plano-convex, 10 – oval, 11 – undeterminable, 12 – Levallois-like. Add/adjust categories if needed.
6. **Shape of the debitage surface**. It will be noted only for blade cores: 1 – triangular, 2 – rectangular, 3 – irregular, 4 – semi-oval. Add categories if needed.
7. **Regularity of removals**. Regularity of negatives on a core will also be recorded only for blade cores: 1 – irregular; 2 – moderately regular; 3 – very regular.
8. **Comments**. Write everything that does not fit into this research protocol, all the notes, uncertainties, and similar.

Appendix 2. Protocol for the analysis of anthropomorphic figurines

Basic info

1. Serial number of the find.

2. Inventory number. Inventory number previously assigned to a find by the previous researchers.

3. Year excavated. Calendar year when a find was excavated (recorded as e.g. G33 in Vasić's excavations).

4. Relative depth. Relative depth of a find, as documented during the excavations.

5. Contextual data.

6. Missing photo. 1 – front; 2 – side; 3 – back; 4 – front and back; 5 – side and back; 6 – front and side.

Fragmentation

*Laterality of body parts is observed in relation to figurine itself, not the observer

7. Undeterminable part. If it is not possible to determine which part of figurine is present due to poor preservation or some other reason, enter 1; else enter 0.

8. Whole/almost whole figurine. If the figurine is completely preserved or it is only slightly damaged, enter 1; if the figurine is fragmented enter 0; 2 – figurine that is only missing one arm. If uncertain/undeterminable enter "?".

9. Head – left side. If present enter 1, if not 0.

10. Head – right side. If present enter 1, if not 0.

11. Chest – left side. If the left side chests are present 1, if not 0.

12. Chest – right side. If the right side chests are present 1, if not 0.

13. Abdomen – left side. If the left side of the abdomen is present 1, if not 0.

14. Abdomen – right side. If the right side of the abdomen is present 1, if not 0.

15. Left arm. If present 1, if not 0.

16. Right arm. If present 1, if not 0.

17. Undeterminable arm. If only one arm of the figurine has been preserved, and it is impossible to determine if it is left or right arm, enter 1, if not 0.

18. Left leg/lower body. If the left leg or the left part of the lower body of the figurine has been preserved enter 1, if not 0.

19. Right leg/lower body. If the right leg or the right part of the lower body of the figurine has been preserved enter 1, if not 0.

20. Undeterminable leg. If only one leg of the figurine has been preserved, and it is impossible to determine if it is left or right leg, enter 1, if not 0.

21. No lower body. If the lower body of the figurine was not modeled (i.e. torso is the lowest part) enter 1, if it was enter 0. If uncertain/undeterminable enter '?'.

Taphonomy

22. Post-depositional surface modifications (PDSM). If there are visible post-depositional alterations (striations, concussions, etc.) on the surface of a figurine enter 1, if not 0.

Technological features

23. Skilled production (skill). Subjective assessment of the skill level required for figurine modeling: 1 – low, 2 – medium, 3 – high.

24. Surface smoothness. If the surface of the figurine looks smooth or polished, enter 1; if the surface looks rough enter 0.

25. Self-standing. If the figurine can stand upright on its own enter 1, if not 0.

Body shape and posture

26. Body position. 1 – standing, 2 – kneeling, 3 – sitting, 4 – sitting on chair, 5 – standing with spread legs. If the lower body is not present, i.e. it is not possible to determine body position, leave the field empty.

27. Position of the left arm. 1 – spread (towards sides), 2 – on hips, 3 – on belly, 4 – on chests, 5 – facing upwards, 6 – facing downwards, 7 – facing forwards, 8 – on genitals, 9 – bent in elbows, facing forwards, 10 – spread upwards, 11 – on face (bent in elbows). If arms some missing or for some reason it is not possible to determine their position, leave the field empty.

28. Position of the right arm. 1 – spread (towards sides), 2 – on hips, 3 – on belly, 4 - on chests, 5 – facing upwards, 6 – facing downwards, 7 – facing forwards, 8 – on genitals, 9 – bent in elbows, facing forwards, 10 - spread (upward), 11 – on face (bent in elbows), 12 – holding a baby. If arms some missing or for some reason it is not possible to determine their position, leave the field empty.

29. Lower body type. 1 – cylinder (no clear separation of the lower body), 2 – distinct lower body without modeled legs, 3 – distinct lower body with legs.

Metric attributes

*If a metric attribute cannot be measured for any reason, do not put 0, leave the field empty.

30. Height (mm). Height of the figurines with lower body, upper body, and head preserved. Height is measured in relation to anatomy of the figurine along the head-feet axis. If only an extremity (arm or leg) is preserved, leave the field empty.

31. Preserved height (mm). If any of the parts needed to measure the original figurine height is missing, measure the maximal height of the preserved part along the head-feet axis.

32. Head height (mm). Measured only if the entire head is preserved, along the chin-head top axis.

33. Maximal head width (mm). Measured perpendicularly to the chin-head top axis.

34. Head thickness (mm). Measured as maximal length from the back to the front of the head (e.g. nose).

35. Length of the torso (mm). Measured from the lowest part of abdomen, i.e. point where the lower body starts, to the base of the head. In other words, it measures the height of the abdominal and chest parts. Possible only if there is clear distinction between upper and lower body, if it is not possible to make this distinctions, leave the field empty.

36. Waist width (mm). Figurine width at the narrowest part of the torso (Singh 2002, cited in Hudson, Aoyama 2007).

37. Waist thickness (mm). Thickness of figurine at the narrowest part of the torso.

38. Hip width (mm). Figurine width at the widest part of the upper portion of the pubic area (Singh 2002, cited in Hudson, Aoyama 2007).

39. Hip thickness (mm). Figurine thickness at the widest part of the upper portion of the pubic area.

40. Thickness in the line of buttocks (mm). The maximal thickness of the upper portion of the pubic area.

41. Length of the left arm (mm). If the arm is bent in elbows, measure the forearm and the upper arm length and calculate the sum.

42. Length of the right arm (mm). If the arm is bent in elbows, measure the forearm and the upper arm length and calculate the sum.

43. Length of the undetermined arm (mm). In some cases when only arm is preserved, it is not possible to determine its laterality. If the arm is bent in elbows, measure the forearm and the upper arm length and calculate the sum.

44. Length of the lower body (mm). If the lower body is clearly separable from the upper body, measure it as a distance from the lowest part of the figurine to the highest part of the lower body,

45. Leg length (mm). If the legs are modeled, measure the leg length from the highest point between the legs to the lowest part of the leg. If the length of two legs are different, calculate leg length as the average of the two leg lengths.

46. Width of the lowest part (mm). Width of the lowest part of the figurine. Note that for the figurines with only upper body the width of the lowest part is the same as the hip width. This should be also noted when comparing width of the lowest part of figurines with no lower body (only upper body) and those with lower body.

Anatomy

47. Breasts. If breasts (either carved or plastically modeled) are present enter 1, if not 0. If part of the figurine which should contain breasts is not preserved, leave the field empty.

48. Belly. If the belly is pronounced, enter 1, if not 0. If it is not possible to determine presence due to fragmentation, leave the field empty.

49. Navel. If navel is represented either as a bump or dent in the line of abdomen, enter 1, if not 0.

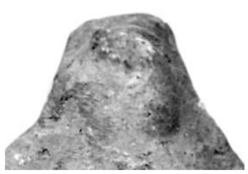
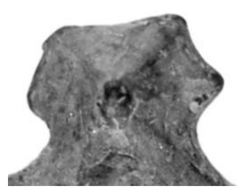
50. Buttocks. If buttocks are present as specifically shaped body part, enter 1, if not 0.

51. Vulva. If any representation of the female genitals is depicted insert 1, if absent 0. If the body part which should contain it is not preserved, leave the field empty.

52. Penis. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

Head properties

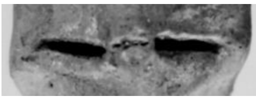
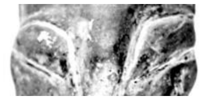
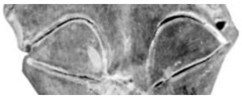
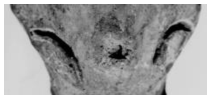
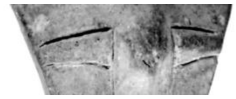
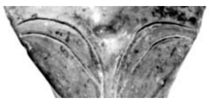
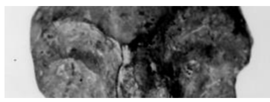
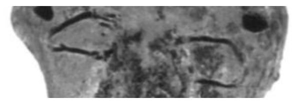
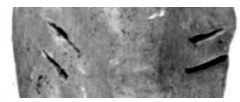
53. Head shape. A very rough classification of figurine head shapes:

Circular/oval	Triangular/ogival	Rectangular	Trapezoidal
			
Pronounced zygomatics	Reverse triangle/trapezoid	Pentagonal	Rectangular with ‘ears’
			
Lozenge	Elongated	Hexagon	
			

54. Head position. 1 – head is facing forward, 2 – head is facing downwards, 3 – head is facing upwards. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

55. Eyes. Present – 1; absent – 0.

56. Eye shape. Rough classification based on the general eye morphology:

Linear	Angular	Triangular	Almond
			
Segment	Arched oblique	Circular	Rectangular
			
Elongated segment	Thick arched	Trapezoidal	Lenticular
			
Parallel lines	Arched	Vertical lenticular	Inverse triangles
			

57. Mouth. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

58. Mask. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

59. Hair. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

60. Nose. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

61. Ears. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

Clothes, ornaments, applications, perforations

62. Head ornaments. If head ornamentation is present enter 1, if not 0.

63. Necklace. If the necklace is present enter 1, if not 0.

64. Torso ornaments. If there are ornaments in the torso area enter 1, if not 0.

65. Arm ornaments. If there are ornaments on either left or right arm enter 1, if not 0.

66. Skirt. If the skirt is modeled enter 1, if there is a lower body ornament other than skirt enter 2, if there is neither skirt nor other lower body ornament, enter 0.

67. Skirt/lower body motives. The ornamental motives are divided into *large patterns* (vertical lines, horizontal lines, belt, oblique lines, zigzag, maze-like/meanders, nets, oblique nets, spirals, triangles, inverted triangles, triangles between the legs) and *small patterns* (horizontal lines, dots, zigzag), and their presence/absence is noted.

68. Perforations on the head. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

69. Perforations on the abdomen. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

70. Perforations on the hips. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

71. Perforations on the left arm. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

72. Perforations on the right arm. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

73. Perforations on the undetermined arm. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

74. Perforations on the lower body. Enter 1 if present, 0 if absent. If it is not possible to determine presence/absence due to fragmentation, leave the field empty.

75. Comments. Write everything that does not fit into this research protocol, all the notes, uncertainties, and similar.