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Shape Reproducibility and architectural symmetry during the Chalcolithic period in the southern Levant

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ABSTRACT

Architecture reflects social aspects of past communities. Structure attributes such as shape, size, building material and decoration, provide valuable information beyond their immediate structural function. However, while attributes such as size can be measured and therefore objectively compared between structures, the comparison of shape between structures is based on subjective observations. In the current study we use two quantification methods for analyzing prehistoric shape-based architectural data: (1) we developed a new method, Shape Reproducibility (SR), based on objective computerized procedure for analyzing the similarity and difference between shapes of ancient buildings; and (2) we use Continuous Symmetry Measure (CSM), a method which was originally developed for analyzing flint artifacts and ceramic vessels to objectively compare between shape symmetry. Applying these methods to settlement data of the Chalcolithic period enables quantification of the level of architectural similarity within and between different sites and their comparison to architectural data of later periods, such as the Early Bronze Age II urban center at Arad. Our CSM results suggest that the symmetry of architecture does not increase through time. Our SR findings demonstrate that in the main cultural Chalcolithic entity, the Ghassulian, the architecture of different sites could not be distinguished from one site to the other. In addition, we demonstrate that the architecture of the Chalcolithic sites in the Golan Heights is homogeneous and significantly differs from other Chalcolithic sites, while Ghassulian intra-site variability is higher. In comparison with Arad, however, this variability is relatively low and limited. These results suggest that status differentiation or hierarchical social organization cannot be indicated from Ghassulian architecture.

1. Introduction

Building is among the prime activities carried out by humans since earliest times (Bar-Yosef, 1992: 31). Architecture is a visible cultural manifestation that influences social behavior and provides the framework for social interaction and community organization (Byrd, 1994: 643; Ingold, 2000: 175–178; Wilson, 1988: 21). It is also evident that dwellings are subject to spatio-temporal changes (e.g. Flannery, 1972; Goring-Morris and Belfer-Cohen, 2008; Kempinski and Reich, 1992). Different attributes of structure such as shape, size, building material and decoration have significance beyond their immediate function. They provide invaluable information about the social aspects of past societies, as well as evidence concerning modes of adaptation to environments, changes in population size, technology and subsistence economy (e.g. Allison, 2002; Banning, 2010, Banning and Byrd, 1987; Binford, 1990; Carsten and Hugh-Jones, 1995; Flannery, 1972; Hillier and Hanson, 1984; Hodder, 1994; Lévi-Strauss, 1963; Rapoport, 1969, 1982; Wilson, 1988).

The first structures in the southern Levant were made of perishable materials leaving practically no traces, and their existence is inferred on the basis of the spatial distribution of other finds, such as in the case of the Early Epipalaeolithic site of Ohalo II (ca. 21,500–20,500 B.C.) (Bar-Yosef, 1992: 31; Goring-Morris and Belfer-Cohen, 2008: 249–250; Nadel and Werker, 1999). Later on, during Natufian cultural phase (ca. 13,000–9600 B.C.), the existence of post-holes indicates some sort of roofing, as at Ein Gev I and III (Arensburg and Bar-Yosef, 1973; Martin and Bar-Yosef, 1979). In other sites architectural remains consist of several walls made of undressed stones that probably supported wooden poles, or a few freestanding walls, oval or rounded in shape (Valla, 1988). Pre-Pottery Neolithic A (ca. 9600–8500 B.C.) architecture consists

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of oval and subcircular structures that were either freestanding or semi-subterranean (Finlayson et al., 2011a, 2011b; Kuijt and Finlayson, 2009; Kuijt and Goring-Morris, 2002: 373). These structures were made of a stone foundation with mud brick superstructure. Worth mentioning is the large Neolithic tower of Jericho. This unique tower is 8.25 m in height and 8 m in diameter made of undressed stone with a staircase built inside (Kenyon, 1957; Kenyon and Holland, 1981). During the Pre-Pottery Neolithic B period (ca. 8500–6400 B.C.) the transition from oval/rounded to rectangular structures is evident. Constructions during this period were mainly of mudbrick on stone foundations (Banning and Byrd, 1988; Bar-Yosef, 1992; Goring-Morris and Belfer-Cohen, 2003, 2008; Kuijt and Goring-Morris, 2002; Kuijt et al., 2011; Moore, 1985; Rollefson, 1997). Stone and mudbrick rectangular architecture continued well into the Pottery Neolithic (ca. 6400–4500 B.C.) and Chalcolithic (4500–3900 B.C.) periods (Ben-Shlomo and Garfinkel, 2009; Garfinkel and Ben-Shlomo, 2002; Garfinkel et al., 2009; Porath, 1987, 1992). In addition to the rectangular above ground structures, subterranean structures were uncovered in Chalcolithic sites of the northern Negev such as Abu Matar, Bir es-Safadi (Perrot, 1984), and Horvat Beter (Dothan, 1959; Rosen and Eldar, 1993). Preservation of mudbrick walls is poor and in many Chalcolithic sites preserved were only fragments of walls, in many cases without side or parallel walls. Bricks were made by hand, of local silts (Porath, 1992: 44), and after their collapse they disintegrated and could not be distinguished from the natural sediment. Along with other destructive processes, walls are under-represented in comparison to pits and other installations (Gilead, 1995: 30).

Architectural studies are usually based on the analysis of structures at different sites in order to explain the similarity or variability of the shape patterns. In many cases the researchers define a 'typical', frequent or 'average' house shape that characterizes specific cultures/periods/regions. Such as the Four Room House or the Israelite house during the Iron age (Faust and Bunimovitz, 2003), or later examples such as the Arab-Islamic House (Ron, 1998) or the Black Tent (Manderscheid, 2001). Analyses of architectural shapes are commonly based on the researcher's skill, intuition, and subjective evaluation which result in biased and sometimes inaccurate conclusions and may lead to equivocal results. Although there are few exceptions (e.g. Dickens, 1977; Fletcher, 1977) most studies of past architectural shapes lacks formal quantitative methods. Below we introduce two methods for objective and accurate quantification for characterizing and comparing between shapes applied here to prehistoric architectural data.

Quantitative analyses of artifact shapes have been carried out for more than half a century (Clarke, 1968: 525–534), and they have increased significantly during recent years (e.g. Durham et al., 1995; Gero and Mazzullo, 1984; Gilboa et al., 2004; Grosman et al., 2011, 2008; Karasik, 2010, Karasik and Smilansky, 2008; 2011; Leese and Main, 1983; Liming et al., 1989; Saragusti et al., 2005, 1998). Such studies are also based on advance computing along with a variety of technologies such as 3D and laser scanning. These studies, however, focus mostly on pottery vessels and lithics, while architectural remains are left behind. These studies have introduced a number of important mathematical methods for quantifying shape attributes such as symmetry, roughness and deformation.

Continuous Symmetry Measure (CSM) is a versatile method which was originally developed to distinguish molecules from each other by their degree of shape chirality (dissymmetry) (Zabrodsky and Avnir, 1995). This tool was first used in archaeology for measuring the degree of symmetry of Lower Paleolithic handaxes (Saragusti et al., 1998). It has been demonstrated that symmetry of handaxes and pottery vessels increases with time (Saragusti et al., 2005, 1998). It should be noted that though there are many aspects of symmetry such as symmetry of rotation, treatable symmetry, etc., the archaeological study of symmetry is usually limited to bilateral symmetry, meaning that the shape does not change upon undergoing a reflection. Bilateral symmetry or reflection symmetry in archaeological studies is referred to simply as "symmetry".

Symmetry appears in the form of artifacts, buildings and built environments all over the world (Wynn, 2002: 390). Many studies regard the degree and nature of symmetry as cultural attributes or as manifestations of cultural progress (e.g. Bridgeman, 2002; Lycett, 2008; Oakley, 1972; Shennan, 2006; Simao, 2002; Wynn, 1985). Others argue that symmetry is related to the evolution of human cognition (Stout and Chaminade, 2007; Toth, 1990; Wynn, 2002), or link it to functional effectiveness (Jones, 1980; Machin et al., 2007; Mitchell, 1996), to sexual display (Kohn and Mithen, 1999), or to aesthetics (Hodgson, 2011; Schick and Toth, 2001: 282). There are, however, studies that show that symmetry could result from coincidental factors such as type of raw material, resharpening (McPherron, 2000; Nowell, 2000, 2002), or post depositional processes which involve environmental disturbances that damage stone tools (Grosman et al., 2011).

Indeed, symmetrical attribute signaling safer, more effective, and more predictable artifacts or buildings than asymmetrical ones (Liu and Kersten, 2003; van der Helm, 2002; Vetter et al., 1994; Wagemans, 1995). However, unlike earlier periods, when manufacturing of Acheulean handaxes was associated with different hominins, and with butchering effectiveness, during later periods the intentional concern for symmetry seems to be detached from the evolution of cognitive, adaptive or functional factors. Thus, it is reasonable to study architectural symmetrically of later periods – the Chalcolithic and Early Bronze Age periods in our case – which are much too short for evolutionary change, as a manifestation of culture change and variability (Bridgeman, 2002: 403, Hodgson, 2011: 38). Symmetry is a key element in architecture which signals balance, since pressure on a structure or building is distributed equally if there is symmetry. In the study of symmetry of prehistoric flint tools, such as Acheulean handaxes for example, the difference between early, less symmetrical artifacts and later, more symmetrical artifacts, is well established and regarded as an indication of more elaborated production techniques and increased skill (Saragusti et al., 2005, 1998; Wynn, 1985). Studies have shown that manufacturing technique involve social dynamics, and the technical knowledge is directly related to social knowledge (e.g. Dobres, 2010; Dobres and Hoffman, 1994, 1999; Schiffer and Skibo, 1987; Torrence, 1989; van der Leeuw, 1993; Wright, 1993). This is necessarily mediated by culture (Dobres, 2010: 106). In addition a progress in technology is driven by cultural accumulation of knowledge (Bridgeman, 2002; Ingold, 1990, e.g. Schiffer and Skibo, 1987). In studying the symmetry of prehistoric architecture we, therefore, expect that difference between less symmetrical structures and more symmetrical structure might reveal aspects concerning the technology and skills which characterize the societies and their cultural contexts.

Beside the degree of symmetry, studies have shown that the shape itself of a house is determined by social or economic factors (Allison, 2002; Carsten and Hugh-Jones, 1995; Donley, 1982; Hillier and Hanson, 1984; Ingold, 1995, 2000; Kent, 1990b; King, 1980; Lau, 2010; Rapoport, 1969, 1982; Wilson, 1988). Nevertheless, there are others who argue that the main factors are environmental or physical. These factors include: climate (e.g. Correa, 1982; Fitch and Branch, 1960; Givoni, 1969; Herzog, 1980; Mauss and Beauchat, 1979; Sozen and Gedik, 2007); topography or land scarcity (e.g. Alexander, 1964; Sopher, 1964); technology and building materials (e.g. Aalen, 1966; Agorsah, 1985; Laksmi, 2006; Rumana, 2007).