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Tracking the emergence of an organized use of space: A direct comparison of the spatial patterning within Middle and Upper Paleolithic open-air sites

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ABSTRACT

Although the 'organization of space' is said to be one of the defining characteristics of modern human behavior, the identification and documentation of such organization has proven to be elusive, especially as rendered in artifact patterning. Without directly comparing artifact patterns within multiple sites, there is no benchmark with which to conclude one site to be more or less 'organized' than another. We can objectively identify patterns within the distribution of archaeological materials, but the decision of whether that patterning constitutes as 'organized' is entirely subjective without a comparative model. In this paper, I present the results of a study in which the spatial distribution of artifacts within nine Middle and Upper Paleolithic sites in France are directly compared to one another, and discernible changes in patterning can be identified. The differences in spatial patterning between the Middle and Upper Paleolithic sites suggest that the organization of space likely became increasingly formalized into and throughout the Upper Paleolithic alongside other cultural norms of behavior. Though more sites are needed to thoroughly document this phenomenon, this study suggests that direct comparisons of spatial patterning have the potential to yield more objective results on the question of spatial organization.

1. Introduction

In several previous papers (Clark, 2016, 2017, 2019), I reported on the intrasite spatial analysis of seven Middle Paleolithic (MP) open-air sites in France. I developed two interconnected methods that I used to directly compare the spatial patterning across a range of site sizes and densities. Lithic artifacts were the only material remaining in these sites, and the dominant spatial patterning was determined by the spatial positioning of core reduction. These methods tracked lithic knapping within these sites and the movement of artifacts from where they were knapped. That study ended in several main findings. First, at these MP sites, differences in site structure could largely be attributed to differences in the length and number of occupations. Second, a large amount of knapping occurred with many usable products left unutilized. Third, lithics selected for use could be identified using these methods, and the lithics selected were often unmodified flakes, in addition to retouched pieces.

In this paper, I present results on the expansion of this study to include two Upper Paleolithic (UP) open-air sites analyzed using the same methods. The analysis of the modern human sites displays two major deviations from the patterning exhibited in the Neanderthal sites. First, unmodified flakes no longer make up a notable component of the selected pieces. There is a much stronger preference toward retouched or bifacially worked pieces. Second, differences in spatial patterning can no longer be largely explained by occupation dynamics. Instead, it appears that site structuring is a product of culturally derived structuring processes. This is the case especially for the more recently occupied UP site, Landry.

An organized use of space is often cited as one potential characteristic indicative of 'behavioral modernity' (Wadley, 2001; Bar-Yosef, 2002; Mellars, 2005). The assessment of spatial organization is complicated by several factors, however. Most simply, we might ask what is spatial organization and how would it manifest archaeologically, thousands or hundreds-of-thousands of years after the original 'organization' took place? We could have a relatively clear idea of how spatial organization is exhibited in the present, but it is much more complicated to assess its presence left only with the spatial position of lithic artifacts, for example. Moreover, most archaeologists are well aware that the degree of spatial organization might depend not only on the cognitive modernity of a given population but also on the duration of occupation. Even during short stays, groups may adhere to organized routines of site use, but the spatial signatures will often be too ephemeral to detect

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archaeologically. In this section, I will briefly summarize how various scholars define spatial organization in an archaeological context and how these definitions have been used to characterize the spatial patterning within MP and UP sites.

In his book, "In Pursuit of the Past", Lewis Binford (1983) argued that modern humans exhibit an organized use of space, with different areas reserved for sleeping, cooking, tool manufacture, and so on. He questioned whether earlier hominins, specifically Neanderthals, would follow such a pattern. In addition, Binford linked the spatial structure of activities to mobility strategies, contending that a foraging strategy would produce 'intensive' activity areas, with all activities focused in a limited spatial area, usually around a hearth, whereas a collector strategy would produce 'extensive' activity areas, with task-specific activity areas dispersed over a wider area. Moreover, Binford argued that Neanderthals would follow a foraging strategy and modern humans, a collector strategy. This was linked to cognition; a collector strategy required greater planning and forethought, whereas a foraging strategy was based on satisfying immediate needs.

Many scholars drew upon Binford's ideas and sought to test his hypothesis. For example, Simek (1987) compared the spatial organization of Neanderthals and modern humans through a k-means analysis of three layers of Flageolet I (UP) and one layer of Abri Vaufrey (MP). He found the spatial structure of Abri Vaufrey to be homogenous whereas the spatial structure at Flageolet to be heterogenous and more dispersed. In Simek's view, the homogenous distribution was a result of repeated, intensive use of space, indicative of a foraging strategy, and the heterogenous distribution, with some separation of activities, was linked to a collector strategy. For Simek, therefore, it came down to mobility strategies and site function, rather than cognition or behavioral modernity, although those markers were implicit. Hietala and Marks (1981) also sought to link spatial organization with mobility strategy. They compared level 1 to level 4 at Boker Tachtit and found that in level 1, discrete activity areas could be observed, whereas the structure of level 4 was more 'generalized'. Level 1 was the result of a longer duration of occupation, and level 4 was occupied during a high-mobility strategy. More recently, Riel-Salvatore et al. (2013) also sought to link spatial patterning to mobility strategies, this time within MP layers only, at Riparo Bombrini. Because they did detect some differences in spatial patterning linked to duration of occupation, Riel-Salvatore et al. argued that Neanderthals were capable of organizing their space.

This contrast between an 'intensive' vs. an 'extensive' use of space and its link to planning and therefore modernity is the fodder that sparked the pursuit of 'activity areas' in spatial analysis studies (Clark, 2017). The identification of activity areas would imply an 'extensive' use of space, thus a collector strategy of mobility, and consequentially, an ability to plan and function as a fully modern human. However, ethnographic studies reveal that an 'extensive' use of space is not always exhibited in extant hunter–gatherer camps, and furthermore, such a pattern might not be detectable in the archaeological record of deep time (O'Connell, 1987; Fisher and Strickland, 1989; Simms and Heath, 1990; Fisher et al., 1991). Binford himself acknowledged that extant hunter–gatherers do not always follow a 'collector' strategy but use different strategies depending on the season or environment (Binford, 1980).

Many archaeologists invoke spatial organization and its linkage to behavioral modernity without implying a link to mobility strategies (e.g., Wadley, 2001). In these cases, researchers postulate that our use of space is sometimes practical, but is also often symbolic, for example, in the way space is gendered in many ethnographic contexts (Binford, 1983: 180; Surovell et al., 2022). In my opinion, this argument, and its relationship to the advent of symbolic behavior, is more clearly linked to the emergence of behavioral modernity. The increasing evidence for symbolic behavior is one of the 'hallmarks' that has withstood many decades of research and, if anything, only seems to be strengthening over time (evidence for Neanderthal symbolism does not undermine this trend, only reinforces it). Further on in this paper, I argue that the emergence of cultural norms dictating how space is used could be another indication of increasing 'modernity' because cultural norms are expected to be more prevalent as culture accumulates. However, the question here is how one is to identify these changes in the use of space.

A major difference in how spatial organization is identified, and used as evidence in this debate, is whether one focuses on artifact patterning or features (or 'latent' verses 'apparent' structuration; e.g., Anderson et al., 2018). An analysis of features is more straightforward. Hearths, of course, are the most commonly found feature in Paleolithic encampments. Archaeologists assess whether they were constructed in the same place, whether they were 'built' by positioning stones or digging into the substrate, and how they are positioned relative to one another and the debris surrounding them (Jaubert and Delagnes, 2007; Stiner et al., 2011; Aldeias et al., 2012; Goldberg et al., 2012; Vallverdú et al., 2012; Spagnolo et al., 2018; Mallol et al., 2019; Murphree and Aldeias, 2022; Clark et al., 2022). These studies are often descriptive in nature and are largely determined by field observations, as well as specialized analyses, such as micromorphology. Sometimes features other than hearths can be identified in Paleolithic sites. These include structures, such as windbreaks, huts, or drying racks, identified via post holes, the positioning of construction materials (i.e., large stones), or phantom 'walls' indicated by voids in the distribution of artifacts (Stapert, 1990; Bourguignon et al., 2002; Jaubert and Delagnes, 2007; Kuhn et al., 2009; Wadley and Langejans, 2014; Gingerich, 2022). The frequency of evidence for such features rises sharply throughout the Paleolithic (Clark and Ranlett, 2022; Clark et al., 2022), but in many cases, one must rely on the accuracy of field observations and direct quantitative comparisons are rarely possible.

The positioning of artifacts has the potential to be more objective since the coordinated points of artifacts can be directly compared to one another. However, this requires access to both the coordinated points and the artifact attributes at many sites, which is unfortunately rarely possible, and so most studies analyze the spatial patterning of artifacts at only one or two sites. The analyses used are diverse, and they are often tailored to a particular site, so direct comparison of these studies is seldom possible. Some analyses have produced robust results (Surovell and Waguespack, 2007; Waguespack and Surovell, 2014; Surovell, 2022), but the patterning of artifacts becomes more difficult to interpret with increasing time depth. Frequently, the sole goal is to identify patterning of some sort. It is often difficult to determine, however, what counts as 'organized' and what criteria should be used to describe such organization as 'modern'. These assessments are left to the individual researcher and their interpretation of whether any patterning constitutes as 'modern' can differ considerably and has the potential to be affected by underlying predispositions.

When one compares the presence and elaboration of structures over large swaths of time, trends do emerge (Clark et al., 2022). Such trends are harder to detect in the patterning of artifacts, however. This study is meant to fill that void, using the same methodology at nine MP and UP sites so that their patterning can be directly compared. There are certainly other ways to detect spatial patterning than the methods used here; for example, one which focuses on hearth-centered activity areas (see Stapert, 1989, 1990). The point, however, is to be consistent in our application of spatial analyses to a larger sample of sites. Indeed, I was able to detect differences in patterning between the MP and UP sites that would never have emerged had I not such a large database of sites.

There are several limitations to this dataset that must be discussed upfront. One is the obvious low sample size of UP sites ($n = 2$) compared to MP sites ($n = 7$). Unfortunately, I was unable to attain access to a larger number of UP sites, and so I decided to proceed with the current sample size, which nevertheless, is the largest direct comparison of MP and UP site structures to date. It is unfortunate too that the two UP sites, Landry and Garris II, have differential access to raw materials, so their use might be somewhat different. All sites in the sample are open-air sites, and they are all located in parts of France where chert is ubiquitous, particularly in riverbeds and drainages. The difference in raw material access is therefore whether a site is directly on top of a raw material source, or merely adjacent to a raw material source, with the exception of Le Prissé where the raw materials were obtained from around 2 km away (Table 1). Therefore, core reduction was still a major activity present at all sites in this sample. Nevertheless, while this analysis has produced some intriguing results, they must be regarded as preliminary and more sites, especially from the UP, must be directly compared before a stronger conclusion can be reached.

2. Materials and methods

2.1. Sites in the study

All sites in this study were excavated and were studied by researchers from the French Institut National de Recherches Archéologiques Préventives (INRAP), a government-funded institution that excavates archaeological sites prior to construction projects. Information on the MP sites can be found in more detail in earlier publications (Clark, 2015, 2016, 2017, 2019), but I will describe them briefly here in a geographic order from north to south (Fig. 1). Three sites are located to the north of Paris, in the loess belt of northern Europe, and were excavated by Jean-Luc Locht (Locht, 2001, 2002; Locht et al., 2003, 2008). Bettencourt-Saint-Ouen, Fresnoy-au-Val, and Villiers-Adam are all located within forest soils weathered in a loess substrate. Topographically, they are situated on gentle slopes facing north or northeast. Both Bettencourt and Fresnoy contain more than one archaeological horizon, but only the highest density layer was included in this analysis (layer N2b for Bettencourt and series 1 for Fresnoy). These two sites are both relatively dense with comparable artifact counts (Table 1). Villiers Adam is unique in that it is very large in surface area but is represented by a very low density of artifacts. The fourth site, La Folie, excavated by Laurence Bourguignon, is located further south outside the city of Poitiers (Bourguignon, 2010; Bourguignon et al., 2002, 2006). La Folie is a particularly well-preserved site, located on a flood plain, and thus is the only site to offer some additional, complementary information regarding site structure. Limestone blocks were moved to this location and may have been utilized in the construction of a windbreak. A posthole associated with one of the blocks was found, as well as a nonpedogenic organic horizon that likely represents an area of bedding. In addition, a fire structure can be identified at La Folie, an exception among the MP sites. Further to the southeast, to the east of Bordeaux, are the next two sites in the sample, also excavated by Laurence Bourguignon, La Doline de Cantalouette II and Champs de Bossuet (Bourguignon et al., 2000, 2005). These two sites are incredibly dense with artifact counts that exceed 15,000 pieces. Both sites are situated on top of high-quality-flint raw material sources, which accounts for their unusually large assemblages. The final MP site, Le Prissé de Bayonne, excavated by David Colonge, lies on a terrace just east of the eponymous city (Colonge et al., 2014; Deschamps et al., 2016). It is a small site with two layers, but only the layer with better spatial preservation is considered here (layer PM1).

Lithic production is clearly a major activity at the MP sites. However, use-wear analysis indicates that many other activities were performed at these sites as well, such as wood working, hide working, and animal butchery (Bourguignon et al., 2000; Locht, 2001, 2002; Bourguignon et al., 2005, 2006; Colonge et al., 2014). Evidence for these other activities was even found at the two sites located on top of high-quality raw material sources, Cantalouette and Bossuet.

The UP sites are located in the same general area as the MP sample. Garris II is an open-air Aurignacian site that is associated with the high-quality Bergeracois flint (Rios-Garaizar and Ortega Cordellat, 2014). The site is found near the eponymous city of Bergerac and is located only a couple of kilometers away from La Doline de Cantalouette II, from the MP sample. Both sites were excavated as a part of the same roadway deviation project, along with other open-air Paleolithic sites associated with the high-quality raw material source (Bourguignon et al., 2004). The excavation of Garris II took place in 2004, led by Illuminada Ortega and Laurence Bourguignon. Garris II is 68 m^2 in area with an artifact count of 2098 lithics (Fig. 2). The main purpose of the occupation appears to be lithic production, but use-wear analysis also indicates the presence of other activities, especially hide processing (Rios-Garaizar and Ortega Cordellat, 2014).

The second UP site, Landry, is located near the city of Perigueux and was excavated in 2012 by a team led by Michel Brenet (Brenet et al., 2014, 2018). It is situated on the alluvial plain of the Isle River, and it yielded two stratified, Late Solutrean layers. Only the more intensively occupied upper layer was included in this analysis; it is comprised of 10, 098 flint artifacts and 2862 metamorphic rocks over an area of 237 m^2 (Fig. 2). It is dated to 21 ka via thermoluminescence on burnt flint. The production of lithic tools, especially points, was a major activity at Landry. Among the artifacts were 130 retouched pieces and over 100 bifacially worked pieces (laurel leaf points and others), many of which were rough outs or were broken. Use-wear indicates many activities related to hunting and carcass processing, such as impact fractures on points and end scrapers bearing wear patterns consistent with hide working. The metamorphic rocks had a variety of functions, including their use in disarticulation, fracturing bones, and as anvils. There were also nonutilitarian engravings on some of the dolerite blocks. Clearly, a variety of activities took place at the site.

2.2. Intrasite spatial analysis methods

Because all sites were excavated by researchers from INRAP, the basic excavation and data collection procedures were the same, even though the specific researchers who directed the projects differed. The INRAP researchers then analyzed the lithic assemblages using a typo-technological system and refit them. This provided me with an extraordinary database for a comparative spatial analysis study.

I used two interrelated methods to analyze these sites (Clark, 2016, 2017, 2019). The first, called the refitting location analysis, is based on

Table 1
Quantitative and qualitative data for the nine sites in the study.

Parameters	Bettencourt	Fresnoy	Villiers Adam	La Folie	Le Prissé	Cantalouette	Bossuet	Garris II	Landry
Site density (lithics/ m^2)	6.26	3.74	0.84	6.10	0.81	54.62	69.29	30.85	42.61
Site area (m^2)[a]	915	1143	1928	207	1075	282	228	68	237
Total lithics[b]	5729	4270	1619	1262	870	15,404	15,797	2098	10,098[c]
Densest square (# lithics)	225	183	108	189	66	443	527	467	333
Raw material availability	Adjacent to source	Adjacent to source	Adjacent to source	Adjacent to source	≤2 km to source	At source	At source	At source	Adjacent to source

[a] The site area was calculated in ArcGIS by 'wrapping' the points in a polygon.
[b] The total lithics is for chipped pieces only, not metamorphic stones used for other purposes (present at Landry).
[c] This figure represents the total lithics greater than 2 cm excavated at Landy, but only 6168 of these underwent technological analysis and were included in this study.

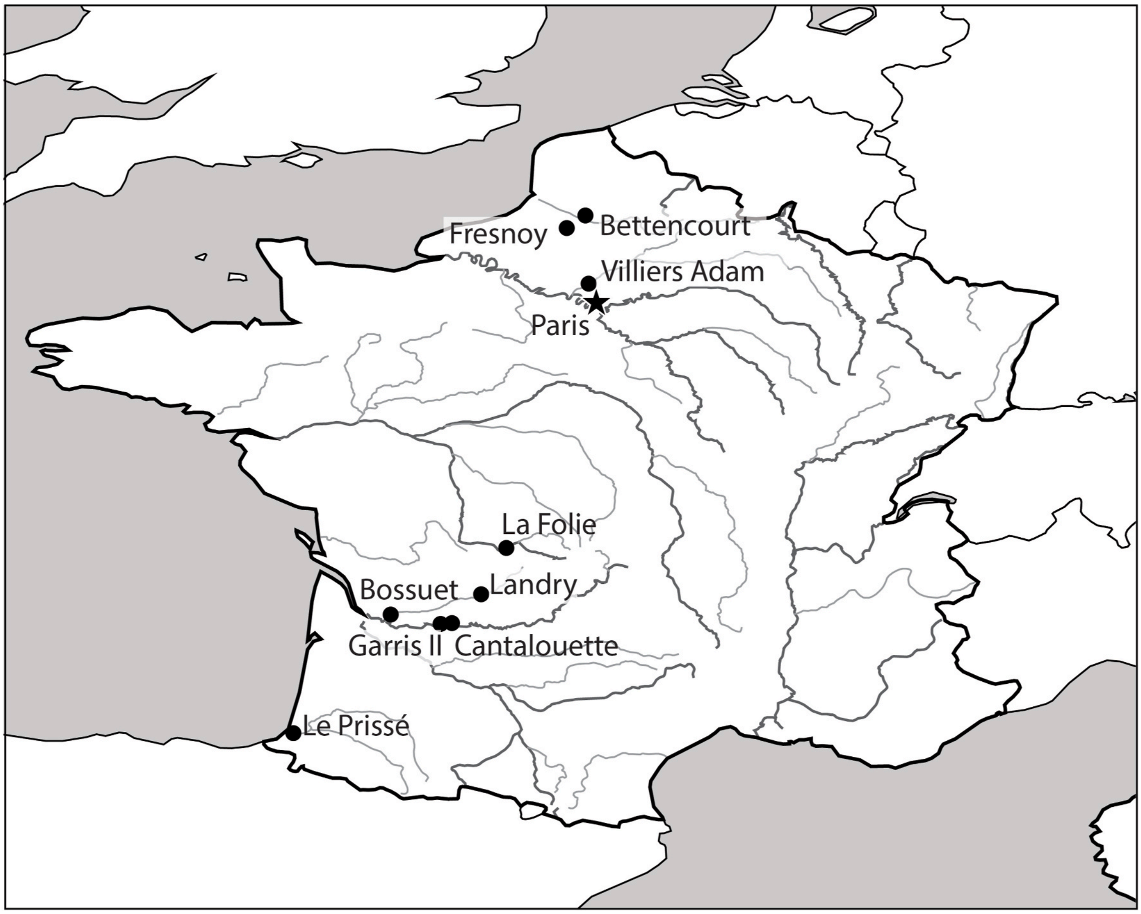

Figure 1. The location of the sites included within this study in France.

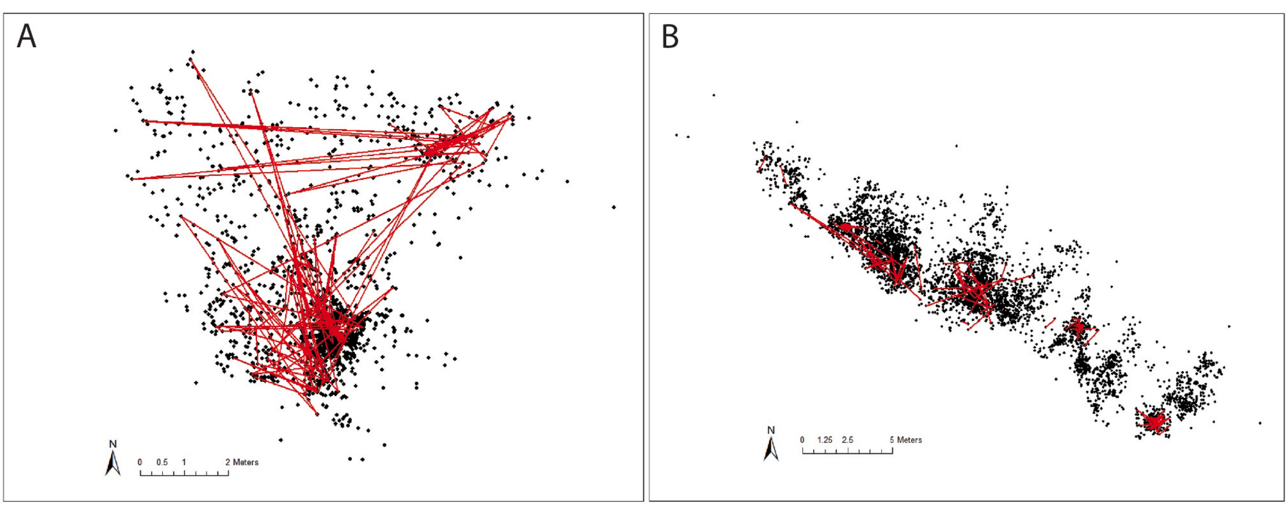

Figure 2. A map of the spatial patterning of flint artifacts within the two Upper Paleolithic sites in the study: (A) Garris II and (B) Landry. The black dots are the location of lithic artifacts and the lines are refitting connections. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

refitted lithics. The group of lithics which refit together (sometimes just two, but often many more), I term them 'sets'. I plotted each set of refitted lithics, and I divided them into groups based on their spatial relationship to one another. Often a few refitted lithics from the same set were clustered in close proximity to one another. After locating the tightest cluster, I assigned all members of the refitted set within one meter of one another to group 1. Refitted lithics from the same set that were two meters away from group 1 (or within three meters of one another for a set with no group 1), I placed in group 2. All other lithics, located further away than two meters, I assigned to group 3. After plotting each refitting set and measuring their relationship to one another, all refitted lithics were assigned to one of the three refitting groups. Therefore, this method quantified the spatial relationship of lithics at the scale of the nodule.

The second method, the density contour analysis, tracks the spatial positioning of lithics at the scale of the site. For this analysis, I used the 'point density' tool located within the Spatial Analyst extension in ArcGIS v. 10.3 (ESRI, Redlands). After plotting the lithic artifacts, I used this tool to generate a raster image, visualizing the point density. When using this tool, the user must select the output cell size (i.e., the resolution at which the output is displayed) and the search radius. The search radius (or neighborhood radius) is the area around each output cell that will be used to compute the density of that area. The number of points that fall within the neighborhood is totaled and is then divided by the area. Larger search areas will result in smoother raster images, whereas smaller ones will generate a raster image with more topography. I played around with both of these parameters to get a sense of what best captured the point density and settled on an output cell size of 0.05 and a search radius of 0.5. Next, I used the 'contour' tool in Spatial Analyst to generate contours based on this raster image. I chose two of the contours that best segregated the 'high-', 'medium-', and 'low-density' parts of the site, based on how I perceived the changes in density on the raster images (playing around with the search radius also helped). I then used these contours to divide the lithic artifacts into these three groups, based on where they were located.

In the end, I had two sets of groups that roughly corresponded to one another: refitting groups 1, 2, and 3 and density groups high, medium, and low. I could then analyze the distribution of technological categories among these groups to understand how the spatial patterning was formed. At Landry, this meant that the artifacts included in this analysis (6168) differed from the total artifact count (10,098; Table 1) because I did not have technological information for every coordinated lithic. For similar reasons, some MP sites were only analyzed using one method and not the other. The assemblages at Bossuet and Cantalouette were too large to analyze each artifact; only tools were analyzed and those pieces that had been refit. Therefore, they were only analyzed using the refitting location analysis. Only a very small percentage of the assemblage at Villiers Adam could be refit (4%), and so, it was not considered in the refitting location analysis. An advantage of this large dataset was that these alterations did not undermine the study.

After forming the refitting and density groups, I assessed their statistical significance by using 95% confidence intervals. To do this, I first calculated the percentage of each technological category by group, for example, the percentage of noncortical flakes in refitting group 1. I then calculated a confidence interval around this percentage and compared it to the percentage of the total assemblage distributed among the refitting groups. If the percentage of the total assemblage fell outside of the confidence interval, the result is significant with a $p < 0.05$.

I inferred that both sets of groups tracked the knapping of lithic nodules at one spatial location and the subsequent movement of the lithics away from that location through a variety of processes. This inference was proven for the MP sites after I studied the technological composition of each group (Clark, 2016, 2017, 2019). Refitting group 1 and the high-density group were largely made up of core reduction debris (including small debris and shatter), whereas refitting group 3 and the low-density group were dominated by tools, unretouched noncortical flakes, and blades. One aim of the current study was to examine whether the UP sample demonstrated the same pattern. High-density areas do not necessarily need to be the result of lithic knapping. For example, they could be a cache of reserved blanks and unexhausted tools or a trash midden where the knapping debris was dumped.

3. Results

Each MP site had a handful of statistically significant results. Some sites were spatially coherent and displayed higher numbers of significant results. I interpreted this to be a result of longer duration occupations or occupations where the spatial organization was maintained upon repeated site visits. In other words, residents chose to knap in the same places when they returned to the site. When I put the results from the seven MP sites together, they told a generally coherent story (Table 2). Products of core reduction were predominantly found in lower-density parts of the site, and away from associated refitted material, whereas small debris, cortical flakes, core maintenance flakes, and other byproducts of core reduction were found clustered together where they were knapped. Interestingly, cores were found with the products, not with the byproducts, of core reduction.

Although the MP sample exhibited a pattern that, together, told a coherent story, there were some conflicting results especially in the technological categories that could be considered production debris. At most sites, these technological categories were over-represented in refitting group 1/high-density areas and underrepresented in refitting group 3/low-density areas, but there was some noise in this general pattern. This suggests that Neanderthals may have sometimes selected these technological categories to be used as tools. At both Bettencourt and Fresnoy, for example, cortical flakes were over-represented in the low-density parts of the sites. There was less noise in the technological categories that could be considered products of the reduction systems (e.g., Levallois flakes, blades, tools). These categories were most often found in refitting group 3/low-density parts of the site, although here too, there were a couple disagreements.

I analyzed the UP sample in the same manner as the MP sample; the results can be found in Table 3. In comparison to the MP sample, both UP sites had high numbers of statistically significant results for the density contour analysis in particular. Landry had an especially high number of significant results, and Garris II had numbers commiserate with the more spatially coherent MP sites. At both sites, small lithic debris was overrepresented in the high-density parts of the site, along with larger pieces (such as cortical flakes), implying that the spatial patterning was not affected by fluvial processes. Furthermore, the coherence of these results suggests that reorganization through geological processes played only a minor role in the spatial patterning.

In addition to a high number of significant results, the UP sites exhibited a pattern that was especially clear in contrast to the MP sample. All lithic categories that could be considered production debris were unified in their patterning for both sites. Every single significant result was over-represented in refitting group 1 and the high-density group and underrepresented for both refitting groups 2 and 3 and the medium- and low-density groups. The results for the cores and tools also told a clear story with no disagreements. However, interestingly, the two sites diverged in their patterning when it came to the potential products of the reduction system. Garris II, the Aurignacian site, exhibited a pattern that was more similar to that of the MP sites, with blades and bladelets under-represented in the high-density group/refitting group 1. Landry, the Solutrean site, however, told a different story. Blades and bladelets were found over-represented in the high-density parts of the site, indicating that these unretouched pieces were left with the reduction debris. In other words, at Garris II, as at many MP sites, unretouched pieces were treated as finished products, whereas at Landry, unretouched pieces were treated as reduction debris, and only retouched pieces were treated as finished products. At both Garris II and Landry, cores were selected in the same manner as tools, like at the MP sites.

In addition to the differences in patterning reflected in the technological categories, one of the most surprising results to emerge from this analysis is the startlingly high number of significant results found for the density contour analysis of Landry; 85% of the categories were found to be statistically significant (Table 4). We might ask whether these results can be attributed to occupation dynamics, such as those I found for the MP sites. Table 4 displays a number of indicators that can help us answer this question, including the lithic assemblage size, the percentage of significant results for the density contour analysis, and the percentage of the assemblage that was refit, along with the distribution of the refitted lithics among the three refitting groups. Together, this information can help us assess how the site structure was influenced by occupation intensity and other phenomena. Each indicator alone is difficult to interpret because it is affected by many factors. For example, the percentage

Table 2
The statistically significant results indicating either over-representation (up arrow) or under-representation (down arrow) for the seven Middle Paleolithic sites, as determined by 95% confidence intervals. Each arrow represents a statistically significant result for one site. The sites included in the density contour analysis were Le Prissé, Fresnoy, Bettencourt, La Folie, and Villiers Adam. The sites included in the refitting analysis were Le Prissé, Fresnoy, Bettencourt, La Folie, Cantalouette, and Bossuet.

General technological category	Specific technological category	High density/group 1		Medium density/group 2		Low density/group 3	
		Density contour	Refitting	Density contour	Refitting	Density contour	Refitting
Production debris	Cortical piece	↑↓↓	↑↑	↑	↓	↑↑↓↓	↓↓
	Débordant/NB piece		↓	↓	↓		↑
	Core maintenance piece	↓	↑↑			↑↓	↓↓
	Debris	↑↑↑	↑↑	↓	↓	↓↓↓↓	↓
Potential products	Flake	↓↓↓	↓	↑↑↑		↑	↑
	Levallois flake	↓↓	↓	↓	↑	↑	
	Blade	↓↓		↑		↑↓	
	Core	↓↓	↓↓	↓		↑↑↑↑	
	Tool	↓↓↓	↑↓		↓	↑↑↑	↑

Abbreviation: NB = naturally backed.

Table 3
The statistically significant results indicating either over-representation (up arrow) or under-representation (down arrow) for the two Upper Paleolithic sites, as determined by 95% confidence intervals.

General technological category	Specific technological category	High density/group 1				Medium density/group 2				Low density/group 3			
		Density contour		Refitting		Density contour		Refitting		Density contour		Refitting	
		Landry	Garris	Landry	Garris	Landry	Garris	Landry	Garris	Landry	Garris	Landry	Garris
Production debris	Cortical piece	↑	↑	↑		↓	↓			↓			
	Débordant/NB piece	↑			↑	↓			↓				↓
	Core maintenance piece	↑				↓				↓			
	Debris	↑	↑	↑			↓			↓	↓		
Potential products	Flake	↑		↑	↓	↓			↑	↓			
	Blade	↑	↓			↓	↑			↓			
	Bladelet	↑	↓			↓	↑				↓		
	Core	↓	↓	↓				↑		↑	↑		
	Tool	↓	↓		↓	↑	↑			↑	↑		

Abbreviation: NB = naturally backed.

Table 4
Various indicators that allow us to evaluate occupation dynamics and site use, including the assemblage size, the percentage of results deemed significant for the density contour analysis, the percentage of lithic assemblage that was refit, and the distribution of refitting pieces among refitting groups 1, 2, and 3. The last column displays the interpretation of occupation dynamics for the Middle Paleolithic sites. The sites are organized according to assemblage size, a commonly used rough indicator of occupation intensity.

Site name	Number of lithics	Percentage of significant results[a]	Percentage of assemblage refit	Percentage in refitting group 1	Percentage in refitting group 2	Percentage in refitting group 3	Interpretation of occupation dynamics
Le Prissé	870	24%	20%	51%	26%	22%	One occupation with background scatter
La Folie	1262	13%	38%	69%	19%	8%	One relatively brief occupation
Villiers Adam	1619	67%	4%	81%	13%	6%	Repeated occupation, but spatially segregated
Garris II	2098	56%	8%	58%	30%	13%	
Fresnoy	4270	58%	9%	51%	27%	22%	Repeated occupation in same place
Bettencourt	5729	41%	14%	58%	31%	9%	Repeated occupation in same place
Landry	10,098[b]	85%	7%	82%	13%	5%	
Cantalouette	15,404		10%	77%	14%	8%	Many short-term visits
Bossuet	15,797		5%	55%	28%	17%	Many short-term visits

[a] This was calculated by adding the total number of significant results for the density contour analysis and dividing by the number of possible significant results for the density contour analysis (e.g., at Landry, 23 of 27 technological categories in the high-, medium-, and low-density groups of the density contour analysis were found to be significant; see Table 3). Bossuet and Cantalouette were not analyzed using this method.

[b] This figure represents the total lithics greater than 2 cm excavated at Landy, but only 6168 of these underwent technological analysis and were included in this study.

of the assemblage that is refit is influenced not only by occupation dynamics, such as the number of occupations, but also by the assemblage size. I used these indicators, as well as contextual information about each site, to interpret the occupation dynamics of each MP site, presented in the last column of Table 4. I hypothesized, for example, that sites with larger numbers of lithics in refitting group 2 (displaced 1–3 m from where they were knapped) might either have experienced higher levels of postdepositional disturbance or were the result of longer-duration or repeated occupations. Both Landry and Garris II have relatively low refit percentages and, also, lower percentages of lithics in refitting group 2. In fact, Landry stands out as having the highest percentage of lithics in refitting group 1 and the lowest in refitting group 3. This might imply a very short occupation, in comparison to the other sites. Yet, when we compare Landry with a site such as La Folie, which almost certainly had a short occupation span, determined both by me and the excavators, there is little to support this conclusion. Landry's assemblage size is much larger, with numerous activities reported. This suggests that there is a level of organization present at Landry that goes beyond factors such as the number and duration of occupations.

We might ask, however, whether the high number of statistically significant results at Landry can be explained by sample size. When we compare Landry to the other sites analyzed using the density contour analysis (Table 4), it is notable that the site with the largest lithic assemblage (Landry) has the highest number of significant results, and the smallest assemblage (La Folie) has the lowest number of significant results. However, when I tested for a correlation between assemblage size and the number of significant results, there is no significant relationship between the variables (Pearson's $r = 0.57$, $p = 0.18$, $n = 7$). The size of the assemblage does play a role, however. Repeated patterns of use will produce spatial structures more easily detectable via spatial analysis. Briefly occupied sites, such as La Folie, will have a patterning that is more difficult to detect, no matter how 'organized' it may be. A site such as Villiers Adam, in contrast, has patterning that is especially easy to detect because the spatial behavior of site occupants was repeated over the course of several occupations. Even better, these reoccupations were spatially segregated, so the patterning was reinforced without becoming jumbled.

In order to compare between similarly sized assemblages (and consequentially, occupations of similar intensities), Table 5 displays the results from only Landry, Bettencourt, and Fresnoy. Here, it is notable that Landry not only has a higher number of significant results but that they also are particularly coherent and interpretable, with tools and cores following a unified pattern and all remaining categories following a pattern consistent with core reduction byproducts. Bettencourt, and especially Fresnoy, have a relatively high number of statistically significant results, but they are often in disagreement, indicating that longer-duration occupations and/or repeated occupations might also result in some jumbling of the spatial organization (see Clark, 2016 for a more extensive discussion of this phenomenon).

Together, these results suggest a highly patterned spatial structuring of lithic material within Landry. This patterning does not extend to the refitted lithics; however; the number of significant results for the refitting analysis is low. Therefore, spatial patterning at the scale of the nodule is not easily detectable, whereas the distribution of lithic pieces was highly patterned at the scale of the site. Recall that Landry has a particularly high number of lithics in refitting group 1, implying that most of the lithic debris was left where it was knapped. This could suggest that the lithic knapping at Landry was highly goal oriented, likely toward the production of points. In other words, the main objective of lithic reduction was to make finished pieces, and the resulting debris was left in place and did not move centrifugally as was seen in the MP sites (Clark, 2017, 2019). Furthermore, the density contour analysis indicates that the production of points and other products was highly organized in space, suggesting that underlying norms of behavior may have governed where these activities took place.

4. Discussion

This study demonstrates a difference in the spatial patterning of MP and UP sites by directly comparing the sites using the same quantitative methods. Many archaeologists have postulated a difference in spatial organization between these periods, but few studies have directly compared the spatial patterning. Stapert (1989, 1990) created the 'ring and sector method', which used the spatial patterning of artifacts to identify dwellings within both MP and UP sites, finding that it worked for both periods, but he did not actively compare the periods. To my knowledge, Simek (1987) is the only other published study to have directly compared the artifact patterning within MP and UP occupations using the same quantitative methods, in this case, k-means analysis. K-means is a method used often by scholars who want to identify 'activity areas' because it segregates the distribution of artifacts into spatial clusters based on both their spatial relationship to one another and their attributes (Clark, 2017). It has some drawbacks, however; it tends to focus on high-density clusters, and the identified clusters are circular and therefore do not always track real-world use of space. Nevertheless, Simek did detect some differences in patterning between the periods. The results of the study presented here, however, are considerably more robust, given that they are based on a database of nine sites, and the distribution of artifact categories can be directly compared between sites, which aids interpretation.

The two main findings of this study have different implications regarding human behavior, the first relating to the use of tools and the second to the use of space. I will therefore discuss them separately in the following sections.

4.1. Differences in tool selection

It has long been clear that UP humans invested more time and energy into the creation and maintenance of tools. This is evident simply from the greater breadth of lithic tool types and, also, the wider range of materials utilized in the manufacturing of tools (i.e., the use of bone and antler). The tools of the UP were thought to be 'specialized' in contrast to the 'generalized' tools used in the MP (Mellars, 1973, 1989; Bar-Yosef, 2002; Kuhn, 2021). However, although it was apparent that a more specialized suite of tools was crafted, it was never possible to determine which tools were selected to be utilized and whether unretouched pieces

Table 5
A comparison of the results of the density contour analysis for three similarly sized assemblages. The arrows indicate whether these groups were significantly over or under-represented as determined by 95% confidence intervals.

Technological category	Group 1 (high)			Group 2 (medium)			Group 3 (low)		
	Landry	Bettencourt	Fresnoy	Landry	Bettencourt	Fresnoy	Landry	Bettencourt	Fresnoy
Cortical piece	↑	↓	↓	↓			↓	↑	↑
Débordant/NB piece	↑			↓		↓			
Core maintenance piece	↑	↓	N/A	↓		N/A	↓	↑	N/A
Debris	↑	↑	↑				↓	↓	↓
Flake	↑	↓	↓	↓		↑	↓		
Levallois flake	N/A		↓	N/A		↓	N/A		↑
Blade	↑		↓	↓	↑		↓	↓	↑
Bladelet	↑	N/A	N/A	↓	N/A	N/A		N/A	N/A
Core	↓	↓				↓	↑	↑	↑
Tool	↓			↑			↑		
Percentage of significant results	100%	56%	63%	78%	11%	50%	78%	56%	63%

Abbreviation: NB = naturally backed; N/A = not available.

played a significant role in the tool kit. Were unretouched blades and bladelets utilized, for example? Use-wear analysis could potentially answer this question, but a systematic comparison of retouched and unretouched pieces for both the MP and UP has not been done. The spatial patterning of lithics can also give us some information about the lithics that were selected to be utilized (Clark, 2019).

The results of this study indicate that unretouched pieces were a more important part of the tool kit in the MP than in the UP. At the MP sites, unretouched pieces were often selected to be utilized. These were commonly Levallois flakes but also noncortical and even cortical flakes. In contrast, the selected pieces in the UP were more often retouched pieces. Indeed, the Solutrean site of Landry exhibited a clear patterning favoring the selection of only retouched pieces. At Garris II, unretouched blades and bladelets were also selected. This suggests a shift to more formal tools over time. However, one might also attribute the differences between Landry and Garris II to differences in site type. Garris II is located on a high-quality raw material source and likely a central goal of the occupation there was to produce blanks (Rios-Garaizar and Ortega Cordellat, 2014). In contrast, the site of Landry is interpreted as a hunting camp (Brenet et al., 2018). However, a closer inspection of these two sites questions whether it is prudent to dismiss the comparison of these two sites due to these general site-type categories. Lithic production was not the only activity that occurred at Garris II; use wear analysis indicated that hide processing also occurred on the site. Lithic production was also a main activity at Landry, and raw materials were abundant immediately adjacent to the site in the alluvial deposits and terraces of the Isle River, as well as in flint outcrops a few kilometers away. Brenet et al. (2018) report the onsite production of blades, short flakes, laurel leaf, and other points. The role of lithic production is also apparent by the assemblage size: the 10,098 coordinated lithics are all greater than 2 cm (Brenet et al., 2018). We can compare this to another potential hunting site: Régismont-le-Haut, an open-air Aurignacian site in the Languedoc region of France, where the lithic industry is dominated by consumption, i.e., tool use, rather than production (Anderson et al., 2018). At Régismont, 75% of the lithic artifacts are smaller than 1 cm, resulting in 3750 pieces greater than 1 cm as of the 2018 publication, and likely many fewer if we consider a cut off of 2 cm. Therefore, considering a site such as Régismont, Garris II and Landry appear more alike than different, especially when we remember that the methods used here generally track the spatial patterning of lithic production. Therefore, although a larger sample of UP sites is warranted, this comparison is robust enough to support a transition to more formalized tools in the UP.

4.2. *Differences in the use of space*

The second main difference between the MP and UP based on these results is the clearer spatial patterning in the UP. This is expressed in two ways. First, both UP sites, but especially Landry, have a very high number of statistically significant results for the density contour analysis. Second, both UP sites exhibit a unified pattern, whereas the seven MP sites together show a clear pattern, but disagreements are common. The only difference between Landry and Garris II is in the selection of unretouched blades and bladelets as mentioned above. This evidence seems to suggest that within the UP sites, and especially Landry, an organized pattern of behavior served to maintain the spatial structure. In MP sites, I did see evidence for habitual patterns of behavior, which helped to make the distribution of debris statistically significant. These routinized actions were especially evident at the longer duration sites, such as Fresnoy, which had higher numbers of significant results. Site occupants would routinely knap lithic nodules, and then, lithics would move away from this location centrifugally as they were selected to be utilized. These selected pieces were sometimes retouched tools and Levallois flakes, but they were also cortical and noncortical flakes. However, where the knapping occurred and where the selected pieces were moved was not highly organized at individual sites. The refitting location analysis—which tracks the spatial organization at the scale of the nodule—followed the density contour analysis very well for the MP, especially when the results from all sites were combined. The refitting location analysis almost always has fewer significant results because the sample sizes are lower. Yet, it is notable that Landry, which had so many significant results for the density contour analysis, had so few for the refitting location analysis. This suggests that the pattern of centrifugal displacement that was documented for the MP sites via the refitting analysis may not work well for the later UP, where unretouched products are unlikely to be used. The density contour analysis works surprisingly well, indicating that not only is the lithic production goal oriented but also the location of lithic production and use is highly structured.

The spatial structure of Garris II was also coherent and clear, lacking any disagreements seen at some of the MP sites. However, the percentage of statistically significant results is more in line with the MP sites rather than Landry. Landry displays an especially clear spatial patterning that appears to have formed from norms of behavior that govern the spatial organization of tool production and use. Again, we might consider whether the differences between Garris II and Landry are result of a gradual transition over time or simply differences in the way these sites were used. Even though lithic production was a primary activity at both sites, based on the assemblage size alone, Landry appears to have been a more intensively occupied site. This is supported by the number of activities present, including the intensive use of metamorphic rocks, the importation of large stones to be used as anvils, and the engraving of dolerite blocks. Therefore, a longer-duration, more intensive use of Landry might have led to an occupation that was more heavily structured by norms of behavior. It also means that certain patterns of behavior were more likely to be detected within the spatial structure. The spatial structure at Landry likely formed via standardized norms of behavior, so that waste products were systematically placed (or left) in certain parts of the site, which are consequentially very high in density, and pieces that might be used in the future (formal tools but, also, cores) were set aside in the low-density parts of the site. The low-density parts of the site are likely where other activities, such as hide processing and woodworking, occurred. Indeed, at Landry, these areas are statistically over-represented in many artifact categories not present (or present in very low quantities) at the other sites, including hammerstones, large nonmobile tools, such as anvils and grinders, incised pieces, and cobbles, many of which were broken and were likely used in cooking. These activities understandably took place away from the main bulk of knapping debris. Although a larger sample of UP and later sites is needed to flesh out these results, it seems clear that social norms of behavior may be contributing to the structuring of space at Landry, via spatially tethered routines of lithic production and use, and perhaps cleaning. This conclusion is supported by research at other open-air UP sites where evidence for cleaning and site maintenance has been documented. One such example can again be found at the Aurignacian site of Régismont, where evidence for the cleaning of hearths was found (Anderson et al., 2018). Other examples include the well-known Magdalenian sites of Pincevent and Étiolles (Taborin, 1994; Julien and Karlin, 2014).

5. Conclusions

This study revealed differences in the formation of spatial patterning within MP and UP sites. The patterning within MP sites appears to be related to routine use of space closely linked to the knapping and use of lithic material, driven by the centrifugal movement of selected pieces away from where they were knapped. The spatial organization of lithic production and use was more highly structured within UP sites, especially Landry. This was likely driven by norms of behavior related to the spatial structuring of site use, potentially in combination with cleaning behaviors. Both UP sites display a pattern that is more coherent than what I expected, given my previous studies of MP open-air sites. And though Garris II and Landry differ in their occupation intensities and the number of activities present on site, they are well within the range found in the MP sample. It is possible, given the differences between these sites, that this process may have been gradual rather than abrupt. However, without a larger sample of UP sites, with a variety of occupation intensities, it is difficult to track temporal change within the UP.

This study helps to clarify what we should be looking for when analyzing changes in spatial organization over time. We can return to the question that I posed earlier in this paper: what *is* spatial organization? A separation of activities to a certain degree (i.e., a separation between noxious activities, such carcass butchery, and sleeping areas, for example) has been traditionally used as an indication of ‘organization’, but ‘activity areas’ are difficult to identify in the patterning of artifacts, especially when we are left with only lithics. In that case, lithic production and use would obviously dominate the ‘activities’ rendered in the spatial signature. Furthermore, Binford’s contrast between ‘intensive’ vs. ‘extensive’ spatial patterning does little to help us understand changes over time because these differences in spatial patterning are more likely the result of factors other than behavioral modernity, such as site type, group site, duration of occupation, and available occupation space. If we want to identify changes in spatial patterning that reflect behavioral changes over time, it is more productive to look for indications of cultural norms governing how space should be structured. It is these cultural norms that introduce ‘spatial organization’ by teaching individuals where certain activities should be performed, where waste should be discarded, and where useful items should be stored. There is, of course, a continuum between cultural norms and habitual use based on practical considerations. For example, the decision to place a hearth near a shelter’s drip line. This decision has obvious practical considerations; the fire should be within the shelter and also well ventilated. Over time, however, the practical considerations might dim, and cultural routines might take precedent, and may get embellished with other norms of behavior. Therefore, we might expect to see the formation and then strengthening of these norms over time. This phenomenon is potentially evidenced in the changes in spatial patterning found in this study. It is also accompanied by changes in the use of lithics, from an ad hoc use of unretouched pieces in the MP to the near-exclusive use of formal tools by the Solutrean. We might also expect to see increasing symbolism related to norms of spatial organization. Over time, as cultural norms increase in strength, they might become codified in the symbolic. For example, gendered division of labor might mean that the use of space is divided based on gender because of practical concerns; because women are doing the cooking, they spend more time around the hearth. Over time, however, the cooking hearth might become symbolically ‘feminine’ such that men are barred from that space. The details of such arrangements will usually be invisible in the archaeological record, but we can look for norms of behavior that are consistent across sites within one region, for example (see Clark and Ranlett, 2022), or we can look for site use that might be ‘overly’ strict and cannot be accounted for by practical concerns only. There is more work to be done in finding ways to identify cultural norms rendered in the spatial patterning of artifacts, but this study demonstrates that this information is accessible, especially if we are able to examine and compare a larger body of sites.

Declaration of competing interest

The author declares no conflict of interest

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