Chapter 4

Testing Retouched Flake Tool Standardization During the Middle Paleolithic

Patterns and Implications

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ABSTRACT

It has long been claimed that retouched flake tools become more standardized throughout the Lower and Middle Paleolithic. Since stone tool standardization has been linked to cognitive abilities, specifically, to the presence of mental templates, the implications of an increase in standardization throughout this time period are that hominid cognitive abilities, including language, became more developed. Such an increase in standardization during this span of time has never been verified empirically, however. In addition, there is reason to question the link between lithic artifact standardization and hominid cognitive abilities. The purpose of this paper is therefore two-fold: first, to empirically test the notion that stone tools become more standardized throughout the late Middle and early Upper Pleistocene, and second, to explore potential causes of standardization more parsimonious than the deliberate imposition of arbitrary form. The results for the first part show no significant increases in standardization among retouched stone tools at three French sites spanning the late Middle and early Upper Pleistocene. The second part yields an interesting new hypothesis regarding circumstances which may lead to standardization among retouched tools, and helps explain why standardization seems to be so much more common after the start of the Upper Paleolithic.

INTRODUCTION

Most research on European pre-Upper Paleolithic stone tools over the past four decades has focused on interpreting assemblage variability and understanding flintknapping technologies. The first venture, best exemplified by the "Great Mousterian Debate" (Binford and Binford 1966; Binford 1973; Bordes and de Sonneville-Bordes 1970; Mellars 1965, 1969, 1973), has led to a better understanding of Middle Paleolithic synchronic variability (*e.g.*, Dibble 1987, 1995; Beyries 1988; Dibble and Rolland 1992; Turq 1992). The second has resulted in the identification of various flintknapping trajectories or *chaînes opératoires*, which may reflect different functions or styles (*e.g.*, Boëda *et al.* 1990; Boëda 1993; Meignen 1993). While both of these approaches have contributed a great deal to our knowledge of typological and technological patterning during this time period, diachronic variability remains remarkably poorly documented, much less understood (for exceptions, see Delagnes and Meignen this volume; Rolland 1986, 1995). One of the main reasons for this has been the lack of an adequate chronology. Now, fortunately, increased application of absolute dating techniques to late Middle and early Upper Pleistocene sites enables us to begin constructing a fairly secure, albeit rudimentary, chronological framework. As chronological resolution increases, it becomes possible to examine diachronic cultural trends across this time period. One such trend is the standardization of retouched flake tools, which has long been claimed to increase throughout this span of time. Since standardization is often argued to reflect cognitive abilities (Gowlett 1984, 1996; Mellars 1989b, 1996b; Wynn 1988; Chazan 1995; see also Marks *et al.* 2001), it is important to verify this claim. This study, therefore, was designed to test whether standardization among retouched flake tools increases throughout the late Middle and early Upper Pleistocene in Western Europe. Second, it explores the causes of standardization, and sets forth a new hypothesis regarding the circumstances which can lead to standardization in stone tools.

The notion that tool standardization increases through time has most recently been applied to the Middle to Upper Paleolithic transition (*e.g.* Mellars 1989a, 1991, 1996b; for rebuttal, see Marks *et al.* 2001). However, it has long been assumed that there is a gradual increase in standardization throughout the Lower and Middle Paleolithic as well. This idea was particularly emphasized at a conference on the Lower to Middle Paleolithic transition held in Haifa, Israel, in 1980 (Ronen 1982). At this conference, for example, Tuffreau (1982:137) characterized retouched stone tools in the Middle Paleolithic as "typologically evolved and well standardized", in contrast to those of the Lower Paleolithic, which he labeled "most of the time rough and typologically little evolved". Valoch echoed this argument, stating that "the shapes of tools were more differentiated" in the Middle Paleolithic than previously (Valoch 1982:193). Finally, Roe characterized Lower Paleolithic retouched flake tools as having "few standardized types or closely repeated shapes," and retouch which is "usually robust and purposeful rather than elegant in appearance" (Roe 1982:180). He described Middle Paleolithic flake tools, on the other hand, as "precisely designed and carefully executed, so that numerous clear types exist (*cf*. Bordes 1961a, *etc*.) and are accurately repeated. There are many different types of retouch, usually accurately and elegantly applied" (Roe 1982:180).

In other words, most participants at the Haifa conference viewed stone tools as evolving from rough precursors during the Lower Paleolithic to perfected forms by the end of the Middle Paleolithic.

Today, although few workers still adhere to a view of unidirectional cultural evolution, most still subscribe to the notion that tools became more standardized and refined through time. For example, in one of the more recent discussions of the subject, Middle Paleolithic lithic assemblages are seen as "characterized by a high proportion of standardised flake-supports and flake tools" (Gamble and Roebroeks 1999:5). In a similar vein, others have emphasized the "more carefully shaped and retouched flake tools" of the Mousterian (Gowlett 1992:353) and the "continued refinement of [its] flake-oriented toolkits" (Trinkaus 1992:349). Tattersall has stated that "the apogee of [flake-tool-making] was achieved by the Neanderthals, whose beautifully crafted Mousterian tools came in a large variety of standardized forms" (Tattersall 1995:244). Callow asserts that Mousterian flake tools are typologically more clearly defined than in preceding periods (Callow 1986:385 as cited in Hayden 1993), and Hayden claims that "classic Mousterian bifaces, points, convergent scrapers, transverse scrapers and other types exhibit degrees of standardization that probably rank among the highest of any flake industry in the world" (Hayden 1993:122). In sum, even today, many archaeologists stress that stone tools become more standardized throughout the Lower and Middle Paleolithic. For the sake of simplicity, the geological period which encompasses these cultural divisions, namely the late Middle to early Upper Pleistocene, is the chronological unit of analysis used here.

THE COGNITIVE IMPLICATIONS OF STONE TOOL STANDARDIZATION

Stone tool standardization has long been regarded as significant in human evolution because it is seen as an indicator of cognitive ability. Most frequently, the presence of standardized artifacts has been interpreted as reflecting the existence of a mental template in the minds of the flintknappers who produced the objects (*e.g*., Mellars 1989a). The notion of mental template was best described by Deetz (1967:34, emphasis mine): "The idea of the proper form of an object exists in the mind of the maker, and when this idea is expressed in tangible form in raw material, an artifact results. The idea is the *mental template* from which the craftsman makes the object." In other words, when a specific form occurs repeatedly in an assemblage, it is assumed that it represents a desired end-product manufactured according to certain socially defined parameters. These parameters result from mental categories similar to those which represent words, and are symbolic in nature (for a critique of the applicability of mental templates to stone tools, see Chase and Dibble 1987; Dibble 1989).

A similar theme emerges in Holloway's seminal paper, "Culture: A *Human* Domain" (Holloway 1969, italics in the original). Holloway's central argument is that the most important elements of culture, those which distinguish humans from other animals, are arbitrary form and the *imposition* of arbitrary form upon the environment (see also Geertz 1964). The imposition of arbitrary form, according to Holloway, can be detected in stone tools, because "there is no necessary relation between the form of the final product and the original material" (Holloway 1969:401). The shape of stone tools, therefore, is symbolic in nature, according to Holloway, and the appearance of stone tools in the archaeological record signals the emergence of modern human behavior or human culture. Holloway links stone tool-making and language by suggesting that they are "similar, if not identical, cognitive processes" (Holloway 1969:396), not only because both of these activities employ symbolization, but because they are both hierarchically organized processes that depend upon socially mediated rules. The existence and application of explicit rules such as those which define words or set the parameters for a stone tool type, according to Holloway, better accounts for the widespread temporal and spatial distribution of certain tool types, like handaxes, than simple imitative and observational learning (but see Wynn 1995).

Although many of Holloway's ideas are now outdated (for critiques, see Dibble 1989; Noble and Davidson 1991), they laid the foundation for a generation of studies which attempted to trace the evolution of human cognitive abilities on the basis of the archaeological record. For example, Gowlett (1984, 1996) has suggested that standardization among bifaces at the Acheulean site of Kilombe in Africa implies that the makers of the bifaces had a specific mental template which they imposed on the stone, suggesting a certain level of cognitive ability, specifically aptitude for mathematics and art. Another set of studies by Wynn (1985, 1988, 1991) attempts to infer the mental abilities of ancient hominids by seeking evidence in the archaeological record for Piagetian stages of cognitive development. Wynn (1988) has focused on the concept of symmetry in bifaces, which he argues is well developed by 300,000 years ago, indicating the attainment of Piaget's concrete operational intelligence stage. He has also suggested that the standardization of tool types implies that the technology was not *ad hoc* and reflects a certain level of cognitive development (Wynn 1988).

The cognitive implications of standardization and imposition of arbitrary form have been most emphasized by Mellars in relation to the Middle to Upper Paleolithic transition (Mellars 1989a, 1989b, 1991, 1996a:133–136). Mellars argues that Upper Paleolithic stone tools appear to exhibit a better-defined pattern of standardization and imposed form than do their Middle Paleolithic counterparts (Mellars 1989a). Under the assumption that the imposition of arbitrary form and standardization are linked to the presence of mental templates, he concludes that there is greater evidence for a symbolic or cognitive component behind tool-making in the Upper Paleolithic than in the Middle Paleolithic. Another study which examines stone tool standardization across the Middle-to-Upper Paleolithic transition was conducted by Chazan (1995). Chazan posits that stone tool standardization reflects the presence of language, in order to test the hypothesis that the appearance of language was one of the catalysts for the Middle/Upper Paleolithic transition. In a study of assemblages from four sites, he finds no evidence for greater standardization of debitage or selection of blanks for retouch in Upper Paleolithic assemblages and concludes that the language hypothesis for the transition is not supported (Chazan 1995). There are, however, a number of problems with his methodology which throw his results into question (see Monnier 1995).

Many of the other studies mentioned above are also flawed. Some are faulty in the sense that the perceived standardization is actually an artifact of the research methodology. For example, Gowlett interprets the Kilombe bifaces as standardized on the basis of a high correlation between biface length and width (Gowlett 1984, 1996). Another explanation for this phenomenon (observed separately by Alimen and Vignal [1952]) has been proposed by Dibble (1989). Dibble suggests that the high correlation is due to technological constraints on the shapes of bifaces (*e.g.*, it is rare that the length of a biface is ever greater than three times its width), as well as being inherent in the definition of bifaces, whereby length is always greater than width. He demonstrates that an equally high correlation between length and width can be achieved on a random series of computer-generated hypothetical bifaces, as soon as length is set to be greater than width. The apparent standardization of bifaces, therefore, when measured simply as a correlation between length and width, is largely a product of the type definition.

Another fundamental flaw in many of these studies is the strength of the hypothesized link between artifact standardization and symbolic or other cognitive abilities. For example, Chase (1991) has argued that standardization can result from functional and technological factors, and therefore does not require the use of symbols. In fact, he emphasizes that only when standardization can be demonstrated to be unrelated to function, technology, or raw material factors can symboling be inferred. In another study, Dibble (1989) has questioned the link between Bordesian artifact types and mental templates by demonstrating that: (1) there is continuous variation between some Bordesian types (specifically sidescrapers); and, 2) much of this variation represents different degrees of utilization and re-sharpening, which means that artifacts are discarded, worn-out tools rather than desired end-products. He has also shown that, sometimes, types which we consider to be "desired end-products" such as Levallois flakes, are no more standardized than types *not* considered to be "desired end-products," such as biface retouch flakes (Dibble 1989). This challenges the link between standardization and mental templates, and questions whether Lower and Middle Paleolithic stone tool types reflect linguistic categories, or merely other factors such as technology, raw material, and our own classificatory methods (see also Chase and Dibble 1987).

In sum, it is clear that the standardization of stone tools is widely believed to contain significant implications for the cognitive abilities of hominids, especially as they relate to the use of symbols and language. It is also clear, however, that there are significant problems, methodological, theoretical, or both, with many studies which have attempted to reconstruct human cognitive abilities on the basis of stone tool standardization. Despite these difficulties, assertions that retouched tool standardization increases throughout the late Middle and early Upper Pleistocene continue to be made, as described earlier. This study first explores whether standardization of retouched tools increases throughout the late Middle and early Upper Pleistocene, and second examines potential causes of standardization. The first question forms the basis for an empirical study which was carried out as part of a broader work on the Lower to Middle Paleolithic transition in Western Europe (Monnier 2000), and is reported in the main body of this paper. The second question, more theoretical in nature, is treated in the Discussion section.

SAMPLE AND METHODOLOGY

Sample

The assemblages included in this study all come from deeply stratified rock shelters in South-Central and Southwestern France: Combe-Grenal (Bordes 1972), La Chaise (Debénath 1974; Blackwell *et al.* 1983), and Orgnac 3 (Combier 1967; Moncel and Combier 1992a, 1992b; Moncel 1999). These sites were selected because they are dated by absolute dating methods, were well excavated, span long periods of time, and contain sufficiently large sample sizes. An additional advantage of this sample is that each site used to be considered transitional between the Lower and Middle Paleolithic (*e.g.*, Combier 1967; Bordes 1972; Debénath 1974), and therefore should be expected to show some of the features claimed to reflect an increase in standardization from Lower to Middle Paleolithic in the papers described earlier (*e.g.*, Roe 1982; Tuffreau 1982). Finally, at Orgnac 3 in the Ardèche region of southern France, Moncel and Combier (1992a, 1992b) have argued that retouched flake tools, especially scrapers, become increasingly standardized throughout the sequence. This study can therefore directly verify their claim.

Basic data concerning these assemblages are presented in Table 1. Only assemblages containing sufficient sample sizes were included, and sometimes similar levels were combined in order to increase sample size. In addition, the selection of assemblages at Combe-Grenal was also based on the criteria that they should be well preserved (not weathered or rolled), span a significant portion of the site's occupation, and lastly, be drawn from a variety of industrial types. At La Chaise, which is comprised of two separate but connected rock shelters, comparisons were made from the oldest levels of the Abri Suard to the youngest levels of the Abri Bourgeois-Delaunay. Although each rock shelter has its own formation history, they are connected and are very similar in technology, typology, and raw materials; therefore, they were treated as a single site.

Methodology

The first step in developing a methodology to test the hypothesis of increasing standardization of retouched stone tools throughout the late Middle and early Upper Pleistocene was the operationalization of a definition of standardization that would yield quantitative, testable implications. Next, an attribute analysis was

Table 1. Assemblages used in this study

Site	Levels	N	Dating
Combe-Grenal	22	328	O.I.S. 3 (Bowman and Sieveking 1983, Mellars 1996:39)
	35	416	O.I.S. 4 (*ibid.*)
	56–57	156	O.I.S. 6 (*ibid.*)
	58	289	”
	60–61	146	”
La Chaise (Abri Bourgeois-Delaunay)	9	245	O.I.S. 5d (Blackwell et al. 1983, Schwarcz and Debénath 1979)
	10	49	”
La Chaise (Abri Suard)	51	69	O.I.S. 6 (*ibid.*)
	52–53	77	”
Orgnac 3	1	184	O.I.S. 8 (Moncel and Combier 1992a; Moncel 1999)
	2-3	145	”
	4a–4b	101	”
	5a–6	189	”

designed on the basis of these test implications. The first objective was achieved by specifying the characteristics that a set of standardized tools is expected to exhibit (Table 2). These characteristics were derived in part from existing descriptions of features contributing to standardization, such as “the choice of specific blank forms for distinct artifact categories, the choice of different types of retouch for shaping the tools, the positioning of this retouch at specific points around the margins of the tools, and so on” (Mellars 1989b:358).

Typology and Standardization – Some Considerations

It is clear that the choice of a “set” of tools to be examined for standardization is arbitrary. Such a set could comprise all the lithic artifacts in a particular assemblage, or any subset thereof, such as debitage, retouched tools, or even a particular type of retouched tool. In this study, each set of tools, which formed the unit of analysis that was traced through time, encompasses a number of related Bordes [1961] types, such as single sidescrapers (types 9–11) or double sidescrapers (types 12–17). There are problems with the use of typology in this kind of study, however. The first is that a set of artifacts classified into a type will undoubtedly be less

Table 2. Characteristics of a set of standardized tools

1. They are similar in shape and size.
2. The type of retouch is the same.
3. The location of retouch is similar, and there is a clear separation between retouched and un-retouched portions of the tool.
4. They are often, but not always, symmetrical

variable, and thus more standardized, than artifacts outside of this type. This is because a type, by its very nature, seeks to organize a group of objects containing certain similar, predefined features. This problem is easily corrected by making within-type comparisons only, rather than comparing attributes across types.

The use of typology in within-type comparisons leads to other issues, however. The most serious is the question of whether the archaeological types correspond to the "real," or emic, types. In other words, does it make sense for us to study the patterning of standardization attributes through time within a given tool type, if that tool type does not correspond to a type that the original toolmakers would have recognized? The question of the "reality" of types and whether or not we can identify emic types is the subject of an age-old debate (Spaulding 1953; Ford 1954). Clearly we will never know whether we can identify emic types or not. This study, fortunately, is designed to test claims that standardization increases throughout the late Middle and early Upper Pleistocene, and therefore it does not need to identify emic types, but simply those types used by the archaeologists who made those claims. For this reason, it was deemed appropriate to use Bordesian types (Bordes 1961), which have been widely used in Old World Paleolithic archaeology for over 40 years.

Test Implications

The expected characteristics of a set of standardized tools listed in Table 2 were used to derive four test implications for the hypothesis that retouched stone tools become increasingly standardized throughout the Middle Paleolithic.

1. The variability in ***tool size and shape*** within a type should become more restricted from older to younger assemblages.
2. The variability in ***retouch type*** within a tool type should decrease from older to younger assemblages. For example, although a "single straight scraper" (Bordes 1961) is defined as having one edge with rectilinear scraper retouch, in practice such a scraper can have other types of retouch on it (*e.g.*, notches) and still be called a single straight scraper. A set of standardized tools would be expected to show less variability in retouch type than a set of non-standardized tools.
3. The ***location of retouch*** should become more restricted through time. In other words, it is expected that a set of standardized tools will exhibit retouch on the same portion of the tool (*e.g.*, tip, edge, both edges), and furthermore, that there will be a distinction between the working and non-working edge(s) of the tool. Younger assemblages, if they are indeed more standardized, should therefore exhibit a more consistent location of retouch (within types) than older assemblages, where retouch is expected to be more haphazard.
4. The proportion of ***symmetrical tools*** should increase through time. Symmetry is often linked to standardization and mental templates (*e.g.*, Wynn 1988, 1991; Mellars 1996b:26), and therefore it is expected that younger

assemblages should have a greater proportion of symmetrical tools than older assemblages. (There are, of course, certain tool types, such as shouldered points, which are asymmetrical yet appear highly standardized, but these are a minority.)

Attribute Analysis Design

An attribute analysis was designed in order to provide quantitative measures of standardization appropriate for application to each of the test implications described above. This was applied to all of the complete, retouched flint tools in each assemblage ("pseudo-tools", such as Bordes' "46-49" category, were not included). The tool classes included in the final analysis are the most common ones: single sidescrapers, double sidescrapers, convergent scrapers, transverse scrapers, notches, and denticulates. A key aspect of the methodology is the orientation of the tools. Each tool included in the study was oriented along the axis of the tool (with the narrower or pointed end up), rather than along the axis of the blank (see Figure 1). Since variability in blank form affects the placement of cutting edges on the tool, this method of orientation makes it more likely that standardization, if present, will be detected. Each tool was then bisected along the longest axis, and again perpendicular to this axis, in order to form four quadrants. These quadrangle lines were then used for measuring tool length and width, respectively, and thickness at the intersection of these lines, relevant to test implication 1. The quadrangle lines were also used as a basis for determining (subjectively) symmetry—longitudinal, transversal, or both—in order to address test implication 4. Test implications 2 and

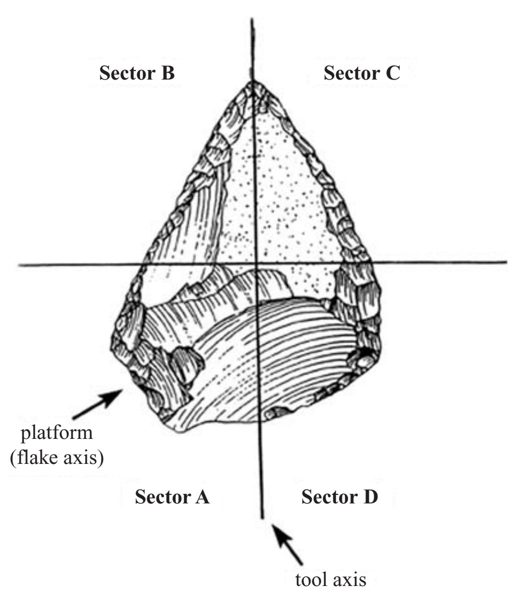

Figure 1. Orientation of Retouched Flake Tools.

Table 3. Major variables used in study

Variable	Description and Attribute States
Length	Measured by caliper along the long axis bisecting the tool (see Fig. 1).
Width	Measured at the midpoint of Length and perpendicular to it.
Thickness	Measured at the intersection of Length and Width.
Retouch Type	Denticulate, Scraper, Notched, Marginal, Abrupt, Quina, Flake, Other.
Location of Retouch	Dorsal Quadrant A, B, C, D, and/or Ventral Quad. A, B, C, D (see Fig. 1).
Amount of Retouch	For each Quadrant: 0%, 1–50%, 51-99%, or 100%. (means were used in the analyses)
Symmetry of Tool	None, Longitudinal, Transversal, Longitudinal and Transversal.

3 were addressed by noting, for each piece and for each quadrant (dorsal as well as ventral), the dominant type of retouch present and the percentage of retouch in that particular quadrant (Table 3). Clearly, retouch attributes are affected by factors such as intensity of utilization (*e.g.*, Dibble and Rolland 1992; Dibble 1995; Holdaway *et al.* 1996). This, however, does not preclude their use for identifying standardization, the causes of which could reflect intensity of utilization, function, technology, or symbolism.

RESULTS

Size and Shape

The first test implication states that variability in tool size and shape should become more restricted through time. Accordingly, we should expect the coefficient of variation (C.V.; a measure of variability which controls for sample size) of some or all of the metrical attributes (Length, Width, Thickness), as well as that of the ratios (Length/Width and Width/Thickness) to decrease from the older levels to the younger levels within a site. A certain amount of variability is always to be expected in archaeology, so no single tool type is expected to exhibit a perfect pattern of decreasing values of the coefficient of variation (C.V.) from one level to the next. However, if such a pattern is truly present within a given tool type, it is expected that at least two or three of the metrical attributes or ratios should show a *general* trend of decreasing C.V. through time. Accordingly, the results for each attribute were interpreted as significant if the C.V. for four out of five levels at Combe-Grenal, or three out of four levels at Orgnac 3 and La Chaise, decrease consistently through time: in addition, the excluded level must fall within the range of that particular attribute.

Significant patterns are highlighted in bold type in Tables 4a–c. Note that certain tool types could not be included in this analysis when sample sizes fell below five. For this reason, double and convergent scrapers at Orgnac 3 and transverse scrapers at La Chaise were excluded from the analysis. (The exclusion of certain levels in other tests also is a consequence of sample sizes falling below five.) At Combe-Grenal, none of the metrical attributes follows the expected pattern except for single sidescrapers, where the C.V. for three out of five metrical attributes and ratios (specifically, Length, Thickness, and Length/Width) shows a general decrease through time (Table 4a). At Orgnac 3, the only tool type which shows a consistently decreasing C.V. across multiple attributes (Length, Length/Width, Width/Thickness) is again single the sidescraper (see Table 4b). Finally, at La Chaise single sidescrapers are also the only tool type which exhibit a decreasing C.V. across several attributes (Length, Width, and Thickness; see Table 4c). Thus, in all three sites there is some evidence that the size and shape of single sidescrapers become more standardized through time. However, there is no evidence that standardization of size and shape for any of the other tool types increases: double sidescrapers, convergent and transverse scrapers (where tested), notches and denticulates. Test implication 1, therefore, is rejected for all tool types except single sidescrapers.

Table 4a. Coefficient of variation for size and shape attributes at Combe-Grenal (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Length	Width	Thickness	L/W	W/Th
Single Sidescrapers	22	144	**20.54**	24.83	**35.93**	**19.36**	33.87
(Bordes types 9–11)	35	248	**21.32**	23.85	**37.1**	**23.8**	38.13
	56–57	57	**20.92**	25.13	**38.41**	**24.21**	40.79
	58	125	**23.57**	24.86	**35.64**	**28.21**	35.77
	60–61	73	**28.25**	27.45	**46.13**	**21.72**	35.84
Double Sidescrapers	22	20	22.22	18.07	42.07	22.56	34.76
(Bordes types 12–17)	35	35	19.65	23.00	52.37	23.18	34.98
	56–57	6	51.99	22.28	41.48	25.45	40.23
	58	8	17.9	32.51	21.26	29.83	43.04
	60–61	7	19.77	28.15	41.68	21.69	23.96
Convergent Scrapers	22	13	26.29	13.25	34.54	25.29	46.76
(Bordes types 18–20)	35	49	17.70	20.65	32.95	20.59	31.69
	56–57	5	24.21	11.38	31.90	32.73	26.03
	58	6	17.66	14.39	51.32	17.77	45.05
Transverse Scrapers	22	84	17.30	20.61	38.40	19.39	38.24
(Bordes types 22–24)	35	51	20.34	20.56	38.56	17.10	30.53
	56–57	16	33.26	26.14	31.71	21.70	27.74
	58	40	23.36	24.56	32.08	20.62	42.56
	60–61	15	18.59	21.14	46.30	18.37	43.82
Notches	22	23	15.57	17.44	39.34	23.80	35.24
(Bordes type 42)	35	18	27.69	29.95	49.57	29.69	27.21
	56–57	24	19.11	20.31	41.27	23.91	33.59
	58	37	26.87	25.07	34.72	23.60	35.36
	60–61	14	22.45	21.16	24.18	18.50	24.61
Denticulates	22	44	18.23	18.81	35.15	21.99	38.77
(Bordes type 43)	35	15	20.74	31.43	37.12	26.17	29.92
	56–57	48	15.19	20.01	29.42	18.00	36.30
	58	73	18.55	23.57	38.44	22.48	34.98
	60–61	36	21.42	25.23	27.64	20.56	23.68

Table 4b. Coefficient of variation for size and shape metrical attributes at Orgnac 3 (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Length	Width	Thickness	L/W	W/Th
Single Sidescraper	1	68	**19.50**	29.31	38.00	**24.58**	**38.30**
	2–3	54	**25.58**	24.12	36.75	**24.74**	**40.11**
	4a–4b	26	**21.50**	23.06	32.05	**24.89**	**46.55**
	5a–6	81	**25.86**	26.52	37.97	**26.73**	**42.19**
Transverse Scrapers	1	31	20.56	20.88	38.54	**20.49**	42.60
	2–3	28	21.06	17.93	36.50	**17.98**	35.42
	4a–4b	15	18.34	44.11	45.64	**19.25**	45.43
	5a–6	36	29.60	24.20	38.11	**23.77**	32.12
Notches	1	22	26.57	20.88	38.54	20.98	42.60
	2–3	21	22.39	17.93	36.50	28.26	35.42
	4a–4b	28	24.50	44.11	45.64	26.62	45.43
	5a–6	21	22.92	24.20	38.11	25.65	32.12
Denticulates	1	38	21.50	26.62	37.22	22.18	**31.56**
	2–3	31	26.88	32.51	47.45	19.03	**38.94**
	4a–4b	27	24.69	25.00	36.22	27.54	**32.00**
	5a–6	40	25.03	24.22	45.53	23.07	**39.70**

Table 4c. Coefficient of variation for size and shape metrical attributes at La Chaise (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Length	Width	Thickness	L/W	W/Th
Single Sidescraper	B-D 9	92	**23.50**	**23.41**	**31.70**	**26.15**	32.73
	B-D 10	19	**20.57**	**23.63**	**38.48**	**31.79**	37.79
	Suard 51	29	**21.73**	**24.19**	**35.35**	**23.72**	31.05
	Suard 52–53	36	**24.21**	**29.17**	**38.62**	**34.65**	32.62
Double Sidescrapers	B-D 9	13	31.32	**17.81**	38.84	23.28	30.79
	Suard 51	11	22.58	**21.82**	19.93	21.57	18.32
	Suard 52–53	8	20.43	**32.80**	37.19	46.07	36.56
Convergent Scrapers	B-D 9	26	27.27	25.43	26.33	19.10	28.72
	B-D 10	5	11.66	18.04	22.23	17.60	14.67
	Suard 52–53	8	28.36	24.49	47.48	26.05	24.78
Notches	B-D 9	24	22.23	28.31	**31.98**	25.46	29.37
	B-D 10	10	21.76	29.83	**38.75**	18.23	25.85
	Suard 51	9	25.06	35.53	**36.62**	28.91	14.29
	Suard 52–53	11	25.02	30.24	**39.64**	24.83	25.07
Denticulates	B-D 9	62	**24.43**	24.75	**34.52**	30.78	37.26
	B-D 10	9	**20.99**	23.48	**20.57**	24.32	21.99
	Suard 51	13	**21.91**	35.42	**43.23**	20.35	27.08
	Suard 52–53	12	**29.48**	31.84	**51.50**	15.98	33.61

Retouch Type

The second test implication in this study is that if standardization increases through time, variability in retouch type within tool types should decrease from older to younger assemblages. This was tested by comparing the mean number of retouch types (other than that which characterizes the type) within each tool type from one level to the next. As can be seen in Tables 5a-b, there is no evidence that the mean number of retouch types decreases through time in any tool class at Combe-Grenal or at Orgnac 3. While it appears that double sidescrapers have a higher mean number of retouch types in levels 2-3 than in level 1 of the latter site, there is no significant difference between these means (Mann-Whitney U = 41,

Table 5a. Mean number of retouch types within tool types at Combe-Grenal (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Mean # of Retouch types	Deviation standard
Single Sidescraper	22	144	1.39	.59
	35	248	1.45	.65
	56–57	57	1.70	.76
	58	125	1.66	.73
	60–61	73	1.34	.56
Double Sidescrapers	22	20	1.25	.44
	35	35	1.69	.72
	56–57	6	1.17	.41
	58	8	1.75	.71
	60–61	7	1.29	.49
Convergent Scrapers	22	13	1.08	.28
	35	49	1.61	.70
	56–57	5	1.40	.55
	58	6	1.33	.52
Transverse Scrapers	22	84	1.35	.55
	35	51	1.49	.61
	56–57	16	1.25	.45
	58	40	1.50	.68
	60–61	15	1.20	.41
Notches	22	23	1.30	.47
	35	18	1.33	.59
	56–57	24	1.38	.49
	58	37	1.27	.65
	60–61	14	1.36	.50
Denticulates	22	44	1.34	.48
	35	15	1.87	.74
	56–57	48	1.73	.82
	58	73	1.32	.52
	60–61	36	1.56	.61

Table 5b. Mean number of retouch types within tool types at Orgnac 3 (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Mean # of retouch types	Standard deviation
Single Sidescraper	1	68	1.26	.54
	2–3	54	1.26	.52
	4a–4b	26	1.27	.45
	5a–6	81	1.26	.49
Double Sidescrapers	1	11	1.18	.40
	2–3	8	1.25	.46
Convergent Scrapers	1	14	1.21	.43
	5a–6	8	1.00	.00
Transverse Scrapers	1	31	1.23	.50
	2–3	28	1.29	.46
	4a–4b	15	1.33	.62
	5a–6	36	1.33	.63
Notches	1	22	1.32	.48
	2–3	21	1.10	.30
	4a–4b	28	1.25	.44
	5a–6	21	1.14	.36
Denticulates	1	38	1.32	.66
	2–3	31	1.26	.51
	4a–4b	27	1.19	.40
	5a–6	40	1.23	.42

n = 19, $p = 0.726$). For transverse scrapers, a pattern of decreasing mean number of retouch types from older to younger levels is not statistically significant either (Kruskal-Wallis Chi-square = 0.654, df = 3, $p = 0.884$). Finally, at La Chaise the only instance of decreasing mean number of retouch types through time is found in transverse scrapers, between levels 10 and 9 of the Abri Bourgeois-Delaunay (Table 5c). However, these means are not significantly different (Mann-Whitney U = 64, n = 33, $p = 0.743$). In sum, there is no evidence for increasing standardization of retouch type through time at these sites, and test implication 2 is rejected.

Location of Retouch

The third test implication states that the location of retouch should be more restricted in standardized tools, and that a distinction between working and non-working edges should be more evident. This was tested by several methods, according to tool type. For example, single sidescrapers, by definition, should have scraper retouch only on one edge. However, in practice, many tools classified as single sidescrapers exhibit retouch on both edges (scraper retouch opposite a

Table 5c. Mean number of retouch types within tool types at La Chaise (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Mean # of retouch types	Standard deviation
Single Sidescraper	B-D 9	92	1.87	.76
	B-D 10	19	2.26	.81
	Suard 51	29	1.93	.65
	Suard 52–53	36	1.64	.68
Double Sidescrapers	B-D 9	13	1.85	.80
	Suard 51	11	2.36	.67
	Suard 52–53	8	1.88	.83
Convergent Scrapers	B-D 9	26	1.88	.86
	B-D 10	5	1.60	.55
	Suard 52–53	8	1.75	.46
Transverse Scrapers	B-D 9	28	1.75	.75
	B-D 10	5	1.80	.45
Notches	B-D 9	24	1.50	.66
	B-D 10	10	1.50	.71
	Suard 51	9	1.89	1.45
	Suard 52–53	11	1.27	.47
Denticulates	B-D 9	62	1.76	.72
	B-D 10	9	2.44	1.33
	Suard 51	13	2.23	.93
	Suard 52–53	12	1.92	.79

notch, for instance). The proportion of such tools should be smaller in a more standardized assemblage; thus it was hypothesized that younger assemblages, if they are more standardized, should contain fewer single sidescrapers exhibiting retouch on *both* edges. Tables 6a-c show the percentage of single sidescrapers containing unilateral *vs*. bilateral retouch. For each site, the percentage of sidescrapers exhibiting only unilateral retouch is expected to rise from the older to the younger levels. There is no such pattern at any of the sites.

Table 6a. Combe-Grenal: Proportion of single sidescrapers with Unilateral vs. Bilateral retouch (significant patterns are highlighted in bold; see text)

Level	Bilateral retouch	Unilateral retouch
22	39 (27.1%)	**105 (72.9%)**
35	76 (30.6%)	**172 (69.4%)**
56–57	19 (33.3%)	**38 (66.7%)**
58	44 (35.2%)	**81 (64.8%)**
60–61	23 (31.9%)	49 (68.1%)

Table 6b. Orgnac 3: Proportion of single sidescrapers with Unilateral vs. Bilateral retouch (significant patterns are highlighted in bold; see text)

Level	Bilateral retouch	Unilateral retouch
1	12 (17.6%)	56 (82.4%)
2–3	6 (11.1%)	48 (88.9%)
4a–4b	5 (19.2%)	21 (80.8%)
5a–6	17 (21.0%)	64 (79.0%)

Table 6c. La Chaise: Proportion of single sidescrapers with Unilateral vs. Bilateral retouch (significant patterns are highlighted in bold; see text)

Level	Bilateral retouch	Unilateral retouch
Bourgeois-Delaunay, 9	47 (51.6%)	44 (48.4%)
Bourgeois-Delaunay, 10	12 (63.2%)	7 (36.8%)
Suard, 51	13 (44.8%)	16 (55.2%)
Suard, 52–53	11 (30.6%)	25 (69.4%)

We should also expect that single sidescrapers which contain retouch on ***both*** edges should become more lateralized through time. In other words, if standardization increases through time, the distinction between the working edge and the non-working edge in single scrapers should become stronger. This can be examined by comparing relative amounts of retouch between both edges. The percentage of retouch along each edge varies from 0%-100% (see Table 3). The mean difference in percentage of retouch between each edge was calculated and is presented in Tables 7a-c. This value is expected to increase from older to younger assemblages among single sidescrapers, as the working edge becomes more clearly defined. At Orgnac 3, this value appears to increase across the four major levels in single sidescrapers (see Table 7b). However, a Kruskal-Wallis test shows no significant difference between the four means (Chi-square = .341, df = 3, $p = 0.952$). At La Chaise and Combe-Grenal, the difference in percentage of retouch between edges among single sidescrapers does not increase from the older to the younger levels (see Tables 7a and 7c). In other words, there is no evidence to support the notion that single sidescrapers become more lateralized, and hence more standardized, through time.

Increased standardization of retouch location through time can also be tested on double and convergent scrapers. For these types, the mean difference in retouch amount between edges is expected to decrease through time, since more standardized double and convergent scrapers, especially the latter, might be expected to exhibit relatively equal amounts of retouch on both edges. However, as can be seen in Tables 7a-c, this is not the case at either La Chaise, Orgnac 3,

Table 7a. Mean difference in retouch amount between tool edges at Combe-Grenal (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Mean Retouch % difference between edges	Standard deviation	Coefficient of variation
Single Sidescraper	22	39	51.602	22.246	43.11
	35	76	52.467	20.718	39.49
	56–57	19	36.842	24.464	66.40
	58	44	37.784	19.344	51.20
	60–61	23	46.195	18.245	39.50
Double Sidescrapers	22	20	18.125	12.484	68.87
	35	34	23.897	21.622	90.48
	56–57	6	18.750	10.458	55.78
	58	8	12.500	13.363	106.90
	60–61	7	8.929	11.890	133.17
Convergent Scrapers	22	13	25.962	21.324	82.14
	35	49	20.408	16.672	**81.70**
	56–57	5	17.500	16.771	**95.83**
	58	6	12.500	15.811	**126.49**
Transverse Scrapers	22	41	48.781	30.208	61.93
	35	32	42.5781	24.151	56.72
	56–57	5	17.5000	18.957	108.33
	58	19	38.158	24.817	65.04

Table 7b. Mean difference in retouch amount between tool edges at Orgnac 3 (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Mean Retouch % difference between edges	Standard deviation	Coefficient of variation
Single Sidescraper	1	12	46.875	27.760	59.22
	2–3	6	45.833	21.890	47.76
	4a–4b	5	40.000	16.298	40.75
	5a–6	17	41.912	23.775	56.73
Double Sidescrapers	1	11	26.136	17.189	65.77
	2–3	8	21.875	14.562	66.57
Convergent Scrapers	1	14	26.786	13.743	**51.31**
	5a–6	7	17.857	14.174	**79.38**
Transverse Scrapers	1	24	27.083	30.766	113.60
	2–3	14	37.500	29.823	79.53
	4a–4b	5	35.000	29.843	85.27
	5a–6	17	27.206	20.839	76.60

Table 7c. Mean difference in retouch amount between tool edges at La Chaise (significant patterns are highlighted in bold; see text)

Tool type	Level	N	Mean Retouch % difference between edges	Standard deviation	Coefficient of variation
Single Sidescraper	B-D 9	47	38.398	23.226	60.65
	B-D 10	12	53.125	16.101	30.31
	Suard 51	13	46.154	26.213	56.79
	Suard 52–53	11	38.636	30.850	79.85
Double Sidescrapers	B-D 9	13	26.923	21.558	**80.07**
	Suard 51	11	17.045	16.079	**94.33**
	Suard 52–53	8	26.563	26.252	**98.83**
Convergent Scrapers	B-D 9	26	20.192	14.176	70.21
	B-D 10	5	17.500	18.957	108.33
	Suard 52–53	8	12.500	11.573	92.58

or Combe-Grenal. It could be argued, actually, that such a pattern would not necessarily reflect standardization since a set of tools could have asymmetrically retouched edges and still be highly standardized, for example shouldered points. One way that this possibility could be taken into account is by looking at the C.V. of the mean difference in retouch percentage between edges, rather than the mean itself. Even if the mean does not decrease through time, there should be less variability in the difference in retouch amount between edges among a set of standardized tools, therefore one can expect the C.V. to decrease through time. This hypothesis applies to all four scraper classes, including transverse scrapers, which often contain some retouch on the edge opposite the main scraper edge. At Combe-Grenal, the only tool type out of the four which shows a decreasing C.V. through time is convergent scrapers (see Table 7a). At Orgnac 3, the C.V. of level 5a-6 for convergent scrapers is higher than the C.V. of level 1 (see Table 7b). However, since only two levels are included, this pattern has a 50% probability of occurring by chance. At La Chaise, the only pattern out of the four tool types which agrees with the hypothesis is the C.V. for double sidescrapers (see Table 7c). In sum, there is little evidence that the way in which relative amounts of retouch are apportioned between the two edges of scrapers becomes more standardized through time. Test implication 3 is therefore rejected, as well.

Symmetry

Finally, the fourth test implication is that the proportion of symmetrical tools should increase in younger assemblages. This attribute (a subjective assessment of the longitudinal or transverse symmetry of a piece) was noted over all tools within each assemblage, rather than within tool types. Any instance of symmetry, whether longitudinal or transversal, was counted. Tables 8a-c show the proportion of symmetrical to nonsymmetrical tools in each level at Combe-Grenal, Orgnac 3,

Table 8a. Combe-Grenal: Proportion of symmetrical tools (all tool types included) (significant patterns are highlighted in bold; see text)

Level	Non-symmetrical	Symmetrical
22	239 (61.9%)	147 (38.1%)
35	288 (62.6%)	172 (37.4%)
41–42/43	21 (58.3%)	15 (41.7%)
56–57	127 (62.9%)	75 (37.1%)
58	244 (63.7%)	139 (36.3%)
60–61	107 (65.2%)	57 (34.8%)

Table 8b. Orgnac 3: Proportion of symmetrical tools (all tool types included) (significant patterns are highlighted in bold; see text)

Level	Non-symmetrical	Symmetrical
1	153 (68.3%)	71 (31.7%)
2–3	112 (63.6%)	64 (36.4%)
4a–4b	85 (63.9%)	48 (36.1%)
5a–6	168 (72.1%)	65 (27.9%)

Table 8c. La Chaise: Proportion of symmetrical tools (all tool types included) (significant patterns are highlighted in bold; see text)

Level	Non-symmetrical	Symmetrical
Bourgeois-Delaunay, 9	249 (85.3%)	43 (14.7%)
Bourgeois-Delaunay, 10	44 (72.1%)	17 (27.9%)
Suard, 51	74 (77.9%)	21 (22.1%)
Suard, 52–53	80 (83.3%)	16 (16.7%)

and La Chaise, respectively. At none of the sites is there a steady rise in proportion of symmetrical tools through time, and therefore test implication 4 must be rejected.

DISCUSSION

The purpose of this study was to test the long-standing and widely held assumption that retouched flake tool standardization increases throughout the late Middle and early Upper Pleistocene. The results of this study provide very little support for this notion. Test implications 2, 3, and 4 are rejected. Regarding test implication 1, there is weak evidence that one of the tool types, the single sidescraper, becomes more standardized through time in some size and shape attributes. This result is intriguing and certainly merits closer examination and further testing, but as such does not constitute sufficient evidence to support the notion that there is a trend towards increasing stone tool standardization during this time period. These results also reject Moncel and Combier's (1992a, 1992b) claims that retouched tools at Orgnac 3, particularly scrapers and "convergent tools," become more standardized from the oldest to the youngest levels.

The implications of these results must be considered carefully. Some might be tempted to interpret an absence of increase in standardization of tools through time as evidence that hominid cognitive abilities did not evolve throughout this time period. This reasoning, however, would be faulty since the link between standardization and cognitive abilities is tenuous, as discussed earlier. Such a conclusion could only be warranted if we could be sure that the tool types used in the analysis correspond to the mental templates of their makers. As mentioned earlier, it is virtually impossible to be certain we have correctly identified mental templates (see also Marks *et al.* 2001), especially since the variation between so many Paleolithic tool types is continuous (Dibble 1987). On the contrary, it is likely that the impression that retouched tools become more standardized throughout the Middle Paleolithic (and earlier) is an illusion, perhaps resulting from the use of old and highly selected assemblages such as those from Le Moustier, where only the clearest representatives of types have been retained, and which contain abundant examples of aesthetically pleasing, finely retouched and symmetrical tools. In fact, even a cursory inspection of the assemblages used in this study, which are by and large intact (not selected), quickly shows that the retouched flake tools do not become more "refined" or "standardized" through time. If anything, the aesthetic nature of each assemblage seems largely to be determined by the quality of the raw material in that particular assemblage, and the degree to which it was reduced.

It may also be true that there simply were no mental templates for stone tools during the Lower and Middle Paleolithic, or only very general ones (*e.g.*, "flake" *vs.* "core"). It is important to recall that the concept of the mental template was originally based upon North American prehistoric material culture (Deetz 1967), which contains ceramic technology and lithic projectile points, neither of which exists in the Lower and Middle Paleolithic of the Old World (but see Anderson-Gerfaud 1990; Shea 1997). This is significant because ceramics and projectile points, whose overall morphology is important, may be much more amenable to the concept of the mental template than Lower and Middle Paleolithic scrapers (where, I argue, overall morphology is not important). Ethnographic research has clearly shown that within the non-projectile component of lithic technology, contemporary stone-users are rarely concerned with the overall morphology of flake tools. For example, Hayden (1987) found that among contemporary Maya manufacturers of *manos* and *metates* using stone tools, the most important factors are cutting edge and raw material. Among the Aborigines of the Western Desert of Australia, edge morphology within a given functional class can vary widely, across categories that we would describe as scraper, notch, and denticulate (Hayden

1979:13). In addition, most lithic tools used ethnographically are unretouched flakes (*e.g.*, Gould 1977; Hayden 1977), and retouch is applied in order to rejuvenate edges, not to shape the overall piece. In other words, most non-projectile lithic tools are made and used "expediently", to use Binford's (1979) terminology. As summarized by Hayden, "the interest displayed by Aborigines in the modification of most stone tools is approximately equivalent to the amount of interest displayed by most people from developed societies in pencil sharpening" (Hayden 1979:16). In sum, the concept of the mental template clearly does not apply to most flake tools manufactured by contemporary Australian aborigines and other ethnographic stone tool-users.

In many Upper Paleolithic and later assemblages throughout the world (including North America) there are, however, types of tools which in whole or in part do seem to be deliberately "designed," perhaps according to some "mental template." Examples of such tools are highly symmetrical, bifacially retouched objects such as projectile points, and many types of tools made on blades and bladelets (*e.g.*, Châtelperronian and Gravettian points, Uluzzian crescents, *lamelles* Dufour, triangles scalène, geometric microlithis, *etc.*) certain drills (*e.g.*, the microdrills of the Channel Island Chumash of Southern California), and hafted endscrapers. What these tools have in common is the following property: part of the tool is dimensionally restricted in order to make a hole (such as a projectile point or drill) or fit into a hole (such as a haft or shaft). In other words, as shown ethnographically (*e.g.*, Hayden 1979), there is little need to design or shape a flake by retouch in order to accomplish tasks such as cutting, sawing, shaving, chopping, scraping, *etc.* Retouch is needed mainly to re-sharpen and rejuvenate edges, as noted above. Certain other functions, however, such as drilling or perforating, do require modification of flakes through retouch, because most flakes do not naturally have points. Thus, retouch can create a drill bit, the point of an arrowhead, or a burin. Retouch can also shape a tool for hafting, usually by modifying the portion of the tool opposite from the working edge (or tip) in order to enable hafting into a shaft that will be parallel to the application of force, such as an arrow or spear, or perpendicular to it, in the case of axes and adzes, and in composite tools such as sickles.

In sum, *it is hypothesized that whereas overall tool morphology is unimportant in the majority of tasks to which stone tools are put, certain tasks, particularly those involving perforating or hafting, do require a very specific stone tool morphology.* In other words, a mental template may well be required for hafted or perforating tools. This concept is well illustrated in the California Channel Island Chumash shell bead-making industry, which produced millions of shell beads from the mid 12th through the early 19th centuries (Arnold *et al.* 2001). The bead holes were drilled with specialized, hafted chert microdrills which were manufactured by the thousands and are extremely standardized (Arnold 1987; Preziosi 2001); however, no formal sets of tools for roughing out the bead blanks have ever been found, and it is assumed that they were chipped expediently using chert flakes or picks or whatever raw materials were on hand (Arnold, personal communication, 2003). This is a slightly different perspective on standardization and hafting than that presented by Marks *et al.* 2001; they suggest that standardization of the part of the tool that fits into a haft would have an adaptive advantage because it would be more efficient to replace (Marks *et al.* 2001:28). Here I suggest that standardization is a by-product of edge modification designed to enable a blank to fit into a haft or to create holes; in other words, the bases of a set of projectile points are standardized because their shafts are always approximately the same width, rather than they were deliberately standardized for easy replacement. But possibly these are two sides of the same coin.

Although "expedient" and "designed" tools are easily distinguished in this example, it remains to be demonstrated whether they can be identified in prehistoric assemblages on a regular basis (the term "designed" as used here is not equivalent to Binford's term "curated" [Binford 1979], since curated tools as defined by him are not necessarily designed according to a mental template, and, conversely, designed tools are not necessarily curated). To complicate matters, there is no necessary relationship between the categories "designed" and "expedient" and standardized *vs.* unstandardized. In other words, while a set of designed tools will be standardized, a set of expedient tools can be standardized as well. The circumstances most likely to produce standardization among a set of retouched tools are increasing degrees of (1) standardization of blank shape, (2) retouch of blank margins, (3) retouch of blank surfaces, and 4) similarity in size (attributes that are very similar to the "defining characteristics for a set of standardized tools" listed in Table 1). These circumstances can result intentionally from design or unintentionally simply through use and re-sharpening. Thus, certain standardized tools may have been deliberately designed either through retouch (as illustrated above) or "predetermined" through blank technology, such as Levallois points, for example. However, the final form of many other tool types may simply be the product of continual re-use and re-sharpening, leading to a much more standardized appearance at the end of their use-lives than at the beginning, according to the principles of the scraper reduction model (Dibble 1995). This fact, combined with possible pressure on raw material availability through time leading to more intensive utilization (Dibble 1988), could well be the explanation for the weak trend in increasing standardization observed among the single scrapers in this study (in test implication 1).

To summarize, using stone tool standardization as a proxy for the development of cognitive abilities is problematic for a host of reasons, including the facts that (1) most stone tools were probably *not* designed according to a mental template, and (2) standardization can result from a number of circumstances, and does not necessarily reflect the application of mental templates.

Finally, another reason why retouched stone tool standardization is not a good indicator of cognitive abilities is that the role of stone tools within the overall technological domain may well have changed throughout the Paleolithic. If the hypothesis described above, which states that stone tools are most likely to be designed when they need to fit into something, is confirmed, then the presence or absence of stone tools standardized by "design" could simply indicate the relative degree to which these functions were filled by stone tools as opposed to tools made of other materials. In other words, perforating tools such as spears were certainly made by Neandertals and earlier hominids, but these were made out of wood rather than stone (*e.g.*, the Schöningen hunting spears, Thieme 1997). Indeed, claims for hafted stone projectile points during the Middle Paleolithic (Beyries 1988; Shea 1988, 1997; Anderson-Gerfaud 1990) remain controversial (Holdaway 1989; Plisson and Beyries 1998; Boëda *et al.* 1999). It is possible that one of the differences between Upper and Middle Paleolithic technology is that stone and bone replaced wood for certain types of tools, although this is, of course, difficult to prove except circumstantially. In other words, the differences between the two periods' technologies may be due less to changes in tool types or functions than to changes in raw materials. The shift from wood to stone and bone could represent significant technological advancements, adaptations to changes in raw material availability, or simply historical contingency.

In conclusion, there are two main components to this paper. First of all, it tests the long-voiced claim that standardization among retouched flake tools increases throughout the late Middle and early Upper Pleistocene. Until just recently it has not been possible to study diachronic trends throughout this time period due to the lack of a chronology. Since standardization has long been linked to hominid cognitive abilities, it was deemed important to (1) verify the claim that standardization increases over time, and (2) examine the strength of the link between standardization and cognition. The first goal was accomplished by studying the retouched tools from three well-excavated, deeply stratified, and absolutely dated sites in France. Numerous different measures of standardization revealed no significant increases in standardization through time. It is concluded that the impression that flake tools become more standardized through time is misguided and is ultimately based upon outdated notions of progressive cultural evolution, compounded by the use of old collections which are highly selected, and therefore portray later Mousterian assemblages as more uniform than they really are. Scraper frequencies do increase throughout the time period included in this study (Monnier n.d.), and may become more reduced through time, which may also contribute to the impression of greater standardization and "clarity" of types. The second objective was based on a more theoretical approach which tries to determine why standardization, and specifically the concept of the mental template which links stone tool morphology to cognitive abilities, is so difficult to identify prior to the Upper Paleolithic. The paper makes a functional distinction between everyday or "expedient" tools, and projectile points and other types which are designed in order to create a hole or to fit into a haft. It is hypothesized that the overall morphology of most expedient lithic tools is unimportant (a claim supported by extensive ethnographic studies), whereas the morphology of tools designed to perforate and/or to fit into a haft has significant functional constraints. In other words, prehistoric flintknappers may not have needed a mental template for expedient tools, but did need one for perforating/hafted tools. There is inconsistent evidence for stone perforating or hafted tools prior to the Upper Paleolithic, as mentioned earlier. Mental templates for stone tools may simply not have existed prior to the Upper Paleolithic, and, hence, there can be no standardization based upon mental templates prior to that time period.

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