Middle Palaeolithic Scraper Morphology, Flaking Mechanics and Imposed Form: Revisiting Bisson's 'Interview with a Neanderthal'

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Bisson (2001) proposes that imposition of form in Middle Palaeolithic scrapers can be recognized when the rules for scraper manufacture, which are based upon functional considerations, are known. He derives these 'scraper production rules' on the basis of experiments with novice flintknappers, and finds that they apply to Neanderthal-manufactured Mousterian scrapers. He interprets the violation of these rules in scrapers from Skhul Cave as evidence that anatomically modern humans imposed form on their stone tools, and therefore had mental templates. This study provides evidence that the 'scraper production rules' are not, in fact, the rules according to which Neanderthals made their tools. Instead, they reflect flaking mechanics and elements of Bisson's experimental design rather than any functional considerations taken into account during scraper manufacture. Furthermore, methodological flaws in Bisson's analysis of Middle Palaeolithic artefacts undermine his arguments that archaeological scrapers either follow or violate the rules. These problems render untenable his conclusion that Neanderthals did not have mental templates and that they lacked flexibility and innovation in stone-tool making.

In 'Interview with a Neanderthal: an experimental approach for reconstructing scraper production rules, and their implications for imposed form in Middle Palaeolithic tools' (Bisson 2001), Bisson proposes the existence of two scraper production rules which characterize the initial retouch episodes of Middle Palaeolithic scrapers. These rules reflect 'the need to create a suitable working edge, and to locate that edge to maximize ease and comfort during manufacture and use' (Bisson 2001, 165). The cognitive implications of these rules, according to Bisson, are that they reflect the process of flintknapping without imposition of form or underlying mental templates. His data show that Middle Palaeolithic assemblages adhere to these rules, suggesting that Neanderthals did not have mental templates for scrapers. However, the rules are violated in an assemblage produced by anatomically modern humans, evidence that modern humans imposed form on their retouched flake tools rather than being constrained by the scraper production rules, and therefore *did* have mental templates.

Bisson's paper is thought-provoking and well researched. His attempt to discover 'rules of scraper production', in many ways a refinement of Dibble's model of scraper reduction (Dibble 1987; 1995), is innovative. He is also to be credited for designing a testable, replicable experiment and for his insightful focus on tool edges rather than overall tool shapes. Unfortunately, there are a number of problems concerning his methodology and underlying assumptions. The following critique will argue that: 1) Bisson's scraper production rules reflect flaking mechanics and elements of the experimental design, rather than Neanderthals' functional needs; 2) methodological flaws in his analysis of Middle Palaeolithic tools undermine his arguments that archaeological scrapers either follow or violate these rules; and 3) Bisson's assumption that novice flintknappers are analogues for Neanderthals is inappropriate. Finally, this article will address some of the theoretical issues concerning uses of the concepts of mental templates and imposition of form.

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Mental templates and imposed form

The question underlying Bisson's study is 'to what extent are the workings of the Neanderthal mind reflected in the forms of their lithic artefacts, and does this differ from the patterns produced by anatomically modern *Homo sapiens*?' (Bisson 2001, 166). The key to this problem, he suggests, lies in the notion of imposed form, which he defines as the deliberate creation, in a raw material, of a specific shape dictated by a mental template. The terms 'mental template' and 'imposition of arbitrary form' are interrelated concepts which have been widely used since their introduction in archaeology in the 1960s (e.g. Deetz 1967; Holloway 1969; see Monnier 2006a for a summary). The notion of imposition of form was first used by Ralph Holloway when he defined culture as 'the imposition of arbitrary form upon the environment', citing a similar definition by Geertz (1964, in Holloway 1969, 395). Holloway suggested that the imposition of arbitrary form can be detected in stone tools because 'there is no necessary relationship between the form of the final product and the original material' (Holloway 1969, 401), concluding that stone tool shapes are therefore symbolic. However, this notion has been debunked by Chase, who pointed out that 'the "arbitrary" in "imposition of arbitrary form" means something quite different from the "arbitrary" in "arbitrary relationship between a symbol and its referent"' (Chase 1991, 196). Nevertheless, many archaeologists continue to use the concepts of imposition of arbitrary form and mental templates to reconstruct cognitive abilities. Mental templates in particular are assumed to be related to the presence of language and symbolism. Mellars, for example, has suggested that Upper Palaeolithic retouched tools show a higher degree of standardization, imposed form, and 'more clearly conceived' mental templates than Middle Palaeolithic retouched tools (Mellars 1989a, 365).

While Mellars focuses on the overall shapes of tools, Bisson suggests that imposed form may exist at the level of the edge rather than of the tool: 'imposed form could potentially be present if, as Bordes assumed, hominids deliberately chose to position retouch in an arbitrary manner relative to flake landmarks' (Bisson 2001, 168). In order to identify imposed form on tool edges, he argues that 'we must first determine the patterning, if any, that governed the manufacture of Middle Palaeolithic scrapers, what might be called their "production rules"' (Bisson 2001, 168). He therefore designs an experiment in which undergraduate flintknappers are used as analogues for Neanderthals, in order to discover the decision-making processes used in the manufacture of Middle Palaeolithic retouched flake tools.

Rules of scraper production

By using undergraduates unfamiliar with stone tools or stone tool-making, Bisson attempts to create 'a situation analogous to the production of tools in a technological tradition where the final form of a tool is not dictated by a mental template' (Bisson 2001, 170). In other words, he assumes that both Neanderthals and modern human novice flintknappers lack mental templates for lithic scrapers. He begins his experiment by training twelve undergraduates in scraper manufacture, demonstrating how to create continuous retouch on the exterior surface of a blank. He then has each student make three single scrapers each, asking them to 'retouch a single edge to make it uniform enough to either scrape dry hide or plane wood' (Bisson 2001, 170). After studying the resulting 36 scrapers, he concludes that they tend to follow two rules: 1) the platform and adjacent edges with 90 degree angles are left intact; and 2) the longest, most acute edge is retouched first. Based upon interviews with the subjects, he interprets these results as reflecting 'the need to create a working edge suitable for the task or tasks to be performed, and the need to situate that edge on the blank in a manner consistent with the greatest ease and comfort during both manufacture and use' (Bisson 2001, 180). He applies these rules of scraper production to assemblages from the Garrod and Ami collections housed in the Redpath Museum, and finds that they are followed 75–82 per cent of the time.

It is contended here[1] that these rules do not represent flintknappers' needs for comfort or designs for suitability and efficiency. Instead, as will be shown below, Rule 1 merely reflects the limits of stone fracture mechanics — i.e. the physical impossibility of removing a flake from a platform whose angle exceeds 90° (Dibble & Whittaker 1981; Whittaker 1994, 91). Rule 2, on the other hand, reflects Bisson's experimental design, since students had to manufacture scrapers under rigid guidelines: they could make them only on the exterior surface, along a single edge, and retouch had to be continuous rather than serrated. Thus, when Bisson identifies the 'need to create a working edge suitable for the task or tasks to be performed,' these are actually the instructions he gave the students, not their independently reached conclusions.

In order to test whether Rule 1 reflects flintknappers' need for comfort and ease during prehension or simply the limits of flaking mechanics, an experi-

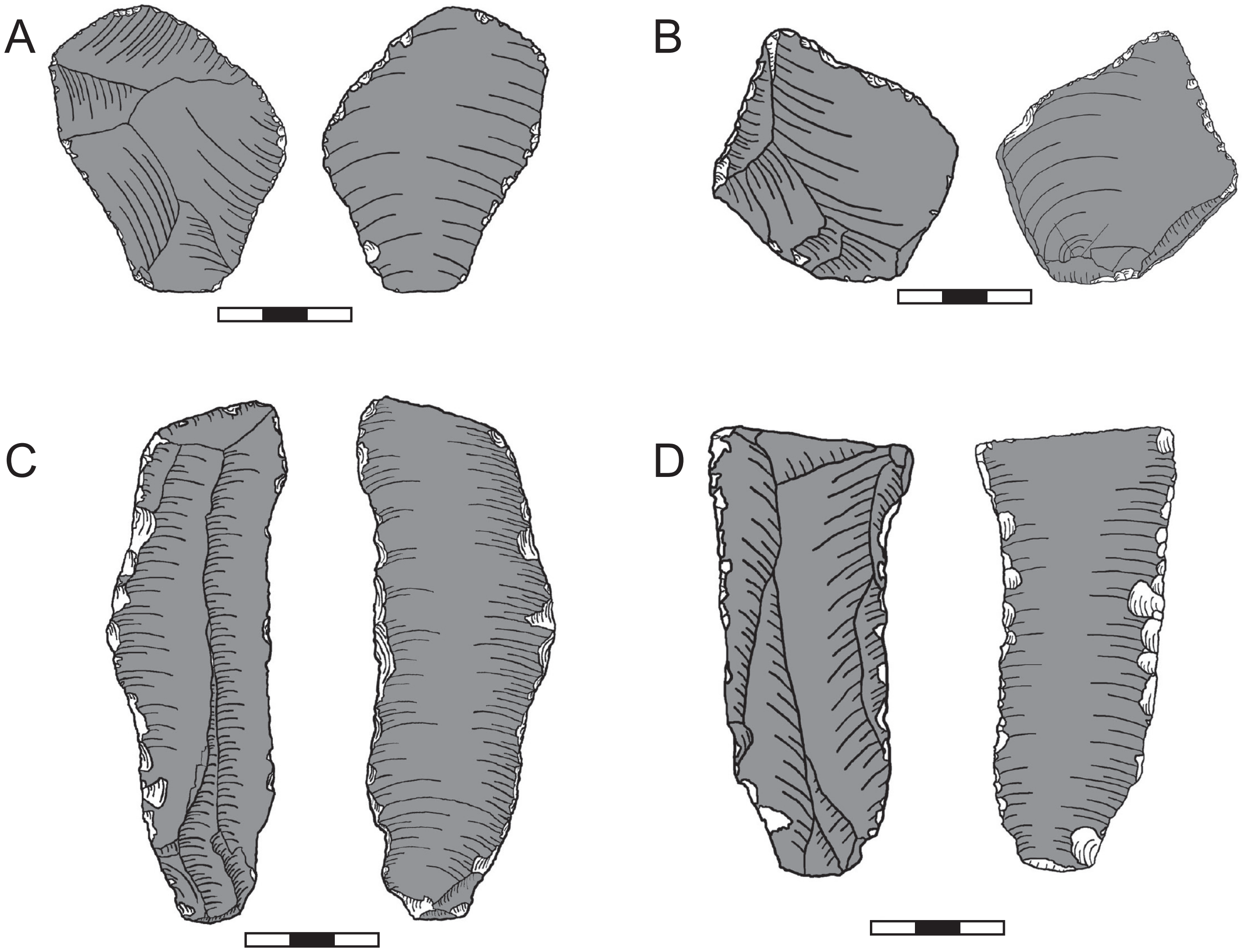

Figure 1. *Examples of retouch created in the rock tumbler (tumbler-induced retouch is indicated by areas left unshaded).*

ment was designed to replicate Bisson's experiment as closely as possible, but without the human element. In other words, retouched tools were created by machine, which avoids the problems inherent in using humans, who already have some ideas regarding what scraping or cutting tools look like (even if they have no knowledge of stone tools), and in teaching them how to knap, which may unwittingly bias the results. Seventy-eight experimental Dacite and Novaculite (both siliceous, conchoidal-fracturing raw materials with physical properties similar to flint and chert) flake and blade blanks were spray-painted with a bright orange-coloured paint on all surfaces in order to make instances of retouch obvious. Each blank was labelled and divided into discrete 'edges' using Bisson's method. After initial observations were recorded, such as size, weight, and edge angles, each blank was placed, individually, in a seven-inch diameter rotary drum rock tumbler with two hammerstones (one of quartz, weighing 315 grams and one of granite, weighing 270 grams) for five minutes. Initial experimentation showed that this was the ideal length of time and number of hammerstones necessary to produce segments of continuous, scraper-like retouch. Shorter times or fewer hammerstones did not result in enough retouch; conversely, longer times in the tumbler resulted in the blank having an increasingly 'rolled' appearance. After the tumbler was run for five minutes, each blank and the chips which had been flaked off in the tumbler were removed, and the retouched blank was again measured and weighed. As can be seen in Figure 1, the retouch on these blanks is marginal although sometimes surprisingly continuous (e.g. Fig. 1, item B) and usually occurs on both faces. Thus, although the tumbler did not produce classic Mousterian scrapers, it did produce retouched blanks with a variety of retouch types and locations. Furthermore, the retouch was applied entirely mechanically. Therefore, the tumbler-retouched tools are a good analogue for Bisson's novice-manufactured scrapers

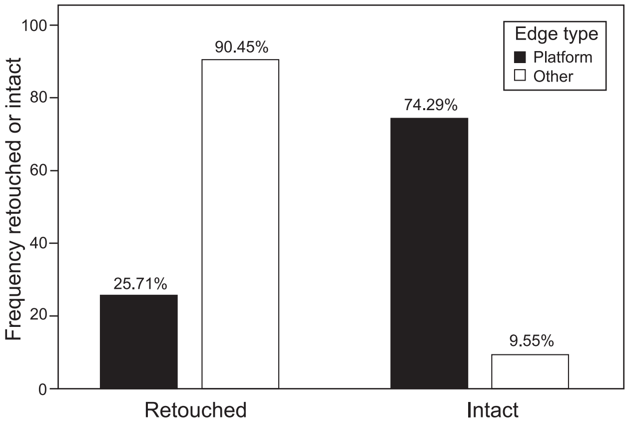

Figure 2. *Percentages of platform versus other edges retouched in the rock tumbler.*

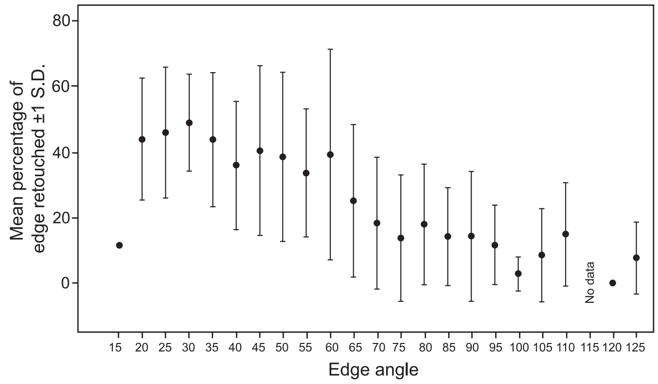

Figure 3. *Relationship between edge angle (measured prior to retouch) and average portion of edge retouched in the rock tumbler.*

Table 1. *Proportions of platform versus non-platform edges that were retouched in the rock tumbler experiments (Fisher's exact test,* p *<0.000).*

	Platform edge	Non-platform edge	Total
Retouched	18 (25.7%)	161 (90.4%)	179 (72.2%)
Unretouched	52 (74.3%)	17 (9.6%)	69 (27.8%)
Total	**70 (100%)**	**178 (100%)**	**248 (100%)**

Table 2. *Average percentage of edge that was retouched in the rock tumbler, for a given edge angle.*

Edge angle (degrees)	N	Mean percentage of edge retouched	Std deviation
15	1	11.70	n/a
20	14	43.98	18.67
25	20	46.01	19.97
30	22	49.03	14.85
35	18	43.93	20.39
40	18	36.02	19.57
45	10	40.47	25.91
50	20	38.67	25.75
55	8	33.66	19.51
60	13	39.44	32.21
65	9	25.15	23.17
70	12	18.44	20.13
75	19	13.76	19.27
80	10	18.08	18.40
85	9	14.45	14.93
90	14	14.42	19.86
95	5	11.79	12.12
100	3	2.96	5.13
105	9	8.70	14.23
110	4	14.96	15.72
120	2	0.17	0.24
125	2	7.78	11.00
Total	**242**	**30.86**	**24.27**

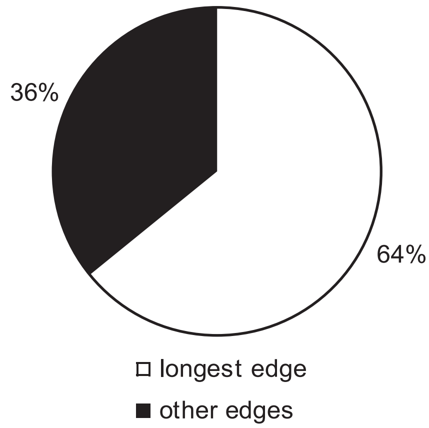

Figure 4. *The longest edge was the most retouched 64% of the time (N = 78).*

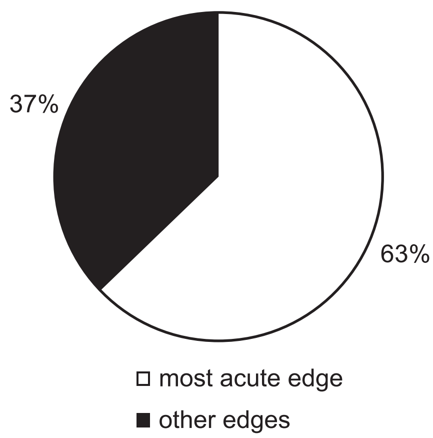

Figure 5. *The most acute edge was the most retouched 63% of the time (N = 78).*

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without the confounding elements of teaching and preconceived ideas.

The location and amount of retouch on the tumbler-retouched tools were measured precisely: each tool was digitally photographed, and the length of retouch on each edge was measured using ImageJ (NIH imaging software). This enabled the calculation of percentage of retouch on each edge (length of retouched segment(s) relative to total length of the edge).

The results of the rock-tumbler experiment show that non-platform edges were retouched[2] 90 per cent of the time, whereas platform edges were retouched only 26 per cent of the time (Fig. 2, Table 1). In other words, platforms were left *un*retouched in the rock-tumbler experiments 74 per cent of the time, almost as frequently as they are in Bisson's archaeological assemblages (83–90 per cent, from Table 2 in Bisson 2001). This reflects the unsuitability of edge angles approaching 90° or more for retouch, whether by humans or by random collisions with a cobble. The mean exterior edge angle of platforms was 79.9° (N = 70, s.d. = 21.0), whereas the mean edge angle of non-platform edges was 47.7° (N = 178, s.d. = 23.0). Further confirmation is seen in Figure 3 and Table 2, which show that edges whose angles are greater than 90° generally have less than 10 per cent retouch.[3]

The same experiment was also used to test Bisson's Rule 2. The results show that the longest edge exhibits the greatest percentage of retouch 64% of the time (Fig. 4), while the most acute edge had the greatest amount of retouch 63% of the time (Fig. 5). These frequencies are significantly higher than would be expected if each edge, regardless of length or acuteness, were retouched with approximately the same frequency (there are usually 3–4 'edges' per blank in the sample used in this experiment). In other words, the longer edges are more likely to be retouched than shorter edges simply as a result of probability. Further evidence for this can be seen in the high correlation between edge length and length of retouch ($r^2 = 0.69$, $p = 0.000$, $N = 178$: see Fig. 6). The results of the rock tumbler experiments therefore show that Bisson's rules of scraper production reflect flaking mechanics (Rule 1) and probability (Rule 2), in addition to an experimental design which biased the results.

Archaeological assemblages' adherence to the rules

Bisson tests archaeological assemblages for adherence to the scraper production rules by studying scrapers from the Ami and Garrod collections in the Redpath Museum at McGill University, and an additional assemblage from Jelinek's excavations at Tabun Cave.

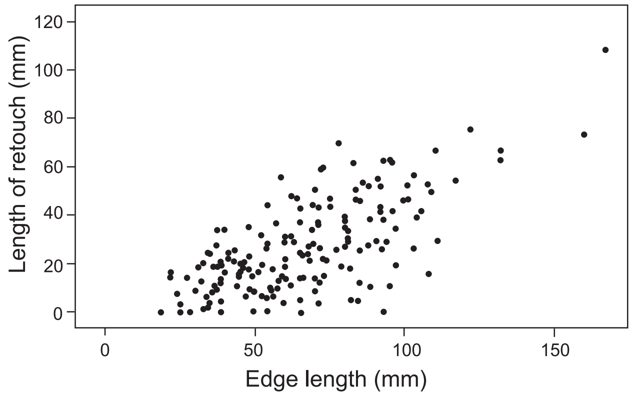

Figure 6. *Positive correlation between edge length and length of retouch* ($r^2 = 0.69$, $p = 0.000$, $N = 178$).

His reliance on the Ami and Garrod collections is problematic, however, because of unknown bias in the composition of these collections. Even though Bisson argues that selection bias is not an issue because he studied 'all available examples of only one tool class, the scrapers' (Bisson 2001, 172), the fact remains that the scrapers included in these collections were determined by Ami and Garrod to be scrapers, and therefore reflect the *excavators'* mental templates. We do not know, for example, if a scraper with a thinned platform would have been included in these collections, which were distributed worldwide as 'representative' samples from their respective sites. The only truly accurate way of testing Rule 1 would be to use all retouched artefacts exhibiting scraper retouch in an assemblage, regardless of their typological assignations. Bisson could apply such a method to the Tabun material from Jelinek's collections, which were included in his analysis and which are presumably complete. In sum, there is an unknown bias in these collections which make them unsuitable for determining whether or not the scraper rules are really followed.

In regards to Rule 2, Bisson claims that in these same archaeological collections the longest, most acute edge is retouched first. However, the assessment of edge angle and length is carried out *post hoc*. In other words, there is a high probability that both edge angle and edge length have changed through retouch, and that these measures, when taken on an already retouched piece, are simply not accurate reflections of the original edge angle and edge length.

Finally, taphonomic factors in the case of Skhul B1 are important and cannot be ignored. Bisson states that the assemblage from B1 is heavily patinated; his illustrations show that many of the pieces are damaged, exhibiting chipping on both interior and exterior surfaces. Therefore, post-depositional damage may

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have affected observed retouch patterns, and possibly the composition of the assemblage, as well.

Rule violations at Skhul B1

The assemblage from Skhul B1 ($n = 31$) is an interesting one because, according to Bisson, it violates both scraper production rules: both rules together are followed only 45 per cent of the time.[4] To illustrate the violation of Rule 1, Bisson shows several pieces with evidence of platform removal from the interior surface of the blank. These results are not comparable to those from his experiment, however, because the undergraduates were trained to retouch blanks on the exterior surface only. Had they been permitted to retouch the interior surface, they may well have retouched the platform.[5] Therefore, the presence of interior platform retouch on the Skhul B1 scrapers does not constitute a true violation of Rule 1, and Bisson's conclusion that the *Homo sapiens* flintknappers at Skhul were imposing form upon their tools cannot rest on these data.

Bisson also claims that Rule 2 is frequently violated (26 per cent of the time), because the more obtuse edges of scrapers sometimes are more intensely retouched than acute edges (although he does not define how he measured intensity of retouch). The problems inherent with estimating original edge angles on retouched edges discussed above apply in this case, too. We simply cannot reconstruct what edges looked like prior to retouch, therefore we cannot know whether the longest and most acute edges were retouched first (and/or most intensively).

In sum, Bisson does not provide convincing evidence that the archaeological assemblages he studied either follow or violate the rules he identified in his experiment with novice flintknappers. His data show that most of the time, platforms are not retouched, which probably reflects the difficulty of retouching an edge whose angle equals or exceeds 90°. When platforms *are* retouched in archaeological assemblages (as they are in the case of Skhul B1), they are usually retouched on the interior surface, which he did not permit the novice flintknappers to do. Secondly, whereas he uses the original edge angles (prior to retouch) to derive Rule 2, archaeologically he has no choice but to measure edge angles *post*-retouch. The two measures are not the same thing, and therefore this rule as stated cannot be applied to archaeological assemblages.

Undergraduates as Neanderthals

Another problem with Bisson's work consists in his analogy of novice flintknappers with Neanderthals. He explains the analogy by stating that he wanted to 'investigate the decision-making processes used to create simple flake tools in the absence of a cultural tradition … a situation in which imposed form was not inherently present' (Bisson 2001, 169). This argument rests upon two problematic assumptions. The first is that novice flintknappers lack cultural constructs affecting their tool-making behaviour. Regardless of their inexperience with stone tools, such novices can never be a *tabula rasa* for stone tool making. This is because modern humans have definite ideas concerning scraping and cutting tools, even if they have no knowledge of stone tools. In addition, as discussed above, the students were given quite a bit of information during training sessions. They had definite goals and ideas in mind when it came time to produce the three scrapers which were the object of the experiment.

Bisson's second problematic assumption is that Neanderthals were part of 'a technological tradition where the final form of a tool is not dictated by a mental template' (Bisson 2001, 170). Not only does this largely assume what he is, in effect, trying to test (the degree of imposition of form in Neanderthal versus modern human-manufactured scrapers), but it also illustrates the failure to realize that the mental templates being discussed are *our own*, rather than the artefact makers'. In other words, as archaeologists we have recognized certain patterns and shapes among artefacts that we *assume* reflect the mental templates of their makers. It is highly unlikely, however, that we have identified emic mental templates. Moreover, the extent to which the form of any artefact is the direct result of the imposition of a mental template on a raw material can be questioned (cf. Ingold 2000).

Re-visiting imposed form and mental templates

The terms 'mental template' and 'imposition of arbitrary form' have long been used in Palaeolithic archaeology in order to make cognitive and cultural interpretations related to aspects of stone tool morphology. As mentioned earlier, these terms began to be explicitly used in archaeology in the 1960s. In 1967, Deetz introduced the notion of the 'mental template' as an idea regarding the proper form of an object which is then expressed in a raw material (Deetz 1967; Monnier 2006a). In 1969, Holloway introduced the notion of 'imposition of arbitrary form', defining it as an arbitrary relation between the form of the final product and the original material (Holloway 1969). This, he argued, was a defining feature of human culture. It is suggested here that both of these concepts, which together suggest that humans visualize an object in their minds first, then impose this

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mental template on the material as they make an object, are unverified assumptions of how the mind works, and ignore the processes of interaction between mind, motor behaviour, and matter.

For example, Holloway's 'imposition of form' does not actually separate human behaviour from that of other animals, since many animals and insects (who lack 'minds') are able to transform raw materials into objects whose final forms bear no relation to the original. A prime example is the transformation of nectar and pollen into honeycomb by bees. Coventry & Clibbens (2002) make a similar point regarding spider webs, and note that different cognitive abilities are not implied by the ability of different species of spiders to spin webs with varying degrees of geometric sophistication. In other words, transforming a raw material into a final product whose shape bears no relation to it does not require a mind.

Yet the concept of imposition of form has frequently been used to highlight cognitive differences between human populations (Bisson 2001; Mellars 1989b; 1991; 1996). For example, Mellars has discussed a number of differences between Middle and Upper Palaeolithic lithic technology as part of a focus on the archaeological patterns surrounding the emergence of modern humans (Mellars 1989b; 1991; 1996). Specifically, he has applied the concept of the imposition of form to the relationship between blanks (the raw material) and retouched tools (the final product). He has suggested that in early Upper Palaeolithic Châtelperron points, effort was expended to reduce the original blanks in order to achieve a deliberately standardized form that bears no relation to the original blank shape, as compared with Mousterian backed knives in which marginal retouch does not affect the original blank shape (Mellars 1989b). He stresses that 'this element of standardization and imposed form goes beyond any purely functional or utilitarian requirements of the tools, and must necessarily imply some symbolic concept of individual tool forms' (Mellars 1996, 382). However, Mellars's argument can be faulted on the basis that there is no actual *evidence* that Châtelperron points are standardized 'beyond any purely functional or utilitarian requirements'. In fact, standardization can result from many factors, including reduction and raw material utilization, as has frequently been pointed out (e.g. Chase 1991; Dibble 1989; Monnier 2006a; Nowell 2002; Marks *et al.* 2001). A possible, though unproven, source of the standardization observed among Châtelperron points could be hafting, which is likely to result in morphological standardization among a set of tools hafted for the same purpose (Marks *et al.* 2001; Monnier 2006a).

Mellars therefore implicitly links the observed standardization among Châtelperron points to cognitive factors as revealed through the imposition of form. A related concept is that of symmetry, which is also seen by some as deliberately imposed during stone tool manufacture. In a recent article, Wynn (2002, 426) asserts that the symmetry of Acheulean handaxes is intentional (therefore imposed) and reflects the evolving spatial abilities of humans between 1.5 mya and 300,000 years ago. Specifically, he argues that symmetry must be intentional on the basis of the following points:

1. three-dimensional symmetry is common at sites with high-quality raw materials;
2. there is evidence for the production of handaxes as finished artefacts at some sites (e.g. Boxgrove);
3. handaxe edge retouch sometimes seems to mirror the opposite edge; and
4. modern flintknappers assert that handaxe shapes are intentional.

None of these arguments constitute sufficient evidence that symmetry was *imposed* upon the raw material, however, rather than being the byproduct of other factors such as function, raw material use, and resharpening (see Nowell 2002). In other words, symmetry, like standardization, can result from more parsimonious factors than the deliberate imposition of form. As stated by Welshon (2002), motor behaviour underdetermines intentional explanation, or more simply, there is more than one valid explanation of patterns interpreted as intent (in this case, imposition of symmetry) for a given flintknapping behaviour.

Another way to say this is that there is more than one valid explanation for the morphology of a stone tool. This point can be illustrated using Hayden's useful analogy between stone tool retouch and pencil sharpening: 'the interest displayed by Aborigines in the modification of stone tools is approximately equivalent to the amount of interest displayed by most people from developed societies in pencil sharpening' (Hayden 1979, 16). If one were to make a study of contemporary sharpened wooden pencil tips, it would appear that they are symmetrical, standardized, and show imposed form. This has not always been the case, however. A historical study of pencil sharpening would show that since the invention of wood-encased pencils in the late sixteenth century until the invention of the first mechanical pencil sharpeners towards the end of the nineteenth century (Early Office Museum 2007), the tips of most pencils were roughly shaped and not perfectly symmetrical, since they were hand-whittled using pen knives. The development of mechanical and electric pencil sharpeners has resulted in much more finely sharpened pencil tips with a greater degree of symmetry and standardization. Thus, a diachronic study of pencils would show increasing degrees of symmetry and standardization through time, although synchronic differences would emerge at any given point in time, due to variability in pencil sharpening styles and instruments. However, none of these differences reflect cognitive abilities of any kind — human cognitive capabilities have not changed in the last 400 years, although technology certainly has. Thus the changes in pencil tip symmetry and shape through time reflect changes in technology — not changes in spatial abilities, mental templates, or endowment of pencil tips with symbolic content. A person's intent when sharpening their pencil is to expose the lead so it can be used for writing; the symmetry of the point is purely a byproduct of the sharpening process. The same is probably true of Middle Palaeolithic stone tools like handaxes: did handaxe makers impose symmetry on the handaxes, or is symmetry simply the byproduct of maintaining a point and sharp edges (McPherron 2000; White 1995)?

In sum, the assumption that symmetry, standardization, or other aspects of lithic morphology can only result from the imposition of form is the central problem underlying current usage of these terms. A radical shift in perspective is proposed as follows: retouched lithic tool morphology is not the result of the imposition of mental templates, but rather of the complex interplay between the material, the mind (which performs complex geometrical and mechanical calculations), and the knapper's motor behaviour. This perspective stems from Ingold's (2000) recent essay on the relationship between artefact form and mind. Ingold draws a parallel between artefacts and organisms, showing that in neither case does the form reflect the application of a design or blueprint (genetic, in the case of organisms). Rather, the form of artefacts and organisms are the result of the *process* by which they are made, or (in the case of organisms) grow. For example, he observes that the distinctive spiral of gastropod shells is the result of the process of growth by deposition, not the copying of a genetic blueprint. In other words, genes code for the process of growth of the gastropod, not its final form. Similarly, Ingold suggests that the highly regular spiral pattern of coiled baskets is the result of the way in which they are *made* (the bending and coiling of material), rather than the result of the application of a *design*:

> The equable form of the spiral base of the basket does not follow the dictates of any design; it is not imposed upon the material but arises through the work itself. Indeed the developing form acts as its own template. (Ingold 2000, 345).

In other words, the final form of an object does not exist in the maker's mind; the artefact is 'the crystallisation of activity within a relational field, its regularities of form embodying the regularities of movement that gave rise to it' (Ingold 2000, 345).

By adopting the perspective that artefact forms in general, and lithic tools in particular, are the result of the processes by which they are made, rather than the imposition of preconceived ideas, many of the problems discussed earlier are resolved, such as how to distinguish emic from etic mental templates and whether to focus on the overall shapes of tools or specific attributes. This perspective also enables us to get out of the business of trying to guess what was in people's minds, and allows us to focus on how things were made. In other words, technological processes (such as length and complexity of steps in a series of flintknapping operations) can be traced and documented, as opposed to the putative existence of prehistoric mental templates. In this, Bisson's emphasis on flintknapping behaviours is important but it is the focus on the sequential cognitive structuring of activities underlying these behaviours (Bleed 2006) which is likely to be informative of cognitive differences across human behavioural evolution.

Conclusions

In conclusion, Bisson has raised some very interesting issues regarding imposition of form and its relevance to reconstructing human cognitive abilities. He has tried to infer the rules by which Neanderthals made scrapers, and interpreted the violation of these rules as evidence that form was imposed. However, as this study has shown, Bisson's scraper production rules can be duplicated by a machine, which indicates that the rules reflect flaking mechanics, probability, and experimental design rather than Neanderthals' functional requirements. Furthermore, the adherence to or violation of the rules in the archaeological assemblages is questionable. Therefore, Bisson's conclusion that Neanderthal scraper manufacture was guided strictly by functional constraints, whereas modern humans imposed form on their tools, is untenable. In addition, the concept of imposed form itself must be re-examined. It is suggested here, following Ingold's work, that the forms of lithic artefacts are not the result of the application of mental templates on the material, but rather are the product of the processes by which blanks are knapped and retouched. In other words, the morphologies of retouched tools do not necessarily reflect the imposition of a design on the raw material, but instead reflect the complex, dynamic processes involved in the use and retouch of blanks. Finally, it is suggested that the cognitive abilities of Neanderthals and early anatomically modern humans will be better understood by reconstructing the sequence of operations used to modify objects than by trying to identify the presence of mental templates.

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Notes

1. A portion of this work was presented by the author at the 2006 Annual Meeting of the Paleoanthropology Society in San Juan, Puerto Rico, as a poster entitled 'Testing Bisson's Rules of Middle Paleolithic Scraper Production'.
2. Retouch was measured as a percentage on every edge, and each edge which contained 10% or more of retouch was considered to be 'retouched', whereas less than 10% was considered to be 'unretouched'. Bisson, on the other hand, describes artefacts as either following or violating the rule; he does not specify what percentage of retouch he considers enough to constitute a modified or retouched platform.
3. The large standard deviations probably reflect that flake edges usually have a variable angle.
4. However, when taken individually, Rule 1 is followed 68% of the time, and Rule 2 is followed 74% of the time (see Bisson 2001, table 2).
5. The angle between the platform and the interior surface will be different from that between the platform and the exterior surface, and may in some cases be more amenable to retouch.

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Author biography

Gilliane Monnier's research focuses on the factors that affect the morphology of retouched flake tools in the Palaeolithic, as well as on temporal trends among lithic industries across the Lower and Middle Paleolithic in western Europe. Her recent publications include 'The Lower/Middle Paleolithic periodization in western Europe' (*Current Anthropology* 2006).

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