A Comparative Analysis of Châtelperronian and Protoaurignacian Blade Core Technology Using Data Derived from 3D Models

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Archaeological Context

Châtelperronian
~45-40 kya cal BP

Protoaurignacian
~42-40 kya cal BP

- Les Cottés
- Roc de Combe
Research Questions / Design

• Can we use 3D scanning to quantify observed qualitative differences between Châtelperronian and Protoaurignacian lithic technology?
  o What are the implications for the relationship between Neanderthals and anatomically modern *Homo sapiens*?

• Three quantitative measures investigated
  o Angle between core surfaces
  o Angle between core axes
  o Platform shape (Elliptical Fourier Analysis)
A Simple Photogrammetry Rig for the Reliable Creation of 3D Artifact Models in the Field

Lithic Examples from the Early Upper Paleolithic Sequence of Les Cottés (France)

Samantha Thi Forest, Morgan Roussel, and Mario Sorassi

The ability to create three-dimensional 3D scans of artifacts has begun to revolutionize the way archaeologists document sites. Artifacts can now be scanned with high accuracy and resolution. Photogrammetry is a technique that uses photographs to create 3D models of objects. A simple photogrammetry rig can be easily assembled using common photography equipment.

Closing the seams: resolving frequently encountered issues in photogrammetric modelling

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ANTiquity

Expedient

Refined

1 cm
3D Models

Chatelperronian

Protoaurignacian

RDC

CTS

5 cm
Angle Between Core Surfaces

Lycett and von Cramon-Taubadel, 2015

Y5-1574
Châtelperronian

Y6-1584
Protoaurignacian
Angle Between Core Surfaces
Results - Angle Between Core Surfaces

[Box plots showing angle distribution for different groups: RDC_CHÂT, CTS_CHÂT, and CTS_PROTO.]

- RDC_CHÂT: Data points range from 35 to 95 degrees, with a concentration around 65-75 degrees.
- CTS_CHÂT: Data points range from 35 to 95 degrees, with a concentration around 65-75 degrees.
- CTS_PROTO: Data points range from 35 to 95 degrees, with a concentration around 65-75 degrees.
There is a statistically significant difference in the angle between core surfaces between the combined Châtelperronian and the Protoaurignacian sample.

Performed a two-tailed t-test assuming equal variance:

$p=0.0102$
Core / Platform Shape

Châtelperronian: Hypothesized Angular Central Tendency

Figure 10. Schematic reconstruction of blade production at Quinçay. Roussel, Soressi, and Hublin, 2016
Core / Platform Shape
Core / Platform Shape
Core / Platform Shape
Core / Platform Shape

SHAPE
Iwata and Ukai, 2002
Results - Platform Shape

60.57% of variance

31.06% of variance

PC1

PC2

RDC_CHÂT
CTS_CHÂT
CTS_PROTO
Results - Platform Shape

31.06% of variance

3.54% of variance

Further investigation needed…
Angle Between Core Axes

Châtelperronian

Protoaurignacian

Hypothesized Central Tendencies

top view
Angle Between Core Axes
Angle Between Core Axes
Results - Angle Between Core Axes
Results - Angle Between Core Axes

There is a statistically significant difference in core axes angles for the combined Châtelperronian and Protoaurignacian sample.

Performed a two-tailed t-test assuming equal variance:

\[ p = 0.0498 \]

There is a statistically significant difference in core axes angles for the combined Châtelperronian and Protoaurignacian sample.

BUT…
Results - Angle Between Core Axes

There is **NOT** a statistically significant difference in core axes angles between the Les Cottés Châtelperronian and Les Cottés Protoaurignacian sample.

Performed a two-tailed t-test assuming equal variance:

\[ p = 0.1145 \]

There is **NOT** a statistically significant difference in core axes angles between the Les Cottés Châtelperronian and Les Cottés Protoaurignacian sample.
What Does Quantitative Analysis Tell Us?

• Lithic artifacts are not biological organisms, and are highly variable

• What is driving our results?
  o Is this ‘real’ evidence of similarities in knapping behavior?
  o Are we measuring / quantifying things ‘the wrong way’?

• We need to take into consideration factors outside of technology
  o Raw material scarcity
  o Types of raw materials available
  o Proficiency of the knapper
  o Allometry
  o Observer error
Future Directions

• Increase the sample size

• Sample differently
  o Separate core types
  o Separate blade vs bladelet cores
  o Exclude more outliers
  o Include size in shape analysis

• Look at different measures
  o Further investigate EFA data (e.g. run discriminant analysis)
  o Use a different definition of cross section
  o Vector analysis and / or indices of convexity (Bretzke and Conard 2012)
Conclusions

• Overall, our quantitative analyses supported previous qualitative observations, but...

• Metrics must be interpreted within the context of their connectedness to human behaviors

• 3D scanning opens up new research avenues
  o We can make new types of systematic observations on artifacts
  o We can make certain observations more accurately
  o We can collaborate more easily
  o We can use 3D scans for many studies without having to travel to collect additional raw data
Thank You

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References


Core / Platform Shape

Chatelperronian

Protoaurignacian
Core / Platform Shape
Core / Platform Shape
Core / Platform Shape
Core / Platform Shape
Core / Platform Shape
Hello everyone. Thanks for coming on this last afternoon of the conference.

Starting with some context, today I’ll be talking about two stone tool industries: the Châtelperronian and the Protoaurignacian. What is interesting about these two industries is that they existed in approximately the same time in approximately the same place, but are associated with two different hominin groups: the Châtelperronian with Neanderthals and the Protoaurignacian with anatomically modern humans. There has been a huge amount of debate on whether these two groups met in Europe approximately 40,000 years ago and how they may have interacted. A great deal of this debate has surrounded their lithic technology. Both the Châtelperronian and Protoaurignacian are blade-based technologies. In simple terms, this means the pieces of stone they were producing to make into tools tended to be long and skinny, or twice as long as they are wide. Many have interpreted this as being an improvement over previous, so called flake based production systems, which were used by Neanderthals in this region before the Châtelperronian. This begs the question, did Neanderthals come up with this more “advanced” technology themselves, or were they somehow influenced by incoming Homo sapiens?

I’m definitely not going to answer that today, but hopefully this project will be one step in getting a little closer to figuring things out. The reason I’m in this session is that we chose to investigate these questions about lithic technology using 3D scans of lithic cores from two sites in France: Roc de Combe, which contains Châtelperronian deposits, and Les Cottés which includes both Châtelperronian and Protoaurignacian layers.

The question being asked in this particular study is can we use 3D scanning to quantify observed qualitative differences between Châtelperronian and Protoaurignacian lithic technology? Later on, we hope to interpret in the context of these larger questions about group interaction, cultural transmission, and so on.

We then investigated similarities and differences between the Châtelperronian and Protoaurignacian using three metrics, which I’ll describe in a moment.

To generate 3D models for this project, we used Agisoft PhotoScan. Images were captured with the help of this rig, which is described in our paper in Advances in Archaeological Practice. Images were taken over the course of three years, between 2014 and 2016. Over time this setup did change progressively for the better. I am well aware the data collection procedures used for this project are not ideal, nevertheless they were quite controlled. For example, in this paper published in Antiquity we compared the control photogrammetry setup I develop with a more expedient rig with the camera on auto,
without a tripod. As we talked about this morning in this session, by using some simple controls you can get a much higher quality model.

Slide 5

Here you can see the 61 3D models we used in our subsequent analyses. In total, our collection of 3D models includes 185 cores. We ended up excluding many artifacts from this analysis, including cores that were abandoned or damaged early on or were of uncertain provenience.

Slide 6

The first measure I’m going to discuss is the angle between what we call the platform surface and the flaking surface of the core. This angle has a big effect on the shape of products extracted from a given core, and needs to be tightly controlled by knappers. This means that differences in this angle between industries would be a strong indicator of knappers making different choices. These are some extreme examples, but based on previous observations we hypothesized that this angle would be higher in the Châtelperronian and lower in the Protoaurignacian.

Angles on stone tools are notoriously difficult to measure physically. When this done with a goniometer, which is traditional, the variation in measured values can be as high as 20 degrees.

Slide 7

By measuring angles digitally, we can greatly increase the precision and very likely accuracy of our measurements. For this study, this was accomplished using Geomagic Design X. The polygons representing the top, platform surface of the core were selected, and used to create a best fit plane. Next, we selected the polyfaces corresponding to the last successful removal on the core, and used those to create another best fit plane. We then measured the angle between these two planes.

Slide 8

Here are the results of our surface angle measurements. On the right, we have this represented as box and whisker plot. Visually we can see that the Châtelperronian sample does indeed appear to have a higher value for this angle measurements.

Slide 9

We combine the Châtelperronian sample from our two sites and comparted it to our Protoaurignacian data using a simple t-test. And we got a statistically significant p-value of 0.01. This supports previous work that indicates this measure is different between these two industries.

Slide 10

The next thing we wanted to investigate was the shape of the core platforms as viewed in cross section from above. Not to bore you with too much lithic technology, but via traditional lithic analysis it has been proposed the Châtelperronian knappers tended to work cores using two distinct surfaces. One surface was worked, then another, back and forth. This hypothetically produces a core with a somewhat triangular cross section.

Slide 11
In contrast, Protoaurignacian knappers theoretically worked the cores using a single more rounded surface. This would result in a rounded cross section. Our idea was to extract actual cross sections from our 3D models, which would be difficult to do accurately without 3D scanning, and then compare the cross sections for Châtelperronian and Protoaurignacian cores using elliptical Fourier analysis.

Slide 12

To obtain 2D cross sections for elliptical Fourier analysis, we again used Geomagic Design. We used that same best fit plane from before, then moved it down to ensure it would cut through the core. We then extracted a cross section based on the intersection of this plane with the 3D model. We also marked points corresponding to the extremes of the flaking surface, and added a vector between them.

Slide 13

We then viewed this from above, orthogonal to the best fit plane and extracted images both of the entire core and the core outline with this additional reference geometry and then turned them into these types of black and white images.

Slide 14

We decided to only include the part of the platform cross section bounded by the vector between the ends of the working area in order to hone in on the areas of the core that were the focus of the knappers.

For this particular analysis we only used the images of the core cross section, but these images of the entire core will come back into play later on.

Slide 15

We used the package SHAPE by Iwata and Ukai to process our cross sections and to conduct the elliptical Fourier and principal components analysis. For the analyses discussed in this paper, scale was not taken into consideration, and we used ten harmonics.

Slide 16

I’d call these results preliminary, and I don’t want to overinterpret things, but looking at the first two principal components graphed, we see a significant amount of overlap. PC 1 accounts for 60.5% of the variance. In terms of interpretation, PC 1 appears to describe whether or not the cross section is skewed to either the right or the left. Cross sections such as these often can be interpreted as resulting from errors made by the flakknapper. In these cases, the stone fractures in a way that makes it difficult for the knapper to shape the core appropriately going forward. These errors are not necessarily more common in one mode of stone tool working versus another.

PC 2 accounts for an additional 31% of the variance, which relates to the relative depth of the platform surface. We have not yet had time to test this, but this likely correlates with different core “types”, whose descriptions I will spare you for now. In order to not overly limit our sample size we did not distinguish between different “types” of cores here. This does mean ended up with a large amount of morphological variation.
Here are PCs 2 and 3. Again, we see a lot of overlap. However, there does appear to potentially be a difference on PC 3 in terms of this questions of rounded vs angular platform shapes. PC3 accounts for a much lower three and a half percent of a variance. It does looks like more Châtelperronian cores tend to have more angular platform cross-sections. This does fit our original hypothesis that was based on qualitative observations.

Nevertheless, the question remains, is this distinction meaningful and driven by difference in lithic technology? Unfortunately, we were unable to run more analyses before this conference, so the answer will have to wait. Again, this principal component only accounts for 3% of the variation in the sample. Further investigation into this measure including some more statistical tests will be necessary to determine what is driving this variation, and if the use of elliptical Fourier is useful for our particular research questions.

Slide 18

The last thing we looked at was the angle between what we are calling the symmetry axis and retreat axis of an artifact. For these figures, you can imagine that you are looking at these cores from above. This area outlined by the dotted line corresponds to the surface of the core being worked. In blue, you have the symmetry axis, which corresponds to either the longest axis of the core, or in some cases an axis perpendicular to the longest core axis. In red, you have the retreat axis of the core. To determine the retreat axis, you first draw a line across the core between the greatest extent of the surfaces that have been worked. So in other words we see removals starting here and continuing until this point. The retreat axis is defined as being perpendicular to this line.

Based on the interpretations and Châtelperronian and Protoaurignacian lithic technology described earlier, we expected the angle between these two axes to be higher in the Châtelperronian due to a oblique progression of the reduction. We expected the angle between these two axes to be lower in the Protoaurignacian, with reduction occurring symmetrically around the axis of symmetry.

Slide 19

For this analysis, we used the same black and white images extracted for the elliptical Fourier analysis. These were then processed using macros in ImageJ. We created a vertical line through the center of the platform area for reference, and superimposed a best-fit ellipse over the entire core.

Slide 20

The images were then superimposed on one another, and the angle between the closest axis of the ellipse and this dividing line were measured in ImageJ to the nearest degree.

Slide 21

Here are the results of our analyses. We have some potential outliers, but overall the raw data matches our prediction that this angle would be higher in the Châtelperronian.

Slide 22

Once again we ran a t-test on the combined sample and lo and behold we once again got a significant p-value, which appears to support our initial hypothesis. But...
if we only look at the sample from Les Cottes and exclude the Roc de Combe material, we do not get a statistically significant difference. What does this mean? I’d say right now it’s hard to say.

There are a few things I can say however to put these results into context. First, stone tools are highly variable. Due to the way in which they are produced, I would also argue that stone cores are more variable then other artifact types that commonly undergo similar analyses, such as ceramics for example.

This means we need to think long and hard about what are driving our results. Are these numbers we’ve generated really representative of knapping behaviors?

We need to take into consideration other factors including the abundance and quality of raw materials in a given area, to how good the individuals who made these artifacts were good at flint knapping. We also need to investigate whether artifact shape changes as artifacts get larger or smaller, also known as allometry. And of course, we need to take into consideration possible errors made by us, the observers.

In terms of future directions, there are a number of avenues we could pursue. In the long term, it would be nice to get access to more material to increase the sample size. Shorter term using the scan data we already have we could play with our sample a bit – for example we could separate core types, separate core based on size, exclude outliers, or add size into our shape analysis.

We could also look at different metrics and statistics. We could run things like discriminant analyses. We could maybe look at cross section a different way. There are also a few methods we have yet to try, namely vector analysis and calculating indices of core curvature, both of which were described in this paper by Bretzke and Conard.

In conclusion, we want to emphasize once again that in archaeology metrics must always be interpreted in the context of their relationship to human behaviors. This study did produce some interesting results that may support interpretations that were previously based on mostly qualitative observations. However, more work needs to be done to account for more of the previously mentioned factors that also effect stone tool morphology.

Finally, we believe this study demonstrates the utility of collecting 3D data for archaeological research. In our case, 3D data allowed us to make new types of systematic observations on artifacts, take certain measurements with more precision, and collaborate with colleagues on the same material despite being on different continents. Furthermore, if we want to run further analyses on these artifacts, we can continue to query our 3D models without having to travel to the artifacts’ physical location.

Thank you

Slides 28+
These slides are here in case someone asks me to more fully explain the data extraction procedure