Musical behaviours and the archaeological record: a preliminary study

Ian Cross
University of Cambridge Faculty of Music
Ezra Zubrow
University of Cambridge, Department of Archaeology / SUNY Buffalo
Frank Cowan
Cincinnati Museum Center

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Introduction

The research discussed here has three different points of origin: the relation between music and human evolution, specifically, human cognitive evolution; the nature of the evidence for musical behaviours in the archaeological record; and the issue of making musical sounds with stones.

One might suppose that music, as a cultural phenomenon, has little to do with evolution. But, from a cognitive-scientific perspective, music is inescapably material, being evidenced in musical behaviours; behind human behaviours lie human minds, and behind human minds lie embodied human brains. Accepting a materialist basis for human behaviours, consideration of evolution's role in those behaviours seems inescapable. Taking an evolutionary approach to human behaviours does **not** necessitate adoption of a gene-centred ontological reductionism; indeed, it may be that evolutionary perspectives afford excellent frameworks within which an understanding of music as individual minded behaviour - material practice - can be reconciled with an understanding of music as embedded in a nexus of shared ways of understanding - music as culture. The existence of an evolutionary basis for music is unlikely to be explanatory of most of the attributes, significances, purposes and interpretations that can be borne by the music of any **particular** culture. But it **can** provide some hypotheses about the dynamics of cognition and interaction that may underlie those attributes, significances, etc. And some recently developed hypotheses about the relation between music and evolution (see Cross, 1999: Brown, 2000: Dissanayake, 2000) constitute the broad context for the present research - specifically, that the emergence of 'musicality' played a significant role in the evolution of modern humans, *Homo sapiens sapiens*.

Turning to the nature of the evidence for musical behaviours in the archaeological record, we run into several problems. What traces would musical behaviours leave? Given that the earliest such behaviours were likely to have been vocal, we are left with trying to make inferences about whether or not any of our predecessors or sibling species had the vocal capacity to articulate the complex timbral and pitch patterns that music requires on the basis of fragmentary human and pre-human remains, and several equally plausible theories appear to lead to different conclusions (see Lieberman, 1991; Frayer & Nicolay, 2000). In any case, all that such research can tell us is whether or not our ancestors had the capacity to produce 'musical' sounds - it can't tell us whether they produced music. Artefacts provide clearer evidence - one might suppose. But there is controversy over just what the earliest musical artefact might be. On one reading, the earliest artefact is an unambiguously musical bone pipe from Geissenklösterle in Germany, dated to about 36,000 BP and associated with modern humans (see Hahn & Münzel, 1995); on another reading, the earliest evidence is a fragment of a bone pipe from Divje babe in Slovenia, dated to around 45,000 BP and associated with *Homo neanderthalensis* (Kunej & Turk, 2000) - though, alternatively, this 'bone pipe' might have been a hyena's lunch (D'Errico & Villa, 1997). One of the aims of the current research is to attempt to work out ways of identifying whether or not an artefact has been purposively produced by human activity **and** has been unambiguously employed to make sounds.

And finally, we turn to making musical sounds with stones. It seems that most human cultures either do this or have done this; evidence for the use of lithophones - lithic idiophones - stretches from Sweden to southern Africa, from the Canaries through Kenya through Vietnam through China to Potosí in the Bolivian Andes (see the entry for 'Lithophones' in The New Grove Dictionary, 2000). It even crops up in Victorian England, where the brothers Richardson performed on their specially constructed 'geological piano' before Queen Victoria (her response is not recorded). The possibility that our ancestors might have exploited the materials and technologies that they knew best - flint, and the processes of working flint to produce artefacts - for sound-production constitutes the narrow context for the research now sketched out, the **Lithoacoustics Project**.

The Lithoacoustics Project

The practical origins of the project arose from posing the question "what traces would musical behaviours leave"? It was eventually agreed that it would be worth exploring the materials and the percussive processes involved in flint-knapping to find out (i) whether sounds that could be interpreted as musical could be produced, and (ii) whether producing musical sounds would leave any unambiguous traces. To leap to the interim findings (the project is not yet completed) the answer to the two questions appears to be "yes" and "yes".

It was decided to focus on the first instance on the tools and the technologies of the Aurignacian period (about 40,000 to 20,000 BP). This is because peoples of around that time used stalagmitic rock formations in caves as lithophones (Dams, 1985), so it seems reasonable to assume that they might have used other types of stones as well. As soon as we began the process of flint-knapping we realised that we had some potential musical instruments in the blades produced (typical blanks produced using a prepared core technology, see Figure 1 below).

Examples of the blades produced and used in the project

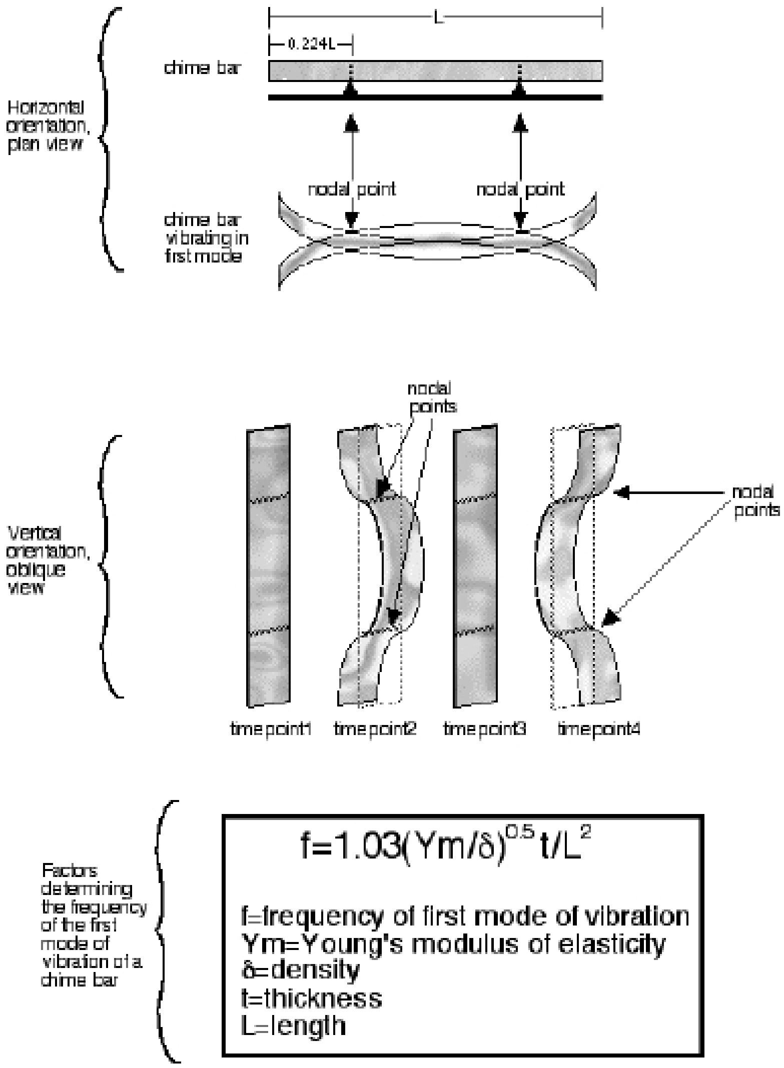
Figure 1

The easiest way to 'play' a blade is to suspend it between thumb and forefinger (or middle finger) about a quarter of the way along its length and strike it in the middle or at the bottom end, as shown in Figure 2.

Playing a blade, here suspended between thumb and middle finger of left hand

Figure 2

It transpires that flint blades can be used as **idiophones** - musical instruments or vibrating objects in which energy input and sound output systems are one and the same - which behave like chime bars; when struck, their first mode of vibration (lowest pitch) has nodal points (points of null displacement) at about 0.224 along their length, and they can produce very clear and quite long-lasting pitched sounds.



The acoustical functioning of a chime bar in usual horizontal position (top) and in the vertical position employed in playing the flint blades (middle). The equation (bottom) shows the terms involved in determining the frequency of the first mode of vibration

Figure 3

Formal protocols were developed for: (i) categorising the blades **- specimens -** on the basis of their physical dimensions and attributes; (ii) formalising and quantifying the procedures to be used in sound production; (iii) analysing and categorising the resulting sounds; and (iv) analysing and typologising the damage that accrued to the surface of the blades when they had been used to make sounds. The third author produced and categorised the specimens; then one of the two assistants on the project (the 'performers') used each specimen to make sounds, assessed its 'playability' according to a number of parameters, recorded the sound at the outset of trialling, percussed the blade for five minutes, recorded the sound again, percussed for a further five minutes, and recorded the sound for a last time. The recorded sounds were then analysed (using CERL's Lemur software [available at http://www.cerlsoundgroup.org/Lemur/]); each specimen was then examined under an optical microscope and digital images taken. Finally, the surface damage or **use-wear** on each specimen was assessed and coded. Some 116 specimens were used, of which 'before' and 'after' microscope photographs were taken of fifteen; two of the specimens were used as percussors. All measurements were entered into a database and the process of analysis was started.

<u>The results</u>

Sound and performance

Taking the sound data first, it was found that, overall, the frequencies, durations and intensities of all specimens conformed to normal distributions; taking the rating of each specimen by the 'performers' into account, clear differences in frequency were found between those specimens rated 'good' and those rated 'acceptable' or 'bad' (see Table 1).

principal component frequency (kHz)		*principal component duration (msec)*		*principal component intensity (dB)**	
good mean	**4.979**	good mean	**180**	good mean	**-37**
acc. mean	**7.263**	acc. mean	**117**	acc. mean	**-37**
bad mean	**8.097**	bad mean	**81**	bad mean	**-45**
t tests:					
frequency		duration		intensity	
good significantly different (p<0.0001) from acceptable and bad, no significant different (p>0.10) between acceptable and bad		good significantly different (p<0.0001) from acceptable and bad, acceptable significantly different (p<0.02) from bad		no significant difference between good and acceptable (p>0.10), good and acceptable significantly different from bad (p<0.05 in both cases)	

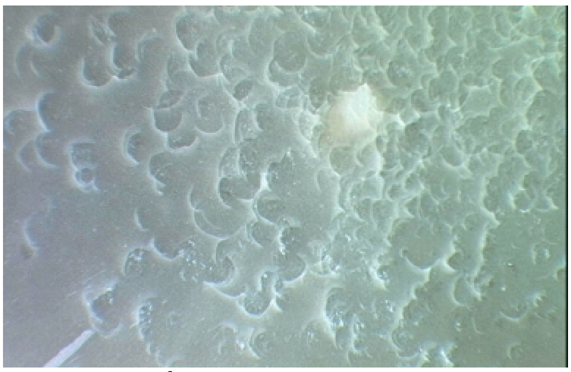
**-80 dB noise floor*

Mean principal frequencies, durations and intensities of good, acceptable and bad specimens, and results of a series of t tests between values
Table 1

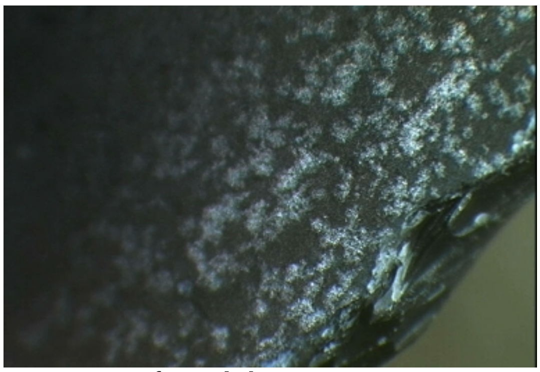
The mean principal frequency of the 'good' specimens is at the upper end of the usable 'musical' frequency range (after Attneave and Olson, 1970), while those of the 'acceptable' and 'bad' specimens was well outside this range; the duration of the 'good' specimens was considerably greater that both the 'acceptable' and 'bad'; while the intensity of the 'bad' specimens was much lower than both 'good' and 'acceptable' intensities. The consistency of these physical values suggests that the categories in which the specimens were placed by the raters in respect of "playability" are (i) directly relatable to the sound-producing characteristics of the specimens and (ii) real. And substantial inter-rater reliability was evident in a series of t tests which showed no significant differences between additional ratings given by each of the two raters to each specimen on dimensions of "pitchedness", 'resonance", "power" and "piercingness". Further t tests on the recorded sound values for all specimens at the outset and at the end of trialling yielded no evidence that repeated percussion changed the sounding qualities of any specimen.

A series of multiple regression analyses (with principal frequency, principal intensity and principal duration as the respective dependent variables and length, width and thickness as the independent variables) showed that for all specimens both length and thickness had highly significant predictive value for the intensity and duration of the sounds produced. However, a more complex variable obtained by dividing the thickness of each specimen by the square of its length (t/L^2) provided a very highly significant predictor for frequency in simple regressions for all rated categories. This complex variable was derived from the equation shown in Figure 3 (above) describing the physics of "chime bars",where principal frequency is a complex function of, among other things, length and thickness (though **not** width). Its functionality as a predictor of the frequencies of the sounds produced confirms that the chime-bar model is operational in respect of these lithic resonators. This set of results can be read as indicating that to a "player" a heuristic indication of the sound-producing capacity of the specimen is immediately available from estimation of its length and (secondarily) its thickness.

Use-wear
While formal use-wear analysis is not yet complete, it was immediately clear that repeated percussion resulted in the consistent appearance of small densely clustered surface cones or of multiple small, densely clustered small areas of surface polish. Occasionally, small scratches occurred. An instance of surface coning is shown in Figure 4, and an instance of surface polish is shown in Figure 5:



Surface coning on specimen 60
Figure 4

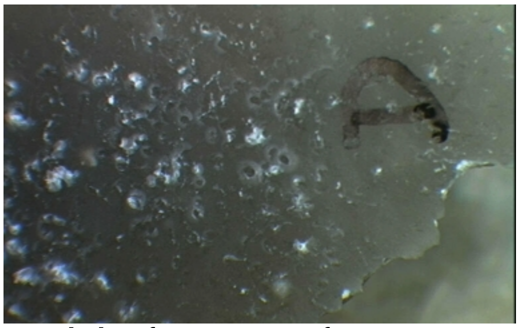


Surface polish on specimen 18
Figure 5

In many instances, edge damage in the form of small, abrupt, step-terminated or hinge-terminated flake scars were found where playing percussion was near an edge. An instance of this is shown in Figures 6(a) and 6(b):

Surface and edge of 104 before percussion

Figure 6(a)



Surface and edge of specimen 104 after percussion Note the extensive surface coning and the edge damage

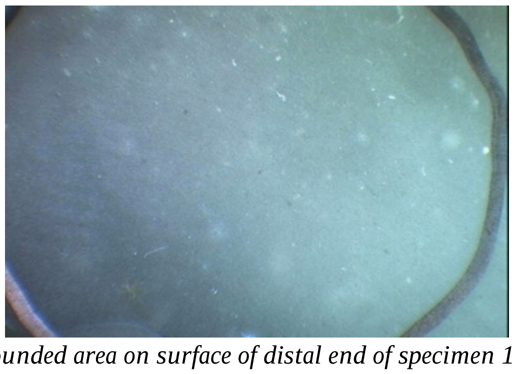
Figure 6(b)

The cone-cracking results from direct, head-on percussion, while the polishes and scratches may result from a softer and more "stroking" impact against the flake surface. In many instances, the cone-fracturing consisted of multiple, overlapping cone-cracks that often occurred in great density, as can be seen in Figure 7 which shows the same surface area before and after percussion.

Surface of distal end of specimen 101 before and after percussion

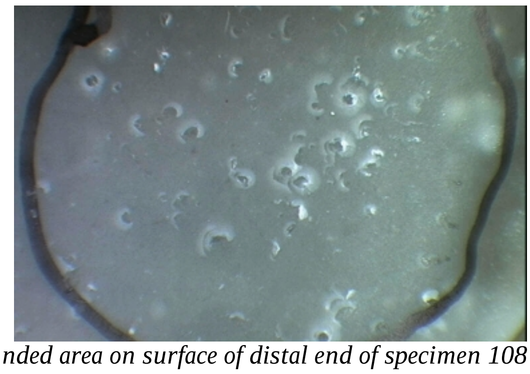
Figure 7

One of the most salient features of the cone-cracking wear is its placement. because of the nodal regions on the chime-bar-like blades, musical wear tended to occur most frequently either at the midpoint of the specimen or at the end of the specimen (beyond the nodal region furthest from the suspension point). This non-random distribution is probably unique to musical play, and is localised to the faces on the antinodal areas. The effect can clearly be seen in Figures 8(a) and (b) showing the same surface area (bounded by a circle drawn on the specimen at the distal, far, end):



Bounded area on surface of distal end of specimen 108 before percussion

Figure 8(a)



Bounded area on surface of distal end of specimen 108 after percussion

Figure 8(b)

Of the three different kinds of damage, the cone-cracking was most consistent and is undoubtedly the most diagnostic use-wear criterion. No other behavioural or geological forces that we can think of are likely to produce the kind of very patterned clustering of cone-cracks as were experimentally produced in musical use. Microscopic images clearly show the patterns of use-wear resulting from this musical use.

It is also noteworthy that use-wear intensity varied with the player. one 'performer' produced a wide range of use-wear patterns, including soft, stroking polishes on the surfaces and very seldom produced intensive edge attrition. The other 'performer', on the other hand, tended to strike the resonators more directly and with greater force. Hence, this performer's instruments tended to accrue, very rapidly, much more densely clustered cone-cracks. This latter performer's instruments also were extensively and intensively "retouched" along the marginal edges. Several specimens that were initially unretouched blades or flakes became typologically identifiable "tool" types with extensive alteration of specimen outline. These "retouched" edges were formed by "play" near the edge of the piece, and the force was sufficient to strike off multiple, overlapping retouch flakes. Nonetheless, the patterns of edge retouch are not very similar to intentional technological retouch.

Initial survey of museum collections

A preliminary examination was then conducted of some of the flint-tool holdings of the Cambridge University Museum of Archaeology and Anthropology. Approximately 425 (10 kg) archaeological specimens were examined from Aurignacian levels of Laugerie Haute, Cro-Magnon, Le Moustier, Masnaigre, and other French Upper Palaeolithic sites (from the Museum's holdings of an estimated 3000 flint specimens of the period). All were scanned for traces of surface use-wear, especially cone-cracking, with a 10x hand lens. Three important observations can be made from this pilot study.

First, cone-fracturing on the ventral surfaces of flakes, blades or tools is extremely rare in the archaeological record. Four specimens out of 425 were observed to have a few potential surface cone-cracks on the ventral surface. This means that this kind of damage is not a common result of either a) prehistoric behaviour, b) fortuitous geological processes after deposition in the archaeological deposits, c) excavation damage, d) post-excavation curation damage (bag-damage). Second, cones are potentially recognisable on ancient archaeological specimens, despite raw material variability, surface patination, breakage, or other altering forces. Third, none of the identified specimens approximated the patterns of wear routinely observed on the experimental specimens. It is therefore clear that musical use of flint blades will result in a very different overall pattern and distribution of cone-cracks than other behavioural or fortuitous causes. So far as our limited exploration of the archaeological record is concerned, there appear to be very few instances of blades or flakes with small surface coning, so if it occurs as a result of "natural" circumstances it would seem to be rare and likely to be differentiable from the type of wear that arises from lithic chime percussion.

Conclusions

At present, the use-wear coding remains to be completed, hence our present conclusions must be qualified somewhat; however, the results that emerge seem to indicate that there are patterns of use-wear on the flint blades that we made and experimented with that are diagnostic of use for sound production.

What might be the implications of this? To return to the issues considered at the outset, it appears that we are now in a position to say whether or not Aurignacian-type flint blades have been used as lithophones. We know that they **can** be, and it appears that doing so leaves diagnostic traces, so we may now be in a position to identify **unambiguously** traces of sound production, and, perhaps, 'musical' performance, in the archaeological record, which will involve examining whether or not any artefacts that have been interpreted as flint tools were in fact used for sound production and perhaps for music. Differentiation between simple sound production - for example, using a flint blade as a sort of Palaeolithic doorbell - and 'musical' use will always be a matter of interpretation of both the artefact and the find context, but finding, say, a grouping of lithic blades all of which exhibit appropriate and localised cone-cracking would be likely to point towards something like music In this context it would also be of interest to explore whether or not other and earlier lithic tool technologies can be exploited in a similar way for sound production, and if so, what traces of use-wear might result.

This project has also shed light on some considerations in exploring the nature of the evidence for sound production in the archaeological record. While it is evident that there will be a relation between patterns of use-wear and the acoustical properties of the objects used to produce sounds, here, a very close fit has been found between acoustical properties and use-wear. This close fit derives from the nature and from the configuration of the materials used and from the constraints that these impose on sound producing action. Indeed, the patterns of use-wear found here should have been predictable in advance from an understanding of the chime-bar like acoustical properties of flint blade idiophones. Although the fit is unlikely to be so close in respect of other materials and configurations (the case of pipes made from bone is one such), it would be worthwhile exploring other materials - bone, wood, and perhaps bamboo - and configurations, particularly where these afford the capacity to be used as idiophones as here the relation between acoustical attributes and use-wear can be expected to be very close.

And finally the outcome of the project might have some significance for our understanding of the relation between music and evolution. Music has been posited as sharing its origins with language (Brown, 2000), and as having been adaptive in precipitating the emergence of the cognitive ands social flexibility characteristic of modern humans. But whether or not music has been adaptive, exaptive or even neutral in respect of human evolution, it is still of interest to discover just when a capacity or propensity for music appeared. Music certainly appears early in the behavioural repertoire of *Homo sapiens sapiens*; the Geissenklösterle pipe at 36,000 BP is a complex artefact that must post-date - and most likely by some considerable period - the emergence of a capacity for music, which pushes the emergence of that capacity back towards the very emergence of *Homo sapiens sapiens*. The longevity of music as a human behaviour is evident (if seldom recognised). The results of the present project and the directions that it suggests for future research **might** help answer some questions about the extent of that longevity and whether or not music is a capacity that we shared with our sibling and predecessor species.

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Examples of sounds produced can be found at http://www.mus.cam.ac.uk/~cross/lithoacoustics/