Journal of Archaeological Science: Reports 3 (2015) 313–320

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: http://ees.elsevier.com/jasrep

Flint knapping and determination of human handedness. Methodological proposal with quantifiable results

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ARTICLE INFO

Article history:
Received 5 November 2014
Received in revised form 16 June 2015
Accepted 16 June 2015
Available online xxxx

Keywords:
Laterality
Handedness
Human evolution
Flint knapping
Flake
Percussion
Parabolic crack

ABSTRACT

The products of technological activity of our ancestors, and particularly the artefacts made by hand, are a potential source of information for a diachronic study of the handedness process in different human species. In the flint flakes, around the point of percussion, a system of fractures is developed in connection with the cone of percussion and the conical fracture of the flint. On this paper we prove that the direction of percussion can be deduced from these fractures, and the knapper's handedness can be determined if the direction of percussion is known.
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1. Introduction

The study of the human mind requires an understanding of the functioning of our brain, its internal articulation, its origins and its evolution during the history of our genus (Stout et al., 2000). Certain brain functions, especially well-developed in humans, such as speech, abstraction and complex thought are physically located on one side of our brain (Corballis, 2005; Llorente et al., 2008; McManus, 1985, 1991; Rogers, 1993). Related to these asymmetrically-distributed functions, the capacity known as handedness consists of assigning different roles to each of our limbs when carrying out a particular task (Marchant et al., 1995). By studying lateralised behaviour, we will better understand brain organisation and asymmetry, while at the same time, by studying the origin and development of handedness, we can attain a historical insight into an understanding of when brain asymmetry appeared and how it has evolved during the history of the genus *Homo*.

Lateralised human behaviour may be reflected in the products of technological activity, and particularly in artefacts made by hand (Uomini, 2011). Lithic reduction, which our genus has performed since the first stages in its evolution, has formed large assemblages, which are usually well-conserved and a potential source of information for a diachronic study of the handedness process in different human species. Since the late twentieth century, following N. Toth's (1985) research, there has been growing interest in obtaining data about handedness through the lithic record. Rugg and Mullane's (2011) study represented significant progress in the analysis of lithic assemblages from the point of view of handedness, and more recently Bargalló and Mosquera (2013) developed a method by which the handedness of a particular knapper can be determined by refitting the flakes extracted from the core. However, these methods involve requirements that are very difficult to fulfil in a large sample from any assemblage, because it is difficult to find many refittings. In other words, to obtain extensive results susceptible to relevant statistical tests, even from not especially large assemblages, we need to identify and assess a trait indicating the knapper's handedness that can be easily found in prehistoric artefacts. This is the objective of the present study.

1.1. Previous research

The first studies aiming at determining handedness from flakes were carried out by Toth in, 1985. The researcher's conclusions were based on the hypothesis that handedness influences the direction in which the core is turned when it is being reduced. According to Toth, a right-handed knapper will turn the core towards the right as flakes are extracted. When the cortex is being removed from the core, this will tend to produce flakes with the cortex on their right side, whereas if the knapper is left-handed, the opposite effect will result. However, later experimental work (Patterson and Sollberger, 1986) found that the geometric shape of the core is decisive in the type of flakes and that a left-handed knapper may produce a certain number of right-

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http://dx.doi.org/10.1016/j.jasrep.2015.06.026
2352-409X/© 2015 Published by Elsevier Ltd.

handed flakes, and vice versa. In the experiment, Sollberg produced 56% right-handed flakes (according to Toth's terminology) despite being left-handed. In a study carried out by Pobiner (1999) with seven right-handed students at the University of Pennsylvania, 284 flakes were produced in a number of knapping sessions. It was found that as the number of flakes increased, the ratio of right-handed/left-handed flakes approached 50:50. Therefore, Toth's method can only be applied to a specific reduction strategy in which flakes are extracted from the same platform following a certain sequence.

It would be important therefore to find a method that is not based on knapping habits by proposing hypotheses based on elements directly related to percussion, such as the angle and direction of the blow from the hammerstone on the percussion platform. In this line, Rugg and Mullane (2011) studied the orientation of the cone of percussion in the flake, as this is conditioned by the direction of the angle of blow. In their experiment they examined 299 flakes, of which 75 were considered valid to determine the knapper's handedness. With this restricted assemblage, they claimed that they were able to determine the handedness correctly in 75% of the cases. However, it was recently shown (Bargalló and Mosquera, 2013) that Rugg and Mullane's method alone is unable to determine the knapper's handedness. By examining the cone of percussion and other characteristics in the flakes, they developed a system to determine the knapper's handedness from several flakes extracted by the same individual. However, this method is not applicable to each particular flake in a large assemblage and is, therefore, limited to the study of lithic refits. Unfortunately most lithic assemblages cannot be refitted, and consequently it is necessary to find a method allowing the determination of the knapper's handedness, with a reasonable level of certainty, even from a single flake.

The present study proposes a method enabling each flake to be associated with the handedness of the knapper who extracted it, without needing several flakes removed by the same knapper, which is a requirement that is nearly always difficult to fulfil. This means that it is an extensive method that can be applied in different periods in the archaeological record. It is based on a characteristic of the mechanics of the conical fracturing of flint that can often be seen on flakes, which means that it can be applied widely. The main limiting factor of this method is that it is still not known whether it is applicable to the reduction of other raw materials, like quartzite, obsidian and basalt, and in these cases, the experimental protocol followed in this study of flint would have to be applied.

Hertz (1882) first described the behaviour of an elastic material under the application of a force and the appearance of the conical fracture named after him. Since then, many studies have considered the forces prevailing in the fracture of several kinds of materials.

Roesler (1956), based on Hertz's (1882) work, described the mechanics of the conical fracture of glass in the following way "When a spherical indenter is pressed against a flat surfaced glass specimen it makes the glass break in a ring crack around the contact area. When the pressure grows the ring crack spreads downwards, flares out and tends in shape to the mantle of a circular cone". In his paper, he gives an ideal pattern of the conical fracture as well as real photograph illustrating a cone of percussion (Fig. 1). Some time later, Frank and Lawn (1967) studied Hertzian fractures again and described the main forces acting on the (semi-infinite) surface of an elastic medium. They also gave a photograph showing the result of hitting a glass surface with a steel ball. The photograph shows, on the glass surface, the "ring crack" described by Hertz (1882) and studied later by Roesler (1956) which consists of a ring-shaped fracture produced beyond the edge of the breakage of the material.

2. Materials and methods

A system of fractures around the point of percussion, similar to a ring crack, occasionally forms in connection with the cone of percussion and the conical fracture of the flint. The present study aims to test two

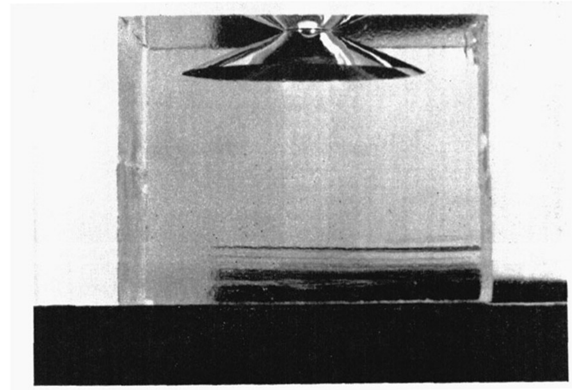

Fig. 1. Photograph of a cone of percussion made by the impact on a glass surface. Taken from Roesler (1956).

hypotheses: 1), that the direction of percussion can be deduced from these fractures, and 2), that the knapper's handedness can be determined from a flake if the direction of percussion is known.

2.1. Empirical observation

During the experimentation prior to this study, in which the effects of the impact of a limestone hammerstone on a flat flint surface were studied, we observed the appearance of a ring crack and its relationship with the bulb of percussion. Clarkson (2007) described it as:

> "Conchoidal flakes (i.e. those with Hertzian initiations) often retain a ring crack at the point of force application (PFA), and an eraillure scar just below the point of percussion on the bulb of force."

The bulb is conical and when the percussion is very violent (over the breakage limit of the material), and the hammerstone is very rigid (not elastic), these types of rings form, representing the intersection of the cone of percussion (or incipient cones) with the striking platform. During this experimentation, it was also observed that if the impact is vertical, a quasi-circular ring, similar to the illustration in Frank and Lawn (1967), is formed. However, most of the impacts occurring during flint reduction are at a certain angle between the hammerstone and the striking platform and then the fractures do not form symmetrically. In consequence, as Rugg and Mullane (2011), the cone undergoes a change in orientation or is skewed, and the sections of the cone of projection that are projected as fractures on the striking platform are elliptical and often open, in a parabolic shape. A parabola (Fig. 2A) is defined as the locus of points in a plane equidistant from a line called directrix and a point outside it called focus. The vertex of the parabola is the point whose distance from the directrix is minimal. The axis of symmetry of a parabola is a vertical line through the vertex and divides the parabola into two congruent halves. We observed that these cracks are related geometrically to the direction of percussion. We propose the term "parabolic crack" for these fractures.

2.2. Experimental testing

Fig. 2 illustrates the shape of the parabolic crack and marks its axis of symmetry. Based on our observations, we hypothesized that this axis indicates the direction of percussion. To test this, in the first place, we built a device with which a flat flint surface can be struck after predetermining the direction and inclination.

For this purpose, we have designed a "percussion machine" (Fig. 3) consisting of a rotating and tilting turntable (Fig. 3B), where the flint fragment (Fig. 4) is placed. A hammer percussor above (Fig. 3A) it falls by gravity vertically on to the fragment, and, therefore, the direction

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