The Movius Line controversy: the state of the debate

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Abstract

Patterns of Palaeolithic variability between eastern Asia and western portions of the Old World continue to engender controversial discussion. Most famously, debate has focused on variability in the absence/presence of 'handaxes' east and west of the so-called 'Movius Line'. However, it is becoming equally apparent that cross-regional contrasts can be made using categories of data other than handaxe presence/absence alone. This, in turn, is leading to a reconfiguration of the archaeological patterns that demand explanation. Here, we outline the current state of the Movius Line controversy in these terms, and undertake a series of metric analyses of eastern and western biface samples. This leads us to highlight specific lines of enquiry that may be important for future attempts to address these enduring questions.

Keywords

East Asia; Southeast Asia; Movius Line; Acheulean; handaxes.

Introduction

> Perhaps the most salient feature characterizing the Lower Paleolithic culture complex of Southeastern Asia, Northern India and China as a whole is the *absence* of certain characteristic types of Lower Paleolithic implements (hand-axes and Levallois flakes), as much as it is the *presence* of others (choppers and chopping-tools).
>
> (Movius 1969: 72, emphasis in the original)

> [I]t seems very unlikely that this vast area [East and Southeast Asia] could ever have played a vital and dynamic role in early human evolution, although very primitive

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> forms of Early Man apparently persisted there long after types at a comparable stage of physical evolution had become extinct elsewhere.
>
> (Movius 1948: 411)

In the 1940s, Hallam Movius (1944, 1948) published the first comprehensive synthesis of the Early Palaeolithic stone-tool industries from East, Southeast and South Asia.[1] The primary lithic toolkits Movius studied were the Soanian (Pakistan, northern India), Choukoutienian (northern China), Anyathian (Burma – now Union of Myanmar), Patjitanian (Indonesia) and Tampanian (Malaysia).[2] Noting the morphological similarities in these stone-tool industries, Movius (1944, 1948) considered all the industries to be representative of an overall chopper-chopping tool culture that was prevalent during the Palaeolithic in eastern Asia and very different from the western Old World. Movius explained this archaeological patterning by stating 'that one of the most vital reasons why the cultures considered here are different from the classical developments found elsewhere possibly lies in the fact that we are also dealing with men belonging to a different branch of the human stock from that found outside the Far East' (1948: 408). In other words, in Movius' view, hominins in eastern Asia were both behaviourally and biologically differentiated from penecontemporaneous hominins from the western Old World.

One of the primary observations that Movius (1944, 1948, 1969) drew from his synthesis was that the lithic toolkits from East and Southeast Asia appeared to lack classic Acheulean bifacially worked implements (i.e. picks, cleavers and especially handaxes) and Levallois cores and flakes (Clark 1994; Hou et al. 2000; Lycett 2007; Lycett and Gowlett 2008; Lycett and Norton 2010; Norton 2000; Norton and Bae 2009; Norton and Lycett 2010; Norton et al. 2006; Pope and Keates 1994; Schick 1994; Wang 2005; Wang et al. 2008). These observations led Movius to draw an arbitrary line between modern-day India and East and Southeast Asia (Fig. 1), with handaxe sites in western Europe, the Levant, Africa and India and chopper-chopping tool sites in East and Southeast Asia.

By the 1960s the term 'Movius Line' had entered the archaeological lexicon (Coon 1965: 48) as a means of referring to this putative line of geographic demarcation between western and eastern portions of the Pleistocene Old World. Indeed, Odell noted some time ago that the Movius Line 'must hold some kind of record for longevity' (1983: 195). Today, the term 'Movius Line' continues to appear in student-orientated textbooks (e.g. Cartmill and Smith 2009: 274; Cela-Conde and Ayala 2007: 237; Klein 2009: 281), encyclopaedia entries intended for a wider audience (e.g. Norton and Lycett 2010), as well as dedicated regional surveys (e.g. Dennell 2009: 187). Such persistence is despite calls from some for the term to be abolished (e.g. Gamble and Marshall 2001; Leng and Shannon 2000; Yi and Clark 1983).

Within the last decade, analyses and discoveries relevant to the Movius Line controversy have continued to appear (e.g. Derevianko 2008; Hou et al. 2000; Lycett and von Cramon-Taubadel 2008; Lycett and Gowlett 2008; Norton et al. 2006; Norton and Bae 2009; Petraglia and Shipton 2009; Wang 2005; Wang et al. 2008; Xie and Bodin 2007). In this paper, we wish to view the Movius Line in historical perspective, but consider specifically what implications its historical legacy has for archaeological discussion today. We place this historical perspective alongside a review of our current knowledge of the Palaeolithic record of eastern Asia, contrasting it with what is known

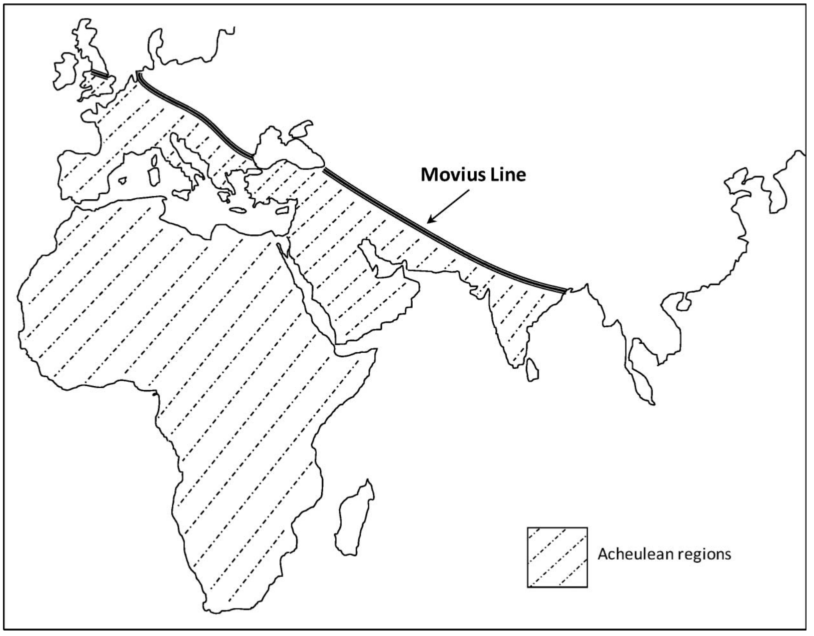

Figure 1 A typical depiction of the Movius Line as originally conceived (*sensu stricto*).

from the West. In considering both the historical aspect and the current knowledge of archaeological patterning, we support arguments that the term 'Movius Line' should be replaced by the term 'Movius Line *sensu lato*' (Norton et al. 2006). We also briefly review the arguments that have been put forward to explain the Movius Line, and undertake a series of metric analyses in order to shed further light on relevant issues. We conclude by suggesting future lines of enquiry that may move the debate still forward.

From Movius Line *sensu stricto* to Movius Line *sensu lato*

From its very conception, the Movius Line has been associated with what can be interpreted as negatively judgemental connotations. For instance, Movius described the lithic assemblages of eastern Asia as 'monotonous and unimaginative' and representative of 'a region of cultural retardation' (1948: 411). While it is always difficult to determine precisely what an individual in another era was intending in their writings, many subsequent commentators on the Movius Line have highlighted such phrases (e.g. Leng and Shannon 2000; Yi and Clark 1983) and there is clearly potential for such negative connotations to drive perceptions and interpretations of the Movius Line as much as archaeological considerations (Lycett and Norton 2010). Indeed, it was Carlton Coon (1965: 48) who first proposed in his book *The Living Races of Man*, dedicated to Movius, that the archaeological contrast between western and eastern archaeological records was 'a geographical frontier that we shall call Movius's Line, after its discoverer'. Coon was a racial typologist who argued that 'sapienization' occurred in living human populations at different times (Caspari 2003). For anthropologists trained in recent years, it is perhaps difficult to read phrases such as we 'find on the other side [of the Movius Line] a much simpler racial situation' (Coon 1965: 125), or talk of 'Caucasoid elements breaching the Movius Line' (1965: 138) or '[e]ast of the Movius Line, light and light-mixed eyes are virtually nonexistent' (1965: 235), without pause. What this reinforces, we contend, is that connotations wider and other than purely lithic artefacts may have driven perceptions about what the 'Movius Line' is or represents. In turn, such considerations may also have driven calls to eradicate the line from the archaeological lexicon.

In general, much of Movius' original archaeological observation on the East and Southeast Asian Early Palaeolithic, however, still holds true. After more than sixty years of further detailed research, it is evident that the Early Palaeolithic stone-tool industries of eastern Asia are dominated by core and flake tools (originally Movius' chopper and chopping tools), which are made on locally available raw materials of varying quality and typically, although not exclusively, have few invasive flakes (Corvinus 2004; Gao and Norton 2002; Ikawa-Smith 1978; Leng and Shannon 2000; Reynolds 2007; Schick and Dong 1993). After about 40 thousand years ago (kya), blade and microblade technologies appear in Northeast Asia, while in Southeast Asia core and flake tools continue to appear into the Terminal Pleistocene (Bae 2010; Gao and Norton 2002; Norton and Jin 2009; Marwick 2008). Moreover, no conventional Levallois flakes or cores have been identified in East Asia prior to around 30 kya (Brantingham et al. 2001; Gao and Norton 2002; Madsen et al. 2001) and Levallois technology remains absent from the Korean record (Norton 2000).

It should be noted that Movius (1944) discussed the presence of a small percentage of Acheulean-like handaxes in eastern Asia, particularly in the Patjitanian (Pacitanian) lithic assemblage from Java (now Indonesia). At the time, little was known regarding the date and/or geological context of these artefacts, a problem that continues to the present (e.g. Dennell 2009: 427–8; Reynolds 1993). Among the 2,419 Pacitanian lithics Movius studied, 153 were identified as 'handaxes' (6.32 per cent of the total lithic collection). However, Movius was quite clear in his belief that these Javanese 'handaxes' were different when he stated that 'there is nothing characteristically Acheulean about the Javanese specimens. Rather, they recall an extremely crude series of Abbevillian types' (Movius 1944: 92). Furthermore, because of this morphological variation, Movius (1948) suggested this might be a case of independent evolution. Indeed, Movius stated that, in his view, 'the Patjitanian type of hand-axes with longitudinal flaking may have developed independently in Java' (1944: 92). This point concerning parallel or independent evolution for handaxes from eastern Asia was again more recently raised by Schick (1994, 1998) and Lycett and Norton (2010). Another major observation by Movius (1944) was that if Acheulean bifaces are present in a region, then Levallois cores and flakes are almost always present in overlying stratigraphic levels. Thus, it has been argued that Levallois technology evolved directly from the earlier Acheulean bifacial traditions (Movius 1944, 1948; Lycett 2007; Schick 1998).

In the years following Movius' detailed synthesis, further bifacially worked implements began appearing in different regions of East and Southeast Asia, particularly at places like Dingcun (Movius 1956), Chongokni (Bae 1988; Norton 2000; Norton et al. 2006; Norton and Bae 2009; Yoo 2007), Bose Basin (Hou et al. 2000; Wang et al. 2008), Luonan Basin (Wang 2005) and Indonesia (Movius 1944; Simanjuntak et al. 2010). This has led some researchers (e.g. Gamble and Marshall 2001; Yi and Clark 1983) to argue that we should discard the concept of the Movius Line altogether. Indeed, there has been recent support for the argument that the eastern Asian handaxes are morphologically similar to implements from the western Old World. For example, univariate and bivariate metric analyses by Wang (2005) and Petraglia and Shipton (2009) led them to conclude that the bifaces from the Chinese Luonan Basin and the Korean Imjin/Hantan River Basins (notably Chongokni and Kumpari) fall within the range of certain handaxe assemblages known from the west (but see Norton and Bae 2009). Furthermore, Simanjuntak et al. (2010: 420) recently concluded that 'the Pacitanian (and other Indonesian) handaxes ought to be classified as ''normal'' handaxes' and Mishra et al. (2010) additionally argued that the Javanese handaxes are similar to Indian bifaces. Unfortunately, morphometric data for the Javanese material have not been published nor are there published comparative, quantitative analyses of the relevant artefacts from the key regions to support these suppositions. We hope in the future that quantitative data from the Pacitanian 'handaxes' are subject to full comparative study. We do note, however, that the presence of Levallois in overlying deposits at these Pacitanian sites has not been reported.

Despite the evidence that handaxes are now known from eastern Asia, it should be noted that these bifacially worked implements are found in relatively low frequencies, in relatively restricted areas at only a few localities scattered throughout East and Southeast Asia. In the Imjin/Hantan River Basin (Korea), for example, where bifaces have been reported at higher frequencies than other sites, such artefacts still represent less than 5 per cent of the total knapped stone artefacts (Bae 1994; Lycett and Norton 2010; Norton et al. 2006). In a similar manner, Simanjuntak et al. (2010) have recently reported that in the Bakosa valley (Indonesia), where handaxes are found at higher frequencies than other Indonesian localities, such tools still represent less than 7 per cent of the total artefacts. Such findings suggest a similarly low representation of handaxes compared with other stone tools throughout East and Southeast Asia. Although it is not unknown for sites west of the Movius Line to exhibit similarly low percentages of handaxes (or indeed an absence of bifaces), Acheulean sites in Africa, Europe and western Asia have all produced examples of localities where handaxe tools predominate (Clark 1994; Dennell 2009). Moreover, as we discuss further below, several key metric indices have been shown to be morphologically distinct in comparative analyses of eastern and western Old World bifaces (Lycett and Gowlett 2008; Norton et al. 2006; Norton and Bae 2009). Indeed, although Simanjuntak et al. (2010) have suggested that the Indonesian artefacts 'ought to be classified as ''normal'' handaxes' they go on to note that '[t]he Indonesian handaxes are generally crude and their shaping is frequently limited to the distal and median parts'. For these reasons, we have argued elsewhere (e.g. Lycett and Norton 2010; Norton et al. 2006; Norton and Bae 2009) that, although a Movius Line in the strict sense of the term is no longer applicable, a Movius Line *sensu lato* (Norton et al. 2006) is supported by the archaeological evidence. This Movius Line *sensu lato* is thus based on four key observations: (1) a lower frequency of handaxe sites in eastern Asia; (2) a lower percentage of handaxes at sites in eastern Asia compared with many coeval Acheulean sites in Africa, western Asia and Europe; (3) the presence of morphological differences between East Asian handaxes and classic Acheulean examples, especially those of Middle Pleistocene age; and (4), in line with the original observations of Movius, a paucity of Levallois (prepared core) technologies in eastern Asia.

Potential explanations for the Movius Line *sensu lato*

The Movius Line *sensu lato* – as was the case with the Movius Line *sensu stricto* that preceded it – is a pattern to be tested and probed. As a conceptual tool, it is useful to the field only if it helps structure questions that might lead (incrementally) to a fuller understanding of the factors that underlie the patterns it describes. Over the years, several potential reasons for a paucity of bifacial handaxes in eastern Asia have been raised (e.g. reviews in Keates 2002; Schick 1994). Many of these reasons still bear careful consideration as potential causes of the Movius Line *sensu lato*, despite the shift in emphasis from the presence of bifaces *per se* to one of understanding differences in the form, relative rarity and low density of distribution of handaxes in eastern Asia. However, because of this shift in emphasis, we have argued (Lycett and Norton 2010) that one particular hypothesis (considerations of demography and related issues of social transmission) can be treated as a null model. We extend the case for this position here by first reviewing the current state of evidence relating to the main hypotheses that have been proposed to explain differences in the archaeological patterns occurring east and west of the Movius Line.

1. The hominin occupation of eastern Asia predates the advent of Acheulean technology

The first appearance of Acheulean technologies in eastern and southern regions of Africa occurred ~1.7–1.6 million years ago (mya) (Asfaw et al. 1992; Gibbon et al. 2009). Dates for the earliest presence of hominins in eastern Asia at Yuanmou (southern China), Majuanggou (northern China) and Sangiran (Indonesia) are still being debated (e.g. see Hyodo et al. 1993, 2002; Swisher et al. 1994; Zhu et al. 2004, 2008). However, if any of the purported 'early' ages (~1.8–1.6 mya) for these sites holds up to further scrutiny, then this would be evidence to support an argument that hominins arrived in eastern Asia prior to the development of Acheulean technology, as noted by Swisher et al. (1994). Such an hypothesis does not, however, explain why the Acheulean tradition did not spread fully into eastern Asia in subsequent millennia, despite its spread from the west into regions such as India (Chauhan 2009; Dennell 2009; Lycett and von Cramon-Taubadel 2008; Lycett 2009a; Petraglia 1998). This hypothesis also does not, in itself, explain the paucity of Levallois industries in the region. Hence, this hypothesis does not appear to explain fully the Movius Line *sensu lato* and its adjunct considerations.

2. Raw material constraints

Movius (1944) noted that the raw materials used to produce the Early Palaeolithic implements in eastern Asia were often low-quality quartz and quartzite. A general argument made, therefore, is that the poor quality of the raw material prohibited the production of refined bifacially worked implements in eastern regions of the Old World.

However, bifacially worked lithics produced on locally available quartz and quartzite river cobbles do exist in eastern Asia (e.g. Zhoukoudian Locality 1, Chongokni, Kumpari). Indeed, Schick (1994: 589) manufactured a highly refined handaxe from tabular limestone collected from a locality close to the site of Zhoukoudian (China). Such tabular limestone is similar to that known from some Acheulean sites such as Isampur in India (Paddayya 2001) suggesting that handaxe-producing hominins were able to recognize the utility of such material for biface manufacture when available. Moreover, as pointed out by Schick (1994), good-quality materials are also readily available in other regions of eastern Asia. Thus, quality of raw material alone does not appear to explain the relative paucity of handaxes east of the Movius Line. Furthermore, it is important to note that Brantingham et al. (2000) have pointed out that the Late Pleistocene occurrence of Levallois (prepared core) technology at Tsagaan Agui Cave, Mongolia appears – ironically – to be in direct response to poor-quality raw material. Hence, raw material quality does not appear to provide a satisfactory explanation for the paucity of Levallois technology east of the Movius Line *sensu lato* either.

3. Geographical and topographical barriers

Besides the clear barrier posed by the Himalaya-Karakoram mountain range and the Qinghai-Tibetan Plateau (Dennell 2009; Norton and Jin 2009), extensive river systems may also have served as barriers to hominin dispersals into eastern Asia (Dennell 2007; Lycett and Norton 2010). For example, the Ganges-Brahmaputra river system in India could have functioned as a formidable impediment (Field and Lahr 2006). In East and Southeast Asia, the Yellow, Yangtze, Irrawaddy and Mekong rivers could also have functioned as major barriers that inhibited population movements and cultural transmission. However, there is clear evidence of normally restricted Oriental biogeographic faunas (e.g. *Bubalus*, *Macaca*) in northern China and Korea during the Middle Pleistocene (Norton 2000; Norton et al. 2010). This indicates that the biogeographic boundary between the Palaearctic and Oriental within eastern Asia oscillated throughout the Quaternary with the changing climatic cycles characteristic of the period (see below). Indeed, despite the potential for barriers to have inhibited hominin population movements out of India – as hinted at by the failure of camels, equids and giraffids to do so (Dennell 2009: 249) – the unequivocal presence of hominins in eastern Asia during the Middle Pleistocene might argue against the relevance of these herbivorous taxa in this regard from a biogeographic viewpoint. Thus, except for the Himalayan and Qinghai-Tibetan Plateau, which were not penetrated until the latter part of the Late Pleistocene (Aldenderfer and Zhang 2004; Dennell 2009; Norton and Jin 2009), 'barriers' in the sense of a total impediment to hominin movements, do not alone appear to provide a full explanation for the Movius Line *sensu lato*.

4. The 'bamboo hypothesis'

Another hypothesis put forward is that, rather than relying on knapped-stone technology, Pleistocene hominins in eastern Asia used bamboo for cutting tools (Boriskovskii 1968; Harrison 1978; Watanabe 1985). Pope (1989) outlines the general argument for this by suggesting that the distribution of bamboo roughly overlaps with Movius' (1948) 'Chopper-Chopping Tool Culture' in eastern Asia. It was noted that exceptions exist in northern China and Korea (e.g. Dingcun, Chongokni) where bifacially worked picks and handaxes have been found, and Pope (1989) attributed these to minor fluctuations in the northern extent of bamboo. However, handaxes were of course known from Southeast Asia since the 1930s (Movius 1944, 1948) and have since been identified in southern China, most notably in the Bose Basin, Guangxi (Hou et al. 2000; Wang et al. 2008).

A further problem with the bamboo hypothesis is that because bamboo is a perishable material, the assertion that Pleistocene hominins extensively exploited it as a resource for cutting tools is difficult to test archaeologically. However, it should be noted that West and Louys (2007) have experimentally shown that cut-marks on bone produced by bamboo can be differentiated microscopically from those of chert flakes, suggesting the exciting possibility that if suitable material is found in the zooarchaeological record, then at least the presence of bamboo cutting tools in eastern Asia might be verified. No such evidence has yet been forthcoming. Perhaps pertinently, West and Louys (2007) also found from their experiments that chert flakes performed butchery activities more quickly and kept their cutting edges longer than bamboo. No direct quantitative comparisons of efficiency in handaxe-like cutting tools versus bamboo tools have yet been reported, although, given differences in weight alone, it is doubtful that the technological performance of these different tool categories will overlap with exact precision. Such considerations are potentially important in evaluating an hypothesis proposing that one technology effectively 'replaced' the other.

The underlying premise of the bamboo hypothesis is that the environment was continuously hot and humid and therefore conducive to the growth and spread of bamboo throughout the Pleistocene of eastern Asia as a whole. However, it should be noted that, even as far back as the 1940s, geologists and Palaeolithic archaeologists working in the region agreed that the environment of eastern Asian was subject to substantial fluctuation. For example, Movius noted that 'ever since Lower Pleistocene (Villafranchian) times in Northern China, the climatic cycle has been interrupted by a series of major fluctuations' (1944: 62; see also Teilhard de Chardin 1941). More recent biogeographic studies (e.g. Jablonski et al. 2000; Norton et al. 2010; Xie et al. 2004) and geoscience research (e.g. Liu 1985; Wang et al. 1997; Yin and Guo 2006) have further shown that the eastern Asian Quaternary environment was subject to periodic fluctuation. Aside from the implications this has for the basic premise implicit in the bamboo hypothesis, it is related to a further problem. There are currently about 1,500 species of bamboo identified throughout South, East and Southeast Asia, with the highest concentration in southern China (Bystriakova et al. 2003; Ohrnberger 1999). Some of these species flower at intervals of 150 years, bloom once and then die. If multiple bamboo taxa in a restricted area flower and die synchronously, then this causes serious problems for the animals that rely heavily on that food item. For example, between 1975 and 1976 at least three bamboo taxa flowered synchronously and died in the Min Mountains (Sichuan Province, China). As a result there was a major die-off of giant pandas (*Ailuropoda melanoleuca*) (138 in total) (Taylor and Qin 1987; Schaller et al. 1985). The same problem could be argued to exist if hominins relied extensively on bamboo. Thus, it might not have been worthwhile, or at least have incurred an increased risk, for early hominins to have relied heavily on bamboo to carry out their routine activities.

Some time ago, Stringer (1990) noted that a putative correlation between bamboo presence and the appearance (or otherwise) of specific stone-tool technologies was difficult to test, not only because of the difficulty of reconstructing the past distribution of bamboo vegetation, but also because of a paucity of chronometric dates for many lithic assemblages in the key regions. In other words, as with attempts to explain breaks in the Acheulean record of other regions by means of ecological factors (e.g. Mithen 1994) establishing a firm causative relationship between putative independent and dependent variables has proven elusive. However, it might be argued that we can indirectly assess the distributional extent of bamboo forests by evaluating the presence/absence of *Rhizomys* (bamboo rat), which feeds primarily on the roots of bamboo (Musser and Carleton 2005). Review of the Chinese Quaternary biogeography indicates that *Rhizomys* is present in northern China only at Middle Pleistocene Zhoukoudian Locality 1 and absent in the Early Pleistocene Nihewan localities and Late Pleistocene Zhoukoudian Upper Cave (Han and Xu 1985; Norton and Gao 2008; Norton et al. 2010).

In sum, the extensive use of bamboo by Pleistocene hominins is yet to be corroborated and putative correlations between bamboo and the presence or absence of specific technological toolkits is not substantiated. Moreover, potential differences in the performance characteristics of bamboo versus handaxe technologies make it difficult to substantiate claims that technologies widespread west of the Movius Line *sensu lato* could readily be substituted by bamboo cutting tools to the east.

5. Demographic and social transmission considerations

The notion that factors concerning the social transmission of techniques and/or traditions of knowledge associated with Acheulean technologies could influence the Movius Line has been mooted by some (e.g. Schick 1994; Schick and Toth 2003). For instance, Schick (1994: 590) argued that, when moving into a new area, a lack of local knowledge on the part of hominins in regard to issues such as raw material sources might lead to a break in the successful transmission of handaxe manufacture to subsequent generations.

In recent years, an increased concern with issues of social (i.e. cultural) transmission in regard to handaxes and handaxe-like artefacts (e.g. Gowlett 1996, 2006; Lycett 2008; Mithen 1994, 1999; Stout 2002, 2005) has mirrored a more widespread recognition in the fields of anthropology, archaeology and psychology that cultural transmission may be modelled as an information transmission system with somewhat similar (although not identical) properties to that of genetic (information) transmission (e.g. Boyd and Richerson 1985; Cavalli-Sforza and Feldman 1981; Durham 1992; Eerkens and Lipo 2007; Henrich 2004; Mesoudi 2007; Neiman 1995; Shennan 2000). In turn, there has been an increase in the use of principles and formal analytical models drawn from the field of population genetics in regard to artefactual variation (e.g. Bentley et al. 2004; Eerkens and Lipo 2005; Hamilton and Buchanan 2009; Lycett 2008; Lycett and von Cramon-Taubadel 2008; Neiman 1995; Rogers et al. 2009; Shennan 2001, 2006).

This increased awareness of the broad similarities between the transmission of genetic information and processes of social transmission has highlighted that – as in the field of population genetics – demographic parameters can have pertinent effects on patterns of cultural variation and change through time (e.g. Henrich 2004; Neiman 1995; Shennan 2000). In particular, it has been noted that in small populations chance (i.e. stochastic) factors will play a greater role in determining which cultural elements will be transmitted to subsequent generations. In other words, the cultural equivalent of genetic drift will be more pertinent in smaller populations, leading to a loss of particular cultural elements (Henrich 2004; Shennan 2000). Moreover, sustained population growth and larger social transmission networks will result in more effective instances of cultural transmission and mitigate the loss of cultural traits via this process of cultural drift (Henrich 2004; Neiman 1995; Shennan 2000). Equally, the successful adoption of novel cultural patterns is highly contingent upon the effective population size (i.e. number of efficient cultural learners and transmitters) (Henrich 2004; Shennan 2001).

Subsequently, we have proposed elsewhere that demographic factors may be an underlying cause of the Movius Line *sensu lato* (Lycett and Norton 2010). Following Henrich (2004) we suggested that the demographic properties of effective population size (i.e. number of skilled practitioners for a given skill), population density and resultant social interconnectedness may be of particular relevance in regard to understanding the Pleistocene archaeological record of eastern Asia. Combining these considerations, we further suggested that factors relating to demography and instances of (in)effective cultural transmission could, in these terms, be taken as a parsimonious null model of technological change during the Pleistocene. Thus, the model predicts that where evidence of population persistency and growth is supported we would expect to see relatively greater incidence of technological innovation and change. Conversely, where there is evidence of *relatively* smaller population sizes, the model predicts potential loss of technological elements and *relatively* lower incidence of technological innovation (see Lycett and Norton (2010) for full discussion). This model may be considered a null model in the sense that while differences in demographic parameters can be taken as axiomatic for hominins widely dispersed in time and space (Lande et al. 2003), cognitive and/or biomechanical parameters that might otherwise affect the appearance or disappearance of technological patterns need not. Hence, the model is parsimonious in regard to these latter factors and – in contrast to many models of Pleistocene technological change – dislocates any automatic link between technological patterns and putative cognitive or biological parameters.

Following Dennell (2003), Lycett and Norton (2010) went on to note that only Africa provides evidence of sustained hominin presence throughout the Pleistocene (although this was not necessarily temporally or spatially homogenous). Moreover, it is notable that, in terms of the crude framework of Clark's (1969) technological lithic 'Modes', Africa provides evidence of major technological innovation in terms of earliest appearance dates for Mode 1 (Oldowan) technology, Mode 2 (Acheulean) technology and some of the earliest dates for Mode 3 (Levallois) technologies. Indeed, Johnson and McBrearty (2010) have recently drawn on similar considerations of demography to explain the occurrence of blade production in the Kapthurin Formation, Kenya at ~500 kya. Hence, there is substantial evidence to suggest that the predictions of Lycett and Norton's (2010) model are supported in regard to the African archaeological record. In contrast to the African situation, Lycett and Norton (2010) detailed evidence suggesting that during much of the

Pleistocene, particular biogeographical, topographical and dispersal factors are likely to have resulted in relatively lower effective population sizes in eastern Asia. In these terms, the archaeological factors associated with the Movius Line *sensu lato* can be interpreted as a 'line' which represents the crossing of a demographic threshold. Under the parameters of the model, the geographically and temporally sporadic occurrences of 'handaxes' in eastern Asia are the product of short-lived instances of convergence with conventional Acheulean examples from west of the 'line', which ultimately do not flourish due to the constraints of relatively smaller effective population sizes. As a consequence, the *in situ* evolution of Levallois technologies is inhibited in eastern Asia. It should be noted that, as is the case with all null models, this is a model to be tested. It is important therefore that the model, as an explanation for the situation in eastern Asia, provides a clear prediction: that is, evidence for lower population sizes should be found east of the Movius Line *sensu lato* especially in comparison with other non-African Acheulean regions such as neighbouring India. It is equally important to note that 'relatively low levels of innovation' is not automatically synonymous with previous notions of 'stagnation'. Hence (*contra* Brumm et al. 2010) such a model is not necessarily at odds with the possibility of regional innovations, merely a recognition of certain constraints on the pattern of such potential innovation within the (extremely) broad limits of a 'Mode 1' technological framework.

A comparative analysis of East Asian handaxes

One essential approach in addressing questions surrounding the Movius Line *sensu lato* is the quantitative comparison of handaxe technologies from the relevant regions in the east and the west (e.g. Lycett and Gowlett 2008; Norton et al. 2006; Norton and Bae 2009; Petraglia and Shipton 2009). Here, we use a larger western Acheulean sample than has been used in these previous analyses ($n = 2925$) in order to compare variation in three key variables (length, width, thickness) against the equivalent variables for two East Asian samples. Data for the western Acheulean sample were taken from Sharon (2007). The data represent a chronologically diverse handaxe sample from various localities across South Africa, East Africa, North Africa, India and the Levant (see Sharon (2007) for full details). The East Asian samples are comprised of handaxes from the Luonan Basin, China ($n = 44$) and a sample from the Imjin/Hantan River Basin (IHRB), Korea ($n = 58$). Data for these localities were taken from Wang (2005) and Norton et al. (2006) respectively. It should be noted that there are a variety of age estimates for Korean bifaces and no reliable age indicator for Luonan, which is obviously of consequence for understanding their importance (or otherwise) in regard to the Movius Line debate (Norton and Bae 2009). However, here we focus solely on the form of the bifaces themselves.

In the first analysis, we used a simple descriptive statistic – the coefficient of variation (CV) – in order to compare general patterns of variation (in the three key variables) as represented by the samples from east and west of the Movius Line *sensu lato*. The CV is calculated by dividing the standard deviation of the sample by the sample mean. The CV may be multiplied by 100 (as here) in order to express mean variation as a percentage. The results of this analysis (Table 1) show that width is consistently the least variable of the

Table 1 Sample sizes (n), mean (mm), standard deviation (SD) and computed coefficient of variation (CV) values for length, width and thickness measures in IHRB (Korea), Luonan (China) and Western Acheulean biface data sets

		Length			*Width*			*Thickness*		
Locality	*n*	*Mean*	*SD*	*CV*	*Mean*	*SD*	*CV*	*Mean*	*SD*	*CV*
IHRB	58	153.86	30.46	19.80	94.16	13.92	14.78	60.19	12.92	21.47
Luonan	44	151.58	32.64	21.53	101.99	13.28	13.02	61.63	12.20	19.80
Western Acheulean	2925	134.37	38.44	28.61	81.35	18.13	22.29	40.38	11.25	27.86

Sources: Western Acheulean data from Sharon (2007); Luonan data from Wang (2005); IHRB data from Norton et al. (2006).

biface handaxe attributes regardless of region. This is a pattern that has previously been demonstrated for Acheulean handaxes (Lycett and Gowlett 2008; McPherron 2006; Vaughan 2001) and is suggestive of a widespread cross-regional functional constraint in terms of biface width (Vaughan 2001). If this supposition is correct, it suggests that bifaces from east of the Movius Line *sensu lato* may have been subject to similar considerations in functional terms as those from the west.

Our second set of analyses was designed specifically to consider factors relating to the potential role of convergence in the East Asian handaxes. As noted earlier, the demography/social transmission null model for the Movius Line *sensu lato* would suggest that the sporadic presence of handaxes in eastern Asia is the result of short-term technological convergence, which ultimately did not flourish due to demographic constraints (Lycett and Norton 2010). Other workers, however, have suggested that the presence of similar artefactual forms east and west of the Movius Line *sensu lato* is suggestive of hominin dispersal(s) from the west into eastern Asia (e.g. Hou et al. 2000; Petraglia and Shipton, 2009). Considerations of handaxe thickness have played a prominent role in these debates (e.g. Norton and Bae 2009; Petraglia and Shipton 2009) since it has sometimes been suggested that handaxes from eastern Asia are generally thicker compared to classic western Acheulean forms (e.g. Keates 2002; Norton et al. 2006; Schick 1994).

In order to shed light on this issue, we undertook a series of inferential statistical tests to determine if thickness in the large western Acheulean sample was significantly different from those of the two East Asian samples. In order to achieve this we utilized the two-tailed *t*-test, whereupon the null hypothesis is that the means in each sample are not statistically different. Since pairwise comparisons were undertaken, only *p*-values of ≤ 0.017 (Bonferroni procedure) were considered statistically significant in order to reject the null hypothesis. The results of this analysis (Table 2) show that mean thickness in the western Acheulean sample is significantly lower than that for either the IHRB sample or the Luonan Basin sample.[3] This supports the premise that East Asian handaxes are generally thicker compared to western Acheulean forms.

Two further analyses were undertaken. First, we compared the CV values for the East Asian bifaces using a statistical procedure termed the D'*AD* test (see Eerkens and Betttinger 2001; Lycett and Gowlett 2008). The null hypothesis in this analysis is that CV values for length, width and thickness are not significantly ($p \leq 0.05$) different. This is potentially important since some workers (e.g. Petraglia and Shipton 2009) have suggested that handaxes from Luonan and those from Korea might be the product of different factors: convergence in the Korean case versus hominin dispersal in the Chinese case. Table 3 shows that CV values for length, width and thickness variables do not differ with statistical significance. This does not support the premise that the Chinese and Korean samples can confidently be regarded as being the product of two separate processes in each case (i.e. convergence versus hominin dispersal). Moreover, we also computed ratios of the mean variables for each of the samples from east and west of the Movius Line *sensu lato* (Table 4). This further demonstrated that both of the East Asian samples are routinely thicker for given length or width values (see data columns 2 and 3 of table 4), while the ratio of width and length is comparatively constant across regions (data column 1 of Table 4).

In combination, our analyses thus suggest that the East Asian handaxes are, on average, a different shape from western examples and that this shape difference manifests itself in a statistically thicker profile. Greater thickness in Acheulean handaxe form is a

Table 2 *t*-test comparisons of mean (mm) thickness values for IHRB (Korea), Luonan (China) and Western Acheulean biface data sets

Thickness comparison	*t*	*df*	*p**
Western Acheulean vs IHRB	13.239	2981	<0.0001
Western Acheulean vs Luonan	12.4204	2967	<0.0001
IHRB vs Luonan	0.57095	100	>0.05
	Mean	*n*	
Western Acheulean	40.38	2925	
IHRB	60.19	58	
Luonan	61.63	44	

Sources: Western Acheulean data from Sharon (2007); Luonan data from Wang (2005); IHRB data from Norton et al. (2006).
Note
*Bonferroni $\alpha = 0.017$.

Table 3 D'AD statistical comparison* of CV values for East Asian biface assemblages ($df = 1$; $\alpha = 0.05$)

	Length		*Width*		*Thickness*	
	D'AD	*p*	*D'AD*	*p*	*D'AD*	*p*
IHRB vs. Luonan	0.32	0.57	0.74	0.39	0.29	0.59

Note
*For details of *D'AD* procedure, see Eerkens and Bettinger (2001); Lycett and Gowlett (2008).

Table 4 Ratios between mean variables east and west of the Movius Line

	Width/Length	*Thickness/Width*	*Thickness/Length*
IHRB	0.61	0.64	0.39
Luonan	0.67	0.60	0.41
Western Acheulean	0.61	0.50	0.30

Sources: Western Acheulean data from Sharon (2007); Luonan data from Wang (2005); IHRB data from Norton et al. (2006).

plesiomorphic trait (i.e. was a feature seen in examples close to the origin of the phenomenon), as indicated by examples such as those from Bed II of Olduvai Gorge (Petraglia and Shipton 2009). It should be noted in this context that 'plesiomorphic' is not necessarily synonymous with 'early', since plesiomorphic features may appear later in an evolutionary sequence via reversions (due to functional reasons or otherwise) towards the characteristics of earlier forms. Greater thickness may also be a feature of unfinished handaxes, but there is no evidence that the East Asian specimens are unfinished (Norton and Bae 2009). Hence, given the rather isolated and sporadic appearance of East Asian handaxes within the context of more widespread non-bifacial assemblages in the region, the most parsimonious conclusion to draw is that this plesiomorphic aspect of East Asian examples is a product of technological convergence with western Acheulean forms. As such, the East Asian material should not be used to support scenarios involving the intrusion of western Acheulean traditions into the region during the Middle–Late Pleistocene.

Conclusions: moving forward with the Movius Line *sensu lato*

For more than sixty years, the observations originally outlined by Movius (1944, 1948) have provoked persistent discussion. Even in the face of new discoveries that challenge the nature of some of Movius' observations, they still look set to incite continued debate over the coming years. In this paper, we have attempted to outline the current state of the Movius Line controversy. On the basis of this, we suggest in closing, future research directions that may be key to addressing the major issues that still remain.

Comparative morphometric assessment of key artefact assemblages from both east and west of the Movius Line *sensu lato* is a research priority in order to determine patterns of similarity and difference with statistical confidence. Unfortunately, quantitative data pertaining to many of the artefacts from eastern Asia remain geographically uneven and are limited to a few key variables (e.g. length, width, thickness). While such analyses are (as we have shown) potentially revealing, there remains considerable scope for improved comparative analysis, especially given recent methodological advances in the analysis of handaxe form (e.g. Archer and Braun 2010; Lycett et al. 2006). Equally, armed with such data, there is the potential to use more direct approaches to assessing potential instances of technological convergence in stone-tool assemblages (e.g. Buchanan and Collard 2008; Lycett 2009b).

As noted above, the demography/social transmission model (Lycett and Norton 2010) predicts that in areas with (relatively) large effective population sizes there will be higher incidences of major technological innovation *vis-à-vis* those with lower demographic levels. Lycett and Norton (2010) argued that evidence from Pleistocene Africa was consistent with this model, while also outlining evidence to suggest relatively lower demographic levels in Pleistocene eastern Asia, which might explain the archaeological patterns described by the Movius Line *sensu lato*. However, it is vital, of course, that the predictions of this model are tested still further. Demography (in terms of population size and density) is a notoriously difficult parameter to determine from archaeological data, a problem compounded when considering the extreme time depth associated with fossil hominin populations. However, recent positive developments in several different chronological and geographic areas demonstrate that research of this nature is not impossible (e.g. Bocquet-Appel et al. 2005; Buchanan et al. 2008; Gkiasta et al. 2003; Grove 2009; Steele and Klein 2006). In addition to spatial data, analyses of this type frequently rely on chronological data and (as we have seen) there is much room for increased resolution of chronological frameworks in eastern Asia, particularly in regard to those datasets of most relevance to the issues under consideration here. Nevertheless, it remains evident that one of the main advantages of the demography/social transmission model is not only its simplicity (i.e. parsimony) of explanation in terms of the patterns described by the Movius Line *sensu lato*, but also that there is an empirically testable prediction (i.e. evidence for demographic levels in Pleistocene eastern Asia should differ statistically from many regions in the western Old World). What recent developments therefore suggest is that with increased knowledge of the archaeological distribution of data in eastern Asia – both in space and time – further testing of the demography/social transmission model will be a vital line of inquiry.

The Indian subcontinent potentially has a key role to play in furthering our understanding of the Movius Line (Petraglia 1998). The region presents something of a paradox in possessing an extensive Palaeolithic archaeological record, yet a dearth of fossil hominin material (Chauhan 2009; Dennell 2009; Korisettar 2007; Petraglia 2006). Equally, the chronology of the region needs to be better understood especially with regard to its Acheulean record (Chauhan 2010; Petraglia 1998, 2006). However, its rich Palaeolithic record and geographic neighbouring of eastern Asia present one of the best opportunities to test parameters with potential relevance for understanding the Movius Line *sensu lato*. This applies both in terms of morphometric interregional artefact comparisons (Lycett and Gowlett 2008; Norton et al. 2006; Petraglia and Shipton 2009) and in terms of testing ideas concerning the role of demographic and social transmission factors.

The particular relevance of data from the Indian subcontinent may be hinted at in some of its particular features that are now becoming more apparent. For instance, a feature of the Late Acheulean going through into the Middle Palaeolithic of India is the occurrence of small or so-called ‘diminutive’ handaxes (Baskaran et al. 1986; Chauhan 2009; James and Petraglia 2005; Jayaswal 1978; Misra 1989; Paddayya 1984; Rajaguru 1985). In any socially transmitted technology, imperceptible copying errors occur and accumulate through time (Eerkens and Lipo 2005). In regard to continuous, quantitative attributes, the accumulation of copying error is proportional to the mean size of attributes exhibited in the previous generation (Hamilton and Buchanan 2009). Hamilton and Buchanan (2009: 56–60) have shown via mathematical modelling and simulations, that due to the accumulation of such copying errors, under conditions of either biased or non-biased transmission, a default position for a long-lived socially transmitted lithic technology undergoing drift is a trend towards negative drift or, quite simply, a reduction in mean artefact size through time. Dennell has noted that '[a]n inescapable aspect of South Asian geography is that India is difficult both to enter and to exit' (2009: 393). The presence of diminutive bifaces in the Late Acheulean of India might therefore be seen as the inevitable outcome of cultural drift, with no external input in terms of socially transmitted diversity and little loss of diversity due to migration. Although this supposition requires further empirical support, it reiterates strongly the region's importance in regard to key issues of relevance to the Movius Line *sensu lato*, especially when combined with new theoretical and methodological tools.

In a recent biography of H. L. Movius, Bricker noted that there 'is no question that Hallam Movius is better known for the Movius Line than for anything else' (2007: 8). As highlighted in the two quotes from Movius cited at the beginning of this paper, the nature of this 'line' has since been subject to reconfiguration and, as a result, the pattern to be understood has somewhat shifted. However, it is evident that many of the questions that Movius' observations provoked are still inspiring research, and will continue to do so for a future generation of Palaeolithic scholars.

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Notes

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1 'Early' Palaeolithic following the two-stage cultural model (Early/Late) proposed by Ikawa-Smith (1978), Gao and Norton (2002) and Norton et al. (2009).

2 Other lithic industry terms have since been added to describe the East and Southeast Asian material (e.g. Chongoknian, Hoabinhian, Lannathaian, Fingnoian, Tampanian; for a review, see Bae 1994; Pope and Keates 1994). It should also be noted that the term

Patjitanian is now spelled Pacitanian, and since the time of Movius the site of Choukoutien has been renamed Zhoukoudian.

3 Repeating this analysis using a larger sample size of handaxes from the Luonan Basin, China (n = 236) for the thickness (only) value reported by Petraglia and Shipton (2009) results in an identical statistical pattern (Luonan vs. Western Acheulean: $df = 3159$; $t = 23.3125$; $p < 0.0001$; IHRB vs. Luonan: $df = 291$; $t = 0.90935$; $p > 0.05$).

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