THE MIDDLE TO UPPER PALEOLITHIC TRANSITION FROM THE LEVANT TO CENTRAL EUROPE: IN SITU DEVELOPMENT OR DIFFUSION?

Gilbert Tostevin

The effort to understand the Middle to Upper Paleolithic transition has been hampered by an overemphasis on the comparison of the Middle Paleolithic record as a whole to the Upper Paleolithic record as a whole. The broad distinctions thus found, however, cannot be as readily recognized when comparing the earliest Upper Paleolithic assemblages to their immediate Middle Paleolithic predecessors (Straus 1983). This generalized approach has resulted in our failure to understand the specific mechanism by which the Upper Paleolithic replaced the Middle Paleolithic on the Pleistocene landscape (Gilman 1983; Harrold 1991). Since we can only attempt to understand why a phenomenon occurred by first determining how it occurred (Kroebber 1931), we must address both the historical events as well as the processes of culture change in order to understand the significance of the Middle to Upper Paleolithic transition in the course of human evolution.

The recent debate (d’Errico et al. 1998; Mellars et al. 1999) over the Neanderthal acculturation hypothesis (Klein 1973; Harrold 1989; Mellars 1993; 1996, 411) has successfully highlighted the question of the process of culture change. The debate has focused, however, almost exclusively on southwestern France and northern Spain. As the “big picture” of how the Middle to Upper Paleolithic transition occurred can only be answered by synthesizing a series of “little”, regional pictures (Harrold 1991), we must recognize the fact that this debate will not reach a positive conclusion until multiple regions are included in the assessment of each hypothesis. A body of interpretive theory designed to give meaning to patterning across multiple regions is clearly called for in order to test the archaeological record against hypotheses of how the transition occurred. The present article represents a movement in this direction.

The Neanderthal acculturation debate points to another difficulty that has plagued research on the transition. The unit of analysis in this debate is the industrial type, specifically the Châtelperronian, Aurignacian, and MTA. The ubiquitous problem of defining acceptable limits to industrial variability, however, remains ignored. How many times has someone dismissed data from an assemblage dating to the transition by claiming that the assemblage is not a true Aurignacian! Constraining assemblage variability into industrial types when we specifically want to understand change in hominid material culture behavior only serves to distort our view of the transition.

The methodology advocated here seeks to remedy this problem by relying on the behavioral procedures which created the material culture as the units of analysis for investigating change between assemblages through time and space. For lithic artifacts, these units of analysis are the specific steps within the lithic operational sequences or chaînes opératoires of the assemblage, covering the technological spectrum from the selection of the raw material, preparation of the core, production of debitage blanks, placement of retouch and resharpening, to the eventual discard of the artifacts. Whether the variability in material culture operational sequences is termed “equifinality,” “technological style” (Lechtman 1977), or “technical choice” (Lemonnier 1986; 1992), the behavioral approach relies upon the concept that two production sequences can produce the same morphological shape and that such variation between equally valid options is learned between generations, creating
material culture traditions. This approach is the central tenet of the following discussion.

This paper reports on a research project in which 18 archaeological assemblages dating between 60 and 30 kya in three regions of western Eurasia were analyzed in order to identify which flintknapping behaviors changed during the Middle to Upper Paleolithic transition and to compare the sequences of these diachronic behavioral changes within and between each region to determine how the transition occurred. Specifically, this research tests three hypotheses concerning change in flintknapping behaviors between 60 and 30 kya in Central Europe, Eastern Europe, and the Levant:

- Hypothesis 2 (Diffusion): flintknapping behaviors changed due to the spread of behaviors from one region to another as a result of either population movement and/or the diffusion of isolated behaviors.
- Hypothesis 3 (Combination): flintknapping behaviors changed due to independent innovation in one or more regions with the subsequent diffusion of the behaviors into adjacent regions.

The regions of Central Europe (specifically, the Czech Republic), Eastern Europe (western Ukraine), and the Levant (Israel) are used for two reasons. First, the archaeological record of these regions spans the apparent east to west geographic progression of radiometric dates for the appearance of the earliest Upper Paleolithic industries (Bischoff et al. 1989; Straus 1989; 1994; Kozlowski 1990; Otte/Keelely 1990; Mellars 1993; 1996; Bar-Yosef et al. 1996; Mellars et al. 1999). Second, a morphological similarity between several of the earliest Upper Paleolithic or transitional industries in these regions has already been noted. K. Valoch (1990) first noticed the similarity between the industry of Brno-Bohunic (Valoch 1976), which became known as the Bohunician (Oliva 1979; 1984; Svoboda 1984), and the transitional industry of Boker Tachtit Level 1 (Marks 1983) in the southern Levant. Subsequently, scholars such as J. Kozlowski, Y. Demidenko, and V. Usik presented syntheses which argued that these similar industries represent one entity, a particular stage in the development of the transition (Kozlowski 1992; Ginter et al. 1996; Demidenko/Usik 1993A). The meaning of these patterns has yet to be investigated.

Ideally, Anatolia and Southeastern Europe should also be part of such a study, but the paucity of data in the former region, and the fact that the material from Temnata Cave is still under study by the excavators, precludes their inclusion in this paper. The sample of assemblages (Tab. 1) was chosen to cover the range of time between 60 and 30 kya in order to cover the regional variation before, during, and after the "transition" so that any changes are placed in their proper context (Kuhn 1995, 5). The assemblages were also chosen to represent variation due to different landscape uses. Thus they include open-air sites as well as cave sites, and raw material workshops as well as typologically heavily-reduced assemblages. The sampling strategy also attempted to include industrial variability known to exist in each region.

1. Expectations of the three hypotheses

The three hypotheses described above were tested by assessing the goodness of fit between the archaeological record and a series of model expectations derived from a combination of archaeological (Andrefsky 1987; Willey et al. 1956; Lechman 1977; Stark 1998), history of science (Gille 1978; Basalla 1988), and social anthropological thought (Steward 1929; Kroeber 1931; 1940; Kluckhohn 1936; Barnett 1953; Rands/Riley 1958; Lemonnier 1992) concerning the problem of distinguishing diffusion from independent innovation. The first step in this methodology is the description of the operational sequence for each assemblage. The second step is the comparison of the detailed operational sequences for assemblages that succeed each other through time within the same region, taking into account possible multi-phylum scenarios. Determining which flintknapping behaviors in each step of the operation sequence appeared for the first time in a particular region or disappeared in later assemblages in that region produces an intra-regional sequence of behavioral change. The third
<table>
<thead>
<tr>
<th>SITE</th>
<th>LAYER</th>
<th>DATE</th>
<th>CURATION &amp; REFERENCES</th>
</tr>
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<tbody>
<tr>
<td><strong>LEVANT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boker Tachtit</td>
<td>2</td>
<td>33,055 ± 4,100</td>
<td>Israel Antiquities Authority, Romema, Jerusalem. (Marks 1983; Marks/Volkman 1983; Volkman 1983, 1989).</td>
</tr>
<tr>
<td>Kebara</td>
<td>Unit VI MP</td>
<td>42,500 ± 1,800</td>
<td>Hebrew University, Jerusalem. (Bar-Yosef et. al. 1996; Bar-Yosef/Belfer-Cohen 1988).</td>
</tr>
<tr>
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<td>Unit IV Ahmarian</td>
<td>36,000 ± 1600</td>
<td>Hebrew University, Jerusalem. (Bar-Yosef et. al. 1996; Bar-Yosef/Belfer-Cohen 1988).</td>
</tr>
<tr>
<td>Kebara</td>
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<td>Hebrew University, Jerusalem. (Bar-Yosef et. al. 1996; Bar-Yosef/Belfer-Cohen 1988).</td>
</tr>
<tr>
<td>Kebara</td>
<td>Unit II Levantine Aurignacian</td>
<td>38,500 ± 1000</td>
<td>Institute of Archaeology, Dolni Vestonice, Czech Republic (Svoboda 1983; Svoboda/Simon 1985; Svoboda 1989; Svoboda 1991; Svoboda/Skrdla 1995).</td>
</tr>
<tr>
<td>Kebara</td>
<td>Unit I Levantine Aurignacian</td>
<td>36,000 ± 1600</td>
<td>Historical Museum of L’viv, Ukraine. (Chernysh 1987; Ivanova/Chernysh 1965; Klein 1973).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EASTERN EUROPE</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Korolevo I</td>
<td>Ia 1</td>
<td>38,500±1000</td>
<td>Institute of Zoology, Kiev, Ukraine. (Gladilin 1989a; Gladilin/Demidenko 1989; 1990; Usik 1989).</td>
</tr>
<tr>
<td>Vedrovice V</td>
<td>Szeletian</td>
<td>37,650 ± 550</td>
<td>Moravské zemské Muzeum, Brno, Czech Republic. (Valoch 1984).</td>
</tr>
<tr>
<td>Kůlna Cave</td>
<td>7a Micoquian</td>
<td>50/53kya ± 5/6 kya</td>
<td>Moravské zemské Muzeum, Brno, Czech Republic. (Valoch 1967, 1988). This is an average value from ten ESR dates with Early Uptake and Linear Uptake (Rink et. al. 1996).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CENTRAL EUROPE</th>
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</table>

Tab. 1 Assemblages. All Dates are radiocarbon unless otherwise noted. Industrial affiliations are for descriptive purposes only.

The step is accomplished by comparing which knapping behaviors in each step of the operational sequence appeared and disappeared through time between adjacent regions, i.e., comparing the intra-regional sequences to produce an inter-regional sequence of change.

The final step in testing the hypotheses is the evaluation of the inter-regional sequence against the following five model expectations. Each expectation is based upon a theoretical principle which predicts how the intra-regional sequences and
inter-regional sequence should appear given Hypothesis 1 (Innovation) or Hypothesis 2 (Diffusion). As Hypothesis 3 (Combination) is the logical extension of Hypothesis 1 in some regions and Hypothesis 2 in others, it is not treated separately in the following description of the model expectations.

Expectation Number 1 (Technological Style). This expectation asserts that material culture traditions can be described based on the variation in how artifacts are made and this “technological style” of different traditions can be used to recognize the difference between an internal and external origin for a particular artifact or trait (Lechtman 1977). As applied to lithic material culture, this expectation is based upon the results of experiments on flake fracture mechanics (Speth 1972; 1974; 1975; 1981; Bonnichsen 1977; Dibble/Whittaker 1981; Cotterell et al. 1985; Dibble/Pelcin 1995; Pelcin 1996) that have demonstrated that a flintknapper has control over a number of independent operational steps during the process of making stone tools. Since each step of the operational sequence contains a number of equivalent options (sensu Sackett 1990, 33), the identification of the specific choices characteristic of an assemblage can be used to construct a unique behavioral signature for that assemblage. For example, since morphologically identical Levallois points can be produced on either bidirectional or unidirectional cores, the consistent choice of one of the two options for the direction of core exploitation can be used to characterize an assemblage. This flexibility in the flintknapping system provides the mechanism by which gradual changes among the equally valid options in operational sequences accumulate through time.

When applied to the archaeological record, this expectation predicts that different operational sequences in adjoining regions are most likely the result of independent innovation. Conversely, similar operational sequences between adjacent regions would support the diffusion hypothesis. It must be emphasized that this expectation cannot distinguish between an example of independent innovation and an example of stimulus diffusion (Kroeber 1940), which is a variant of diffusion in which the shape of an artifact spreads between regions without the exact manufacturing process. Since the “technological style” expectation is based on differences in how artifacts are made rather than their final form, any case of stimulus diffusion which occurred during the transition would bias the result in favor of independent innovation.

Expectation Number 2 (Antecedents). This expectation asserts that “...any innovation is made up of preexisting components...No innovation springs full-blown out of nothing; it must have antecedents...” (Barnett 1953, 181). Therefore, the presence or absence of specific flintknapping behaviors of a lithic operational sequence in a region can be used to judge the probability that a subsequent operational sequence appeared in that region through independent innovation or diffusion. This assertion is corroborated by social anthropology (Kluckhohn 1936; Kroeber 1940), history of science (Basalla 1988, 49, 55), and archaeological theory (Willey et al. 1956; Andrefsky 1987). Thus, the presence of antecedent elements for the behaviors in a given lithic operational sequence increases the likelihood that independent innovation was the mechanism by which the operational sequence appeared in that region, while decreasing the likelihood that diffusion played a role.

Expectation Number 3 (Number of Changes). This expectation asserts that a few flintknapping behaviors found in two operational sequences in adjoining regions can be explained by independent innovation but as the number of such shared behaviors increases, so does the improbability of their independent recurrence (Taylor 1896; Andrefsky 1987). Therefore, a quantitative measure of similar knapping behaviors between assemblages can be used to judge the parsimony of the competing hypotheses.

Any quantitative method, such as counting similar behaviors in two assemblages, must use independent units so that the presence of one unit does not affect the appearance of another unit and bias the result (Rands/Riley 1958). Bias due to the interdependence of units of analysis, known as Galton’s Problem (Tylor 1889 in Moore 1961; Thomas 1986, 448), is reduced in lithic technology by using the results of fracture experiments that have shown that flintknapping steps related to platform treatment, external platform angle, platform thickness, dorsal scar ridge morphology, and
subsequent placement of retouch are all functionally independent and together determine the morphology of each flake and tool (see Pelcin 1996). This independence allows quantification of similar behaviors between assemblages to be used to test the competing hypotheses.

Expectation Number 4 (Number of Domains). This expectation asserts that a diffusion event causes many more types of material culture to change at one time than an innovation event (Linton 1936, 372; Lechtman 1977). This is due to the fact that although an instance of innovation in one material culture domain, ceramics for instance, may affect another material culture domain, such as metallurgy, it is unlikely to affect several independent domains simultaneously. Thus, one can use the number of independent material culture domains that show changes at the same time as an indicator of a diffusion event. While the Paleolithic record possesses one major material culture domain, lithic technology, the principle of this expectation can nevertheless be applied by viewing independent flintknapping domains as analogous to independent material culture domains. The independence on a flake-by-flake basis of the knapping operations discussed above allows the division of the operational sequence into roughly independent domains of knapping behavior: core modification, platform maintenance, direction of core exploitation, blank morphology production, and tool manufacture. The comparison of assemblages' operational sequences by means of these five domains of knapping behavior allows the quantification of the number of domains with similar knapping behaviors between two assemblages to be used to evaluate the competing hypotheses. Thus, this expectation predicts that the likelihood of the diffusion hypothesis increases, and the innovation hypothesis decreases, in proportion to the number of the five knapping domains which possess behaviors shared between assemblages in adjoining regions.

Expectation Number 5 (Parsimony of the Inter-regional Sequence). This expectation predicts that the multi-regional patterning of behavioral changes between 60 and 30 kya should document a historically logical sequence of movements between adjacent regions if diffusion were the mechanism for the appearance of the behavioral changes. Conversely, it predicts that independent innovation is more probable given a temporally and geographically sporadic appearance of dissimilar behaviors on the multi-regional scale.

2. Description of Operational Sequences

In order to identify past choices made during the flintknapping process, each lithic assemblage in this paper was studied using an attribute analysis designed to isolate specific steps in the flintknapping process. Many of these attributes were selected from the wealth of published research on lithic technology, including Baumler (1988), Bergman (1967), Bordes (1961), Crew (1975), Dibble (1995), Dibble/Whittaker (1981), Geneste (1985), Henry (1989), Hours (1974), Kuhn (1990, 1995), Meignen (1995), Movius et. al. (1968), Ohnuma (1986), Pelcin (1996), Speth (1981), Tixier et. al. (1980), Van Peer (1992), and Volkman (1989). This methodology (Tostevin 2000a) was applied to the debitage, tools, and cores of each assemblage (or a representative portion of the excavated assemblage, depending upon the state of curation of the collection), resulting in over 9,000 artifacts studied with over 50 attributes noted for each. The analysis of the attributes then proceeded by univariate tests and comparisons of pairs of flake and core attributes. Additional information from published refitting studies was incorporated into the description of the operational sequences.

3. Comparison of Operational Sequences

The three competing hypotheses were evaluated by testing the goodness of fit between the archaeological record and the predictions of the five model expectations. The demonstration of this assessment here would require, unfortunately, too much space due to the lengthy description and comparison of the operational sequences of all 18 assemblages. Please see Tostevin (2000b) for the detailed discussion of each
operational sequence, as well as Tostevin (in prep.) for the data and analysis specific to the Levantine sample. Limiting the evaluation to those assemblages dating between 60 and 40 kya in each region, however, is an appropriate way of explaining the results of this study. First, however, it is necessary to introduce the method used in this study to compare operational sequences.

Table 2 presents the results of a comparison of the operational sequences of the assemblages from Kůlna Cave, layer 7a (Valoch 1967; 1988), and Stránská skála IIIa level 4 (Svoboda/Svobodová 1985; Svoboda/Simán 1989; Svoboda 1983, 1991; Svoboda/Škrda 1995; Škrda 1996). The lithic data collected from each assemblage was organized into the individual steps of the operational sequence. The first column of (Tab. 2) lists each knapping step in the sequence, separated into the five behavioral domains which fracture experiments have shown to be independent (Speth 1972; 1974; 1975; 1981; Bonnichsen 1977; Dibble/Whittaker 1981; Cotterell et. al. 1985; Dibble/Pelcin 1995; Pelcin 1996). The next two columns contain a characterization of the cumulative behaviors used by the knappers for each step of the sequence in the production of the two assemblages, respectively. These characterizations usually consist of a measurement of the central tendency of the variability within the particular knapping step. It is necessary to average out the variability within each step since one can find almost every knapping option used, if only to a small extent, in any given assemblage. The fourth column contains my judgment of the significance of any difference between the Kůlna 7a option and the Stránská skála IIIa level 4 option for each step in the operational sequence. This judgment is qualitative or quantitative, depending upon the nature of the type of lithic data available; steps related to data taken from cores is often qualitative while steps related to data taken from flakes and tools is mostly quantitative. A "p" value in this column indicates the probability that the data obtained from the two assemblages were derived from the same random sample (i.e., produced by the same behaviors); a significance level of 5% is used for all statistical tests. The specifics of the test, either the student's t or G2 likelihood ratio (approximating the chi-square distribution) (Sokal/Rohlf 1969), is given in the following description of each knapping domain and its steps.

To produce a quantitative measure of the difference between assemblages, one cannot simply sum up the number of operational steps in which a significant difference is judged to exist between the two options as this would bias the results through the interdependence of the units (Galton's Problem). In order to quantify the pair-wise assemblage comparisons, therefore, the knapping steps in which significantly different options were used between assemblages are first summed within their specific flintknapping domain (i.e., within the independent categories of core modification, platform maintenance, direction of core exploitation, blank production, and tool manufacture) and divided by the total number of steps within that domain. The resulting numerical value of all five domains are then summed up to produce a measure ranging from 0 (for assemblages with identical operational sequences) to 5 (for entirely different operational sequences). This procedure thus scales the measure of difference according to the variability seen between these five knapping domains and removes the problem of interdependent variables.

The first domain, "core modification," concerns the initial removals of flakes which delineate the knapping surfaces of the core. The first step in this domain, labeled "core orientation," is characterized by the qualitative distinction between different core forms. In the case of Kůlna 7a, a predominately unifacial discoidal form was evidenced in the majority of cores, and thus is a different variant of the technology Boeda (1993) observed within this assemblage but comparable to that seen at the Middle Paleolithic sites of La Borde and Mauran (Jaubert et al. 1990; Jaubert 1993). In the majority of the Stránská skála IIIa level 4 cores, a quite different, longitudinal blade/flake core form is evidenced. The second step in this domain, labeled "core management," includes the knapping options which allow the knapper to continue reducing the core form to exhaustion through specific modifications of the surface convexities. In the case of Kůlna 7a, core management proceeded by centripetal removals from predominantly one face, made at an acute angle to the plane of the core, which constantly refreshed the convexity of the surface. The Stránská skála IIIa
<table>
<thead>
<tr>
<th>FLINTKNAPPING STEPS BY DOMAIN</th>
<th>Kulna 7a</th>
<th>Stránská skála IIIa-4</th>
<th>Significant Change?</th>
</tr>
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<tbody>
<tr>
<td>Core Modification</td>
<td>Unifacial Discoidal</td>
<td>Longitudinal</td>
<td>Yes</td>
</tr>
<tr>
<td>Core Management</td>
<td>Centripetal removals, secent surfaces</td>
<td>Débordants &amp; side blade removals</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Changes/2 Steps</td>
<td>2/2 = 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platform Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platform Treatment</td>
<td>Unprepared: 58% n=167</td>
<td>Unprepared: 58% n=448</td>
<td>No p=.90</td>
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<tr>
<td>Prepared: 42%</td>
<td></td>
<td>Prepared: 42%</td>
<td></td>
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<tr>
<td>External Platform Angle (degrees)</td>
<td>mean: 83.8, s.d.: 14.8, n=153</td>
<td>mean: 83.2, s.d.: 15.3, n=425</td>
<td>No p=.31</td>
</tr>
<tr>
<td>Platform Thickness</td>
<td>mean: 9.08, s.d.: 4.63, n=153</td>
<td>mean: 4.8, s.d.: 2.5, n=433</td>
<td>Yes, p=.00</td>
</tr>
<tr>
<td>Number of Changes/3 Steps</td>
<td>1/3 = 0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direction of Core Exploitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direction of Cortex Removal</td>
<td>Unidirectional changing to Crossed</td>
<td>Unidirectional</td>
<td>Yes</td>
</tr>
<tr>
<td>Direction of Blank Removal</td>
<td>Subcentripetal changing to Unidirectional</td>
<td>Bidirectional changing to Unidirectional</td>
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</tr>
<tr>
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<tr>
<td>Laminarity: Length/Width Ratio</td>
<td>mean: 1.44, s.d.: 0.49, n=273</td>
<td>mean: 1.7, s.d.:0.67, n=543</td>
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<tr>
<td>Lateral Edges of Blanks</td>
<td>Parallel: 54% n=198</td>
<td>Parallel:49% n=514</td>
<td>Yes p=.01</td>
</tr>
<tr>
<td></td>
<td>Convergent: 23%</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Expanding: 20%</td>
<td>Convergent: 24%</td>
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</tr>
<tr>
<td></td>
<td>Ovoid: 13%</td>
<td>Expanding: 18%</td>
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<tr>
<td>Profile of Blanks</td>
<td>Straight: 64% n=225</td>
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<td>Twisted: 14%</td>
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<tr>
<td>Cross-Section of Blanks</td>
<td>Triangular: 39% n=231</td>
<td>Triangular:44% n=527</td>
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<td></td>
<td>Trapezoidal: 54%</td>
<td>Trapezoidal: 51%</td>
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<tr>
<td></td>
<td>Other: 7%</td>
<td>Other: 5%</td>
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<tr>
<td>Convexity: Width/Thickness Ratio</td>
<td>mean: 2.83, s.d.: 1.06, n=273</td>
<td>mean: 3.99, s.d.: 1.82, n=543</td>
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</tr>
<tr>
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<td>Tool Manufacture</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Selection for Laminarity of Blanks</td>
<td>Same as Debitage, p=.67</td>
<td>More Laminar, p=.05</td>
<td>Yes</td>
</tr>
<tr>
<td>Selection: Length</td>
<td>Same as Debitage, p=.17</td>
<td>Longer, p=.00</td>
<td>Yes</td>
</tr>
<tr>
<td>Selection: Width</td>
<td>Same as Debitage, p=.17</td>
<td>Wider, p=.00</td>
<td>Yes</td>
</tr>
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<td>Selection: Thickness</td>
<td>Same as Debitage, p=.12</td>
<td>Thicker, p=.00</td>
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<tr>
<td>Selection: Dorsal Scars</td>
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<td>Bidirectional, p=.00</td>
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<td>Selection: Cortex</td>
<td>Same as Debitage, p=.07</td>
<td>Non-cortical, p=.00</td>
<td>Yes</td>
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<td>Selection: Axis of Propagation</td>
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<td>Same as Debitage, p=.31</td>
<td>No</td>
</tr>
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<td>Same as Debitage, p=.49</td>
<td>No</td>
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<td>Selection: Distal Terminus</td>
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<td>Same as Debitage, p=.38</td>
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</tr>
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<td>Same as Debitage, p=.49</td>
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<td>Same as Debitage, p=.30</td>
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<td>Prepared, p=.00</td>
<td>Yes</td>
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<td>Selection: Impact Placement</td>
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<td>Same as Debitage, p=.17</td>
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<td>Same as Debitage, p=.16</td>
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</tr>
<tr>
<td>Unique Types of Retouch</td>
<td>Flat bifacial retouch</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Tool Types</td>
<td>MP tools dominate</td>
<td>UP tools dominate</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Changes/16 Steps</td>
<td>10/16 = 0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Measure of Difference Weighted by Behavioral Domains</td>
<td>3.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
level 4 cores evidenced, through both the attribute analysis and P. Škrdla's refittings (Svoboda/Škrdla 1995; Škrdla 1996), management of the convexities through lateral débordant removals and, in particular instances, the subsequent removal of blades from the lateral, narrow side of the core, situated 90 degrees to the previous surface. This is a peculiarity of the Bohunician industry (see Ginter et al. 1996). A significant difference is qualitatively judged to exist between the two options taken by the Kůlna Layer 7a and the Stránská skála IIIa level 4 knappers in this step.

The next knapping domain, "platform maintenance," includes the steps whereby the flintknapper modifies the platform surface and platform edge before each removal. These steps included platform treatment options (being "prepared" with different types of scarring and faceting or "unprepared" for plain and cortical platforms), external platform angle, and platform thickness (all dimensional variables used in this study are given in millimeters). The latter two choices together determine the mass of the resulting flake (Dibble/Pelcin 1995). The significance of the difference in the options exercised within the two assemblages is determined through a G² likelihood ratio test for platform treatment and t-tests for the other two steps. In the case of the Kůlna layer 7a and Stránská skála IIIa level 4 comparison, only mean platform thickness is significantly different, due to Kůlna's much thicker platforms.

The next knapping domain, "direction of core exploitation," concerns the variability resulting from different options of removing flakes from single to multiple platform cores, creating debitage with particular dorsal scar patterns. The dominant strategy used in each assemblage was determined using the principles of dimensional change during core reduction (Holmes 1919; Frison 1968; Newcomer 1971; Collins 1975; Jelinek 1976; Stahle/Dunn 1982; Henry 1989; Dibble 1987) and cortical change of debitage during core reduction (Sullivan/Rosen 1985; Geneste 1985; Mauldin/Amick 1989; Bauml 1988; Ahler 1989, 1989b; Dibble 1995). As a core is reduced, it becomes shorter due to platform rejuvenation and the general subtractive nature of flintknapping. As the core gets shorter, so do the flakes struck off the cores. Thus, assuming that the general trend is for longer blanks to be produced earlier in core reduction and shorter blanks to be produced later, with the understanding that no particular blank can be absolutely placed in a stage of reduction based on its length, a correlation between debitage length and debitage dorsal scar pattern in an assemblage can indicate whether a change of directional strategy during the continued reduction of the cores occurred. For example, a strong change in dorsal scar pattern is evidenced in the non-cortical debitage from Stránská skála IIIa level 4. The dorsal scar pattern of the longest blanks is primarily bidirectional, while the frequency of unidirectional scar patterns increases as flakes decrease in size. This strong trend in the debitage data indicates that cores were initially exploited bidirectionally and as they became smaller, they were exploited unidirectionally. It is thus more parsimonious to conclude that one reduction strategy was used, shifting from bidirectional to unidirectional reduction, than that two separate reduction strategies existed. A similar principle holds for the relationship between percentage of cortex and debitage length. The debitage of Kůlna layer 7a, for instance, indicates that blanks with the most cortex were produced unidirectionally, while perpendicular scar patterns (i.e., one lateral direction plus the direction of the flake propagation) become dominant as the percentage of cortex decreases. For the non-cortical debitage from Kůlna, the largest non-cortical blanks are subcentripetal, while the smaller ones are unidirectional, suggesting a shift from a centripetal to a unidirectional strategy throughout the exploitation of the cores. Both of these directional options were judged to be significantly different between the Kůlna and Stránská skála IIIa assemblages.

The "blank production" domain includes the five knapping steps which determine the morphological shape of the debitage products as determined by the nervure-guide or ridge pattern of the core exterior (sensu Van Peer 1992). These steps are quantified by the following debitage attributes: lateral edge type, profile type, and cross-section type. The significance of different options for these three attributes is determined through a G² likelihood ratio test. The significance of the convexity and laminarity measurements, both characterizations of the tendencies to remove particular volumes of stone, is determined using a t-test.
<table>
<thead>
<tr>
<th>Regional Sequence of Change</th>
<th>Comparison of Assemblages Through Time</th>
<th>Measure of Difference (Maximum=5, Minimum=0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Europe</td>
<td>Kulina 7a versus Stránská skála IIIa-4</td>
<td>3.76</td>
</tr>
<tr>
<td></td>
<td>Stránská skála IIIa-4 versus Stránská skála III</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Stránská skála III versus Vedrovice V</td>
<td>3.22</td>
</tr>
<tr>
<td></td>
<td>Kulina 7a versus Vedrovice V</td>
<td>3.64</td>
</tr>
<tr>
<td></td>
<td>Vedrovice V versus Stránská skála IIIa-3 &amp; IIa-4</td>
<td>2.91</td>
</tr>
<tr>
<td></td>
<td>Stránská skála III versus Stránská skála IIIa-3 &amp; IIa-4</td>
<td>2.93</td>
</tr>
<tr>
<td>Levant</td>
<td>Kebbara VI versus Boker Tachtit I</td>
<td>4.33</td>
</tr>
<tr>
<td></td>
<td>Boker Tachtit 1 versus Boker Tachtit 2</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Boker Tachtit 2 versus Boker Tachtit 4</td>
<td>2.33</td>
</tr>
<tr>
<td></td>
<td>Boker Tachtit 2 versus Kebara IV</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>Kebbara IV versus Kebara III</td>
<td>3.04</td>
</tr>
<tr>
<td></td>
<td>Kebara III versus Boker Tachtit 4</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td>Kebara III versus Kebara II</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>Kebara II versus Kebara I</td>
<td>1.51</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>Molodova V-11 versus Korolevo II-III</td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td>Korolevo II-II versus Korolevo I-1a</td>
<td>1.25</td>
</tr>
<tr>
<td>Inter-Regional Sequence</td>
<td>Boker Tachtit 1 versus Stránská skála IIIa-4</td>
<td>1.93</td>
</tr>
<tr>
<td></td>
<td>Stránská skála IIIa-4 versus Korolevo II-II</td>
<td>1.93</td>
</tr>
<tr>
<td></td>
<td>Stránská skála IIIa-4 versus Korolevo II-II</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>Kebara I versus Stránská skála IIIa-3 &amp; IIa-4</td>
<td>1.81</td>
</tr>
</tbody>
</table>

Tab. 3 Measurement of the Difference in Flintknapping Behaviors between Sample Assemblages.

The final domain in the lithic operational sequence is "tool manufacture." The first step within this domain consists of the knappers' selection of particular blank types to retouch into tools. The potential selection criteria include dimensions (length, width, thickness, etc.) as well as shape attributes (distal terminus type, profile, lateral edges, etc.). For each assemblage, each potential criterion for blank selection is statistically tested for deviation between the tool sample and thedebitage sample. The remaining two steps within the tool manufacture domain relate to qualitative issues of retouch. The first of these steps treats tendencies in retouch placement, characterized roughly by the dominance of Upper Paleolithic versus Middle Paleolithic
tool types. This judgment is made using the Bordes and Hours type-lists. The second step differentiates retouch types, a qualitative operation to be sure but potentially meaningful given the appearance of such different retouch applications as the flat bifacial retouch of the Central European Micoquian and Szeletian industries and the carinated retouch of Aurignacian industries.

The final measure of difference between the operational sequences of Kůlna layer 7a and Stránská skála Illa level 4, weighted by the five knapping domains, produces a value of 3.76 out of a possible maximum difference of 5.0, indicating that the operational sequences are more than moderately distinct.

4. A QUANTITATIVE ASSESSMENT OF THE INTRA-REGIONAL SEQUENCES

Table 3 presents the measure of difference between pair-wise comparisons of assemblages through time within each of the three regions and between specific assemblages between regions. Following the comparison of Kůlna 7a and Stránská skála Illa level 4, the next pair-wise comparison, between Stránská skála Illa level 4 and the temporally subsequent assemblage in the Czech Republic, the Bohunician from Stránská skála III, demonstrates a very close similarity of 0.98. The minor difference between Bohunician assemblages is mainly due to the more highly retouched condition of the later assemblage. When we place these measures of difference in their regional and temporal context, we see that a marked change in flintknapping behaviors occurred between the activities which created the assemblage of Kůlna layer 7a and those which created the Bohunician assemblages of Stránská skála III and Illa.

When this measure of difference is applied to the Levant, it shows the last Middle Paleolithic assemblage, Kebara Cave Unit VI, and the first non-Middle Paleolithic (or transitional) assemblage, Boker Tachtit level 1, to be more different than are the Central European Micoquian and the Bohunician, producing a value of 4.33 (the highest value in the study). The agreement between the transitional levels of Boker Tachtit 1 and 2, however, is extremely close (0.33), closer than that between Bohunician assemblages.

The Eastern European sequence shows a similar pattern as the other regions: a marked contrast between the last Middle Paleolithic assemblage, Molodova V level 11, and the first non-Middle Paleolithic assemblage, the transitional Korolevo II Complex II (3.44). The agreement between Korolevo II Complex II and Korolevo I layer 1a is much closer (1.25).

5. ASSESSMENT OF THE INTER-REGIONAL SEQUENCE

Moving to the inter-regional comparison, pair-wise comparisons between Boker Tachtit level 1 and the first Bohunician assemblage (producing a value of 1.93) and between Boker Tachtit level 1 and the first non-Middle Paleolithic assemblage in Eastern Europe, Korolevo II Complex II (producing a value of 1.93), are extremely surprising given the geographical separation. The first comparison is almost as close as between the Bohunician assemblages themselves (0.98) or between the directly stratified Levantine Aurignacian assemblages (1.51). The Boker Tachtit level 1 to Stránská skála Illa level 4 value is almost as close as the value between the European Aurignacian and the Levantine Aurignacian (1.81). These comparisons point to a common behavioral pattern appearing after the last Middle Paleolithic assemblage in each region.

It must be stressed that this measure of difference compresses all of the variation existing between two operational sequences into a single value, simplifying the differences; it is useful, however, for viewing the rough intra-regional and inter-regional patterns (see Tostevin 2000b for the detailed comparisons). When one examines the actual behavioral options employed in each of the assemblages' operational sequences to determine which knapping options appeared and
Levant

Kebara Cave Unit VI
Core Modification: Broad-face Orientation; Débordant Core Management
Platform Maintenance: Prepared Platforms, ~87 degree External Platform Angle, ~5 mm Platform Thickness
Direction of Core Exploitation: Unidirectional changing to Subcentripetal Cortex Removal, Independent Unidirectional & Bidirectional Blank Removal
Blank Production: Varied Lateral Edges, Straight Profile, Length/Width Ratio of 1.78, Width/Thickness Ratio of 5.18
Tool Manufacture: Levallois flakes & sidescraper tool kit

Boker Tachtit Level 1
Core Modification: Longitudinal Orientation; Débordant & Frontal Crest Core Management
Platform Maintenance: Plain & Facetted Platforms, ~88 degree External Platform Angle, ~4 mm Platform Thickness
Direction of Core Exploitation: Unidirectional Cortex Removal, Bidirectional changing to Unidirectional Blank Removal
Blank Production: Parallel & Convergent Lateral Edges, Length/Width Ratio of 2.25, Width/Thickness Ratio of 4.43
Tool Manufacture: Emireh points, Levallois points, & endscraper tool kit

Eastern Europe

Molodova V Level 11
Core Modification: Broad-face Orientation; Core Management by Débordant & Centripetal Removals
Platform Maintenance: Facetted Platforms, ~86 degree External Platform Angle, ~6 mm PT
Direction of Core Exploitation: Centripetal Cortex Removal, Subcentripetal changing to Centripetal Blank Removal
Blank Production: Varied Lateral Edges, Length/Width Ratio of 1.78, Width/Thickness Ratio of 4.94
Tool Manufacture: Mousterian points & sidescraper tool kit

Korolevo II Complex II
Core Modification: Longitudinal Orientation; Débordant & Frontal Crest Core Management
Platform Maintenance: Plain Platforms, ~90 degree External Platform Angle, ~8 mm PT
Direction of Core Exploitation: Unidirectional Cortex Removal, Bidirectional changing to Unidirectional and Crossed Blank Removal
Blank Production: Length/Width Ratio of 1.71, Width/Thickness Ratio of 4.10
Tool Manufacture: Flatly-retouched Foliate points & UP endscraper tool kit

Central Europe

see Table 2 for Kűlna Cave Layer 7a and Stránská skála IIIa Level 4

Tab. 4 Operational Sequences for particular Assemblages dating between 60 & 40 kya
**Bohunician Behavioral Package**

*Core Modification*: Longitudinal Orientation; Débordant & Crested Blade Core Management  
*Platform Maintenance*: Plain & Facetted Platforms, ~86 degree External Platform Angle, ~4 mm PT  
*Direction of Core Exploitation*: Unidirectional Cortex Removal, Bidirectional changing to Unidirectional Blank Removal  
*Blank Production*: Length/Width Ratio of 1.80, Width/Thickness Ratio of 4.25  
*Tool Manufacture*: Levallois point & endscraper tool kit  
*Assemblages*: Boker Tachtit 1 & 2, Stránská skála Illa-4 & Illa-III, Korolevo II-II, Brno-Bohunice, possibly Kulychivka lowest complex (Demidenko & Usik 1993b), possibly Temnata Cave Layer VI, Sector TD-II (Ginter et. al. 1996), and possibly Korolevo I-2B (Demidenko & Usik 1993a).

**Aurignacian Behavioral Package**

*Core Modification*: Longitudinal Orientation; Front & Rear Crest Core Management  
*Platform Maintenance*: Plain & Linear Platforms, ~83 degree External Platform Angle  
*Direction of Core Exploitation*: Unidirectional Cortex Removal, Independent Unidirectional (Dominant) & Bidirectional (Minority) Blank Removal  
*Blank Production*: Straight & Twisted blanks, Length/Width Ratio of ca. 2.10, Width/Thickness of ca. 3.75  
*Tool Manufacture*: Carinated endscraper & burin tool kit  
*Assemblages*: Kebara Units II & I, Stránská skála Illa-4 & Illa-3, possibly Bacho Kiro Layer 11 Levels I-IV (Kozlowski/Ginter 1982), and possibly Temnata Cave Layer 4 Sector TD-I (Ginter et. al. 1996).

**Tab. 5** Knapping Behaviors of the Two Diffusive Behavioral Packages

disappeared through time within and between adjacent regions, one sees that the three terminal Middle Paleolithic operational sequences differ greatly from each other (Tab. 4). One also sees that the behavioral options employed in the different steps of the operational sequences of Boker Tachtit level 1, Stránská skála Illa level 4, and Korolevo II Complex II (the first non-Middle Paleolithic assemblages in each regions) are predominantly the same. The similarities are found in a very specific combination of knapping options in many steps of the operational sequence (Tab. 5).

Examining the presence and absence of antecedent elements for the flintknapping options employed in each assemblage (Tab. 4), it is apparent that few antecedents can be found for the behaviors used in the operational sequences of these three post-Middle Paleolithic assemblages within the last Middle Paleolithic assemblage of each region (Tostevin 1999; 2000a; 2000b). For instance, the shift from a unidirectional to a unidirectional method of core exploitation, as seen in Boker Tachtit level 1, Stránská skála Illa level 4, and Korolevo II Complex II, is not seen in any of the preceding Middle Paleolithic assemblages in any of the three regions. Similarly, no evidence of the recurrence or clustering of the specific knapping options seen in these three later assemblages (Tab. 5) is seen in the earlier assemblages.

Due to the lack of antecedents in each region (Expectation 2) and the high number of similar knapping options (Expectations 1 and 3) used in all five independent domains of the operational sequence (Expectation 4) evidenced in Boker Tachtit level 1, Stránská skála Illa level 4, and Korolevo II Complex II, parsimony favors the conclusion that all of these assemblages possess the same behavioral
package as part of their operational sequence. While the entire operational sequence is not exactly the same in each assemblage, one would not expect them to be, given the tendency for diffused behaviors to deviate through time and space, a process Deetz and Dethlefsen called the Doppler Effect (1965). Regardless of this expected deviation, they are still startlingly alike. Furthermore, the temporal and geographic progression of the appearances of these particular assemblages is indeed historically logical (Expectation 5). This cluster of knapping options, labeled the “Bohonician Behavioral Package,” appears first in the Levant at 47/46 kya, possibly next in the Balkans if the preliminary results from Temnata Cave layer VI, sector TD-II (Ginter et al. 1996) are confirmed, next in Central Europe at 41 kya, and finally in Eastern Europe by 38 kya. The geographic trajectory is even more complete in Eastern Europe if the highly suggestive but extremely preliminary reports on the lowest complex of Kulychivka (Savich 1975; Demidenko/Usik 1993b) and Korolevo layer 2b (Gladilin 1989a; 1989b; Gladilin/Demidenko 1989; 1990; Usik 1989; Demidenko/Usik 1993a) are confirmed. It must be emphatically stressed that this label is NOT a new industrial type but merely a noun to describe this particular grouping of knapping behaviors.

While the data presented in this paper are limited to assemblages dating between 60 & 40 kya, the results of this research project demonstrate the diffusion of another behavioral package, presented in Table 5, which unites a series of assemblages dating between 36 and 30 kya, and which have been traditionally labeled “Aurignacian.” The set of knapping options that appears together in all three regions may be termed the “Aurignacian Behavioral Package.”

6. Conclusions

The goodness of fit between the archaeological pattern of behavioral change and the five model expectations supports the diffusion hypothesis (Hypothesis 2) rather than the independent innovation hypothesis (Hypothesis 1). The third hypothesis, a combination of the first two, is also unlikely as none of the three regions possess antecedent behaviors for either behavioral package. One may hazard a guess that the Bohonician Behavioral Package came from the hole in our data represented by Anatolia but this will remain a theory until more data from this region is available. Similarly, our data set is still too poor to identify a source of origin for the Aurignacian Behavioral Package.

While other regions are likely to have witnessed quite different processes of change, for instance the Crimea (Chabai this volume; Marks/Monigal this volume), the intriguing result of this study is the fact that the Middle to Upper Paleolithic transition in these three regions appears to result from the diffusion of TWO behavioral packages, the earlier appearing between 46 & 42 kya and the later appearing between 36 and 32 kya. It is also interesting that the first diffusion event, the Bohonician Behavioral Package, did not apparently reach Western Europe and does not appear to have contributed its particular technological style to the subsequent Upper Paleolithic industries of Central and Eastern Europe (although there is evidence that it contributed to the later Levantine Upper Paleolithic). The role played by the Bohonician Behavioral Package in these regions was thus not a herald of the “whole” Upper Paleolithic phenomenon but a particularistic first step within a process that led to the Upper Paleolithic.

The implications of these results for the debate over the origins of anatomically modern humans (Stringer/Andrews 1988; Thorne/Wolpoff 1992) are not entirely straightforward. Certainly, the two diffusion events evidenced between 60 and 30 kya in these three regions disprove the archaeological expectations of behavioral continuity argued by Clark and Lindy (1989a; 1989b) in favor of the Multi-Regional Hypothesis. These results, however, do not provide conclusive archaeological confirmation of the Out of Africa Hypothesis since the two diffusion events may be the result of either population movement or the diffusion of isolated behaviors (i.e., “ideas”). While one might be able to distinguish between population movement and
isolated behavioral diffusion in complex societies (since they possess many independent material culture domains such as ceramics, metallurgy, art, architecture, and writing), our control over the chronology (Pettitt, this volume) and resolution of Paleolithic assemblages is far too inadequate to enable this distinction. Nevertheless, the fact that these regions witnessed behavioral discontinuity is consistent with the Out of Africa Hypothesis.

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