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Chronology of the Dutch Neolithic Bandkeramik Culture: a new attempt

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in memory of prof.dr P.J.R. Modderman

An analysis and statistical comparison of the ceramics from 23 LBK sites in the Netherlands resulted in a chronological scheme based exclusively on the evolution of the pottery decoration. This scheme is meant to replace the Modderman 1970 scheme, which mixes heterogeneous data sets. My analyses consistently point to spatula forms, zonation and components of the decoration, and complexity of the rim decoration as indicators of the evolution of the pottery decoration over time. Chronological ordering of the finds yields the important result that the earliest LBK sites in the Netherlands occur on both sides of the Meuse River, equal scores suggesting a single colonization event. The ordering also suggests a slightly later end to the Dutch LBK than the closure of the Elsloo cemetery; again, 'latest' finds occur on both sides of the Meuse River. The quantitative distribution of the find units on the chronological axis confirms the division into two periods of the north-western LBK.

1 Introduction

Recently I had the opportunity to analyse the ceramics from twelve older unpublished or under-published Bandkeramik excavations in the Netherlands (a so-called Odyssey Project; Van Wijk and Amkreutz, in print), among them the 1925 excavations by Holwerda on the Belvédère headland near Maastricht. This provided the occasion for an updated chronological overview of the Dutch branch of the Early Neolithic Linear Pottery Culture (or 'LBK', for Linearband Keramik), as in the preceding years I had been analysing, counting and coding most published ceramic complexes of this culture in the Southern part of the Netherlands, from the cemetery at Elsloo to the settlement on the Janskamperveld near Geleen, and several more (sources are listed separately below).

2 The present state of the Dutch and north-western LBK-chronology

Research into the Early Neolithic Bandkeramik in the Netherlands (and the north-western LBK (NW-LBK) between Cologne and Brussels in general) is hampered by a wiggle in the calibration curve (5210-5060 BCE) right in the centre of the chronological distribution of this culture; only its earliest beginnings and latest manifestations can be reliably dated. Moreover, organic materials have been badly preserved in the decalcified loess soil of the area, hence dendrochronological dating is not feasible either. In the German Rhineland, immediately to the east of the Dutch LBK territory and home to closely related LBK groups, the well at Erkelenz-Kückhoven provided firm tree ring dates, from which the beginning of the LBK in the area was estimated at around 5230 BCE. This was later amended to 5220 BCE through six AMS readings on grain from the bottom of pits along the earliest houses at the Geleen-Janskamperveld site (Van de Velde 2008a, 217). The demise of the LBK is also fixed by reference to the same Kückhoven well to around 5000 BCE (Lanting and Van der Plicht 2002, 44; Lüning 2005). It is generally agreed that the graves in the Elsloo cemetery constitute the latest traces of this culture on Dutch soil (Brinkman and Modderman 1970). The recently excavated Beek Erdwerk stands a chance of being even younger, but it only yielded a typological dating of a decorated sherd to the final LBK-2d phase, yet no "scientific" proof can be quoted (Van de Velde *et al*. 2009).

Within these chronological bounds of the local LBK, developments and facts have to be interpolated by other means, ^{14}C being of no avail (discussion in Lanting and Van der Plicht 2002). Traditionally the decoration on the sherds left by this culture is invoked to this end. Buttler and Haberey (1936) described the first systematic attempt in the Köln-Lindenthal publication. Mainly on choro-stratigraphic arguments, they worked out a chronological scheme based on the classification of the ribbons in the decoration. After his excavations at Elsloo and Stein in the 1950s, the Buttler and Haberey scheme was (unintentionally[1]) reworked by Modderman to a means to chronological differentiation for the NW-LBK that has been in general use until recently (Modderman 1970, esp. p. 122). Like its predecessor, it was largely based on a phenomenological analysis of the strips or ribbons (hence Linear Band Keramik) that make up the decoration on the bellies of the pots of this culture. For the older parts of the scheme, where the differences in decoration were not so clear cut, it relied on developments in the architecture of the longhouses (Modderman 1970, 125-131). Still implicit in Modderman's account, the statistical implications and possibilities were fully developed by Dohrn-Ihmig,

then one of the research fellows attached to the Aldenhovener Platte Project of the Archaeological Institute of the University of Cologne (Dohrn-Ihmig 1974; 1976). When computers were introduced into archaeological research, Stehli – similarly working on the Aldenhovener Platte Project – refined and extended the Modderman scheme to incorporate larger amounts of data, first only towards local relative chronologies (Stehli 1982; 1988), later also in interregional comparative studies (Stehli and Strien 1986). Others followed suit (e.g. Claßen 2006), modifying and extending the framework of the 14 'types' originally defined by Buttler and Haberey, to 18 in the Modderman classification, and 30+ in Stehli's early setup, to over eight hundred "characteristics" (Kneipp 1998; his definitions of these marks take up a full 54 pages). The Stehli-scheme was quite influential in other areas and adjacent periods as well (e.g. Spatz 1996, with 81 pages (!) of "type" definitions to analyse southern German Middle Neolithic pottery).

Several objections to this development can be framed, both from methodological and from practical viewpoints. Practically, the more recent classificatory schemes are hardly or not manageable by other researchers than their authors, if only because of their formidable extent. Therefore, the results cannot readily be checked, a scientific original sin. Of course, this sticks much less to the Buttler/Modderman/early-Stehli schemes, which can easily be mastered by anyone interested in LBK problems. The main methodological problem, however, is that one never knows whether all possibilities have been included, whence overlaps or in-betweens tend to be incorporated in the type-lists until counting 800-plus "types" – some of which being indicative of one single pot's decoration only. Then, as already recognised by Dohrn-Ihmig, the reference by Modderman to house architectural details to underpin the first phases is awkward, as the latter are frequently unavailable and substantially questionable as they presuppose neat and synchronic transitions from one type of construction to another.

Contemporaneous with Dohrn-Ihmig's and Stehli's reworking of the Modderman scheme, Modderman encouraged me to take another direction and to set up a classificatory scheme, which would answer my objections to his'. Inspired by analyses of geometrical decorations at large (e.g. Shepard 1954, 255-305) on the one hand, and the structuralists' basic notion that social life is patterned in space and time (Lévi-Strauss 1955; 1958), I developed an analytical classificatory scheme which answered all mentioned problems (Van de Velde 1976; 1979, 13-25) – yet it was not accepted by the wider community. Without entering into specialities, my basic point was (and is) that decoration is a systematic composition of different independent variables each with its own independent development over time. In the case of Bandkeramik pottery decoration, the layout or format of the field of decoration, the auxiliary constructions, techniques of application, main motif definition and structure, the different elements, which are part of the decoration, are conspicuous variables. Each of these variables has alternative manifestations or mutually exclusive attributes, e.g. single or twin- or multi-dented spatula define the execution of the technique variable, presence or absence of neck decoration (next to the ever present belly decoration) make up the variable zonation, etc. As it appeared when confronted with real data, many of these variables had no clear meaning outside the decoration. Two of them, however, could be tied to important social dimensions (esp. kinship; this was recently followed up and extended by a.o. Claßen 2006; Frirdich 2005). In addition, three or four of these newly defined variables proved chronologically relevant: techniques, general layout or zonation, the components of the decoration, and the differentiation of the rim decoration. The attributes of these variables vary systematically and independently over time and space; instead of variables, they also could be called 'habits of decorating the pots', their single attributes expressing their frequencies over time in so-called "battleship curves" (e.g. Dohrn-Ihmig 1976). Below, I will restrict my writing to these four variables.

Time can be imagined as a sequence of things happening one after another, and the act of decorating a pot can be framed as an expression of how this should be done at that place and moment in time. Therefore, difference in the decorative repertoire is an indicator of a difference in place and/or time. This implies that by quantifying the differences, it should be possible to obtain a relative ordering in time through statistical manipulation (I will not consider spatial variation here: most sites in this text are only a few kilometres apart). With more observations, this manipulation seeks to arrange the quantified descriptions of the individual complexes in such a way that differences between neighbouring rows are as small as possible so that smooth transitions appear and no 'jumps' remain – which should be the mirror of the 'systematic change' referred to in the previous paragraph. Applying this procedure to all of the LBK pottery decoration available then yields a (pseudo-) chronological ordering of the units.

3 On statistical methods

To obtain an ordering of the counts as indicated above, several statistical methods are available (see, e.g. Ihm 1978; 1983; Thomas 1986); the oldest one is seriation, developed in the early years of the 20th century by Sir Flinders Petrie as a means to sequence a set of Egyptian graves. In a table with the graves on the rows and their contents in the columns, columns and rows are shifted in order to get the

largest counts of the characteristics on a diagonal; the sequence of the rows is their chronological (relative) order, so it is claimed. Though laborious, this method can be manually executed when the number of rows and features is not too large; punch cards and knitting needles are indispensable to achieve a result (a late and very explicit example is given in Dohrn-Ihmig 1976, the German label for seriation is *Goldmannsches Verfahren*). With the coming of computers in the 1970s, the procedure was soon programmed, and larger files could be handled relatively easy as well. Yet, both in manual and electronic form, the problem with this method remains to determine the meaning of the ordering: the sequence may just as well signal a gradient of status, or of wealth, as of chronology.

The meaning of the characteristics is not (or at best, hardly) reflected upon either when Correspondence Analysis (CA; in German: KA) is applied, which is a newer and much more sophisticated method of ordering. It is simply stated, not argued that the first or main axis emerging from the computations reflects the chronological ordering of the data. In its theoretical foundations, Correspondence Analysis is quite similar to Principal Components Analysis, discussed below: from a table with finds on the rows and characteristics in the columns new variables ('axes', also 'Eigenvectors') are computed, which group characteristics that have similar distribution patterns in the data. Admittedly, in LBK archaeology chronology is nearly always the most dominant source of variation in the data, given intra-regional datasets, and therefore the chronologies published by Stehli and his successors can be accepted; however, inter-regional analyses are much less reliable. Thus, in Stehli and Strien (1986), SW-German and NW-LBK do not synchronize on the same Eigenvector, and recourse is taken to a reduction of the set of characteristics to the common ones, without much effect, though. In a later publication, Stehli compares a number of data sets – among which Elsloo-Koolweg and Geleen-De Kluis – one by one with the Merzbach (=Aldenhovener Platte) sequence and finds few differences: even the Merzbach settlement phases can be recognized in all datasets involved (Stehli 1994). Again, there is no discussion of either this why selection of the characteristics of the vessel decoration or the variation on the second Eigenvector apparent in his graphs.

Correspondence Analysis has been available from very early on in German computer libraries; in the Netherlands those years we had to make do with the SPSS package in which (then) CA did not figure, and Principal Components Analysis (PCA) was the best approach to the same end. PCA and CA are nowadays widely available, also in the public domain (e.g. in the PAST package employed here). As with CA, PCA seeks to reduce the variation on many variables to a smaller number of axes or 'principal components'. The contribution of each of the original variables to the newly defined components allows interpretation of the latter. For instance, the component (not necessarily the first one) which has high contributions of twin- and multi-dented spatulas, presence of rim decoration, increasing counts of ribbon fillings with hatching or stab-and-drag on the one hand, and single dented spatula, absence of rim decoration, and preponderance of lines in the decoration on the other identifies a component with a strong chronological stamp. In my opinion this explicit dissection of the variability in the data is the main methodological advantage of PCA (and to a lesser extent, of CA as well) over all other methods of data analysis that have been applied to chronological problems. Evidently, Stehli misses the point entirely when he writes, "Surely, the depiction of the facts [by PCA] is pluri-dimensional and does not conform to our idea of the uni-dimensionality of time" (Stehli 1988, 453).

Whatever statistical method of ordering the data is chosen, its result is a relative ordering, and an absolute chronology does not follow. An approximation is possible through the incorporation of associated, well-dated finds on which the ordering can be pinned down. To that end, the finds from Geleen-Janskamperveld, with six reliable AMS-readings of 5220 BCE, may serve as an anchor for the early part of the scale; and the Elsloo cemetery with probably the latest LBK in this area may provide an anchor at about 5000 BCE on the other end of the scale; both datasets have been incorporated in the analysis below.

4 On counting and figures

Statistics is the manipulation of numbers; for reliable results, comparable numbers are required. The units of collection identified by find numbers consist of all things collected from a single archaeological feature like a post hole or a side pit; they are supposed to have been deposited together, or at least within a short time of one another, the so-called 'homogeneous' or 'closed find'. Their contents may differ importantly from one unit to another, in kind as well as quantity, which renders numerical comparison knotty. Moreover, homogeneity is but an assumption, not a fact, admixture cannot be excluded. For that reason not collective pits but individual pots might better be employed to this end (cp. Spatz 1994), with the additional boon that they are comparable in size. Normally, sherds of the same vessel can be singled out without much difficulty; only in the case of very large pits, this poses problems. Yet, complete pots do not occur in LBK settlement debris, only small fractions of the original vessels remain – which again poses problems of comparability. In a pilot study, the surface areas of the sherds deriving from the same pots ('sherd families'; Orton *et al*. 1993) were measured, in order to refer the counts to a fixed standard surface area. It then turned out that the differences between the individual vessels were too large

to allow an ordering of them in a continuous array, decoration is apparently too much a matter of either/or – it is executed either with a single-dented or another type of spatula, it consists either of hatchings or of stab-and-drag points, etc. Therefore, this project had to be dropped. Composite units like finds fare much better in this respect: they assemble different pots with different decorations, which were discarded at about the same date in prehistory, and they tell of the decorative spectrum current at that moment.

What is counted in practice: sherds are first grouped into sherd families (remains of a single pot, each) based on their appearances and feel. Per sherd family, the number of sherds is recorded as a kind of index of the reliability of the counts. In addition, the spatula type with which the decoration has been applied is recorded, as is the general structure of the decoration (i.e. with or without distinct rim decoration). Every single line, point, stab, or hatched line is counted, taking fitting sherds into account as singles; and the set-up of the rim decoration (if any) recorded. These figures constitute the basis of the present analysis. To do away with the undesired consequences of different sizes of the finds, the counts per find are converted to percentages per variable: five sherd families decorated with a simple spatula, three with a twin-dented and two with a five-pronged spatula register as 50%, 30% and 20% respectively on the variable technique of decoration. Similarly so for zonation, components of the decoration, and structure of the neck decoration. Of course, other models of standardization are conceivable: the number of pots represented or sherds present, sherd area, and some more, probably. Percentages have been selected here because they are more easily computed from the raw counts, and allow rapid and simple comparison with other collections than the present one with possibly different conditions of retrieval.

5 On validity, a pilot computation

Table 1 presents the factor loadings meant to convey the structure of the chronological ordering. 'Factor loadings' are the correlations of the original attributes with in this case one of the newly defined 'principal components'; they may take values from +1 (complete agreement as to content and direction) via 0 (no relation, neither in content nor in direction) to -1 (complete agreement, yet in opposite direction). The loadings in the column PCA1 have been computed from 421 finds with full rows of data from eight LBK excavations in Dutch Limburg that have been published previously. Those headed PCA2 derive from 170 full rows in the twelve excavations encompassed by the Odyssey Project referred to above. The loadings in the column PCA3, finally, were obtained from the earlier and Odyssey-related excavations, augmented by a few unpublished, recent data sets, together from 23 excavations with 334 finds with more than ten decorated sherds.

variable	attribute	PCA1	PCA2	PCA3
technique	simple	-0,51	-0.55	-0.63
	2-tuple	+0.32	+0.26	+0.36
	multiple	+0.42	+0.44	+0.52
zonation	none	-0.87	-0.86	-0.88
	continuous	-0.19	-0.04	-0.10
	separate	+0.91	+0.82	+0.86
components decoration	lines	-0.80	-0.67	-0.80
	pointlets	+0.42	+0.10	+0.18
	stab-and-drag	+0.43	+0.47	+0.58
	hatchings	+0.34	-0.02	+0.25
structure of rim dec'n	absent	-0.91	-0.87	-0.90
	single row	+0.22	-0.13	+0.04
	2 rows	+0.60	+0.18	+0.57
	>2 rows	+0.38	+0.56	+0.49
of total variance		33.2%	26.9%	33.8%

Table 1 Loadings of the chronologically relevant attributes in three Principal Components Analyses. (see text).

Originally, several other attributes of other variables were included in the computations; their low to negligible loadings on the supposed chronological component (and conversely, the low loadings of the attributes in the table on the components where the other variables loaded high) served to pinpoint relevant and irrelevant attributes relative to chronological computations. The structures of the three principal components that can be associated with chronology are clearly very much alike in the table. Thus, single-dented execution of the decoration, absence of zonation (or: no decoration on the vessel rim), and a preponderance of lines – as indicated by the higher negative coefficients – are opposed by moderate to highly positive loadings of multi-dented spatulas, explicit zonation (i.e., separately decorated rims next to belly decoration on the pots), and complex fillings of the ribbons by means of stab-and-drag components. Everybody familiar with LBK archaeology will agree that the three components shown here have everything to do with chronology, negative values pointing to the beginnings, positive loadings to the younger parts of that culture. More importantly, the agreement of the outcomes computed from different data sets with few (PCA1) and with strong restrictions (PCA3) argues for the robustness of the obtained chronological ordering.

6 The relative ordering and absolute chronology of the sites

In figure 1, the spreads are shown of the scores of the finds over the chronological factor of the different complexes. As

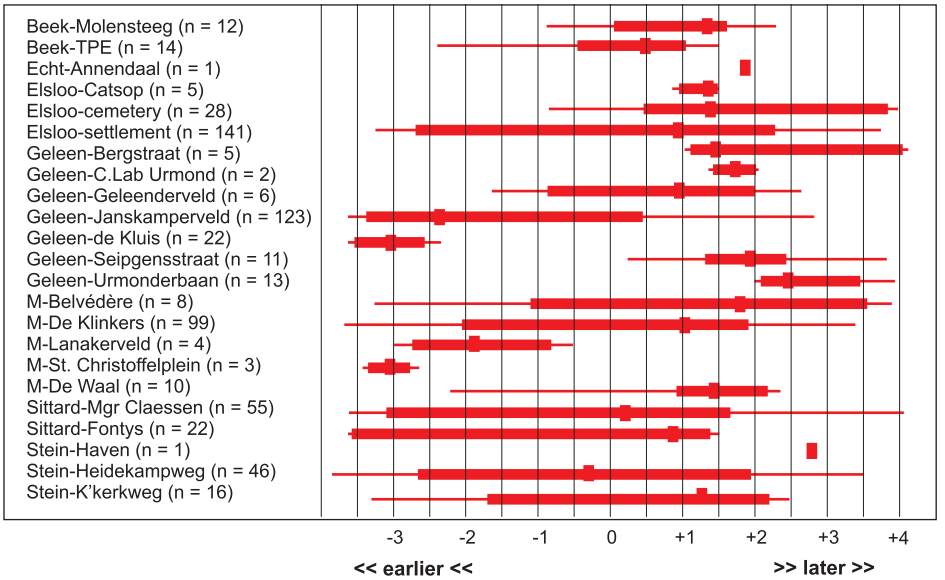

Figure 1 Spreads of the finds per excavation over the chronological axis (n = 649) (thin lines: all finds, thick lines 10/90% of the finds, crossbar: median of spread of finds) ("M", municipality of Maastricht).

the restrictions have been relaxed for the computation, 649 finds are represented here with well over 13,000 sherds representing 4570 sherd families. The largest complexes (Elsloo-settlement, Geleen-Janskamperveld, Maastricht-de Klinkers, Sittard-Mgr Claessenstraat to be grouped with Sittard-Fontys) together neatly span the full range, with the smaller excavations scattered in between. The earliest scores are accorded to Geleen-Janskamperveld, Geleen-de Kluis, Maastricht-de Klinkers, Sittard and Stein-Heidekampweg; they may have been the first agricultural colonies on Dutch territory. By the AMS-readings from Geleen-Janskamperveld, this event should have occurred around 5220 BCE. It should especially be noted that this first settlement occurred also on the left bank of the Meuse (the De Klinkers site). At the other end of the scale, the cemetery of Elsloo did not yield the latest score as expected, the Geleen-Bergstraat and Sittard settlement sites had even slightly later scores. Given the generally accepted c. 5000 BCE date for the closure of that cemetery, the LBK-occupation may have continued by another decade or so if it can be assumed that decorated pots in a grave are part of the same stock as regular household ware.

The bars in the box plot of figure 1 are very dissimilar in actual contents: some represent over a hundred finds, while others barely account for ten such units. Figure 2 depicts the spread of the individual finds with more than four sherd families each on the computed (chronological) factor scale. The 'phases' in the graphic are nothing but equal intervals in

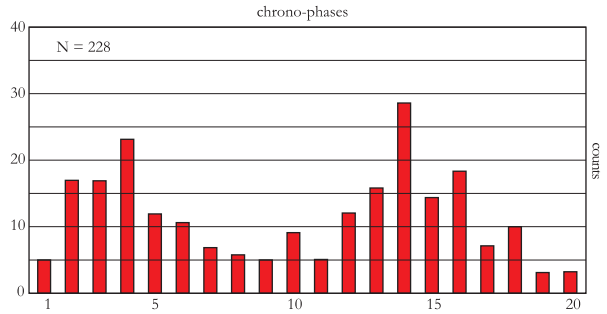

Figure 2 Distribution of the finds over the chronological axis, arbitrary phases (phases: 1 = oldest, 20 = youngest).

the factor scores, there are no equal time lapses implied, and the graph of figure 2 can be appended to figure 1 with but a little contraction due to the different widths.

The most salient feature of figure 2 is the near divide between an earlier and a later part of the sequence, respectively the phases 1 – 9 and 9 – 20. Checking the descriptions of the finds aside this divide, the latter coincides with the LBK-1 / LBK-2 transition, with pot decoration consisting in lines and points, with only simple neck decoration, and exclusive use of single-dented spatula technique before, and more complex fillings of the motifs, more complex rim decoration, and rapid increase of the use of multi-dented spatulas after. At the same time, the graph is much like the distribution of the *houses* of the Aldenhovener

Platte LBK over time (Stehli 1989, 67; Lüning 2005), although there, houses are counted, and here, in the present text groups of decorated pottery are. One would certainly expect correspondences between the two series, but on closer inspection, I could not lay my hands on it. Thus, the Geleen-de Kluis site, which is known for its five houses of an early type, has only one find unit in the first ceramic phase, five in the second, four in the third, and two in the fourth phase – a spread somewhat larger than hoped for. Similarly, the Elsloo graveyard – on extra-ceramic grounds expected to have incorporated selected deceased from the three (at most, four) final human LBK generations – yields ceramic dates from phase 10 onward right to the end, full ten ceramic phases (see also, Van de Velde 2011). When Stehli wrote that he recognized similar chronological patterns in the finds from two sites in the Dutch LBK as from the Aldenhovener Platte (Stehli 1994) the likeness will not have gone much beyond this general two-peaked distribution of the finds. In all likelihood, the juxtaposition of data from many excavations as here has obscured what patterns there are at the individual site level.

A cautionary note: the scales in the figures/factor scores cannot be translated directly into calendar years: equal differences in scores represent equal differences in counts on the pottery decoration (which equate with equal changes in the decoration), whereas real-world social change is sometimes fast, sometimes slow. There is no direct conversion possible: the first (left hand) eight or nine bars of figure 2 are probably representative of the first LBK period (i.e., phases 1-b, 1-c, and 1-d), whereas the later (right hand) eleven bars group the changes in the second LBK period (i.e., phases 2a to 2d). The Aldenhovener Platte Project has demonstrated that the two phases differ in length by some 20 years only (Lüning 1991, 63), seemingly less than suggested by counting the bars in the graph above.

7 (Dutch) LBK pot decoration over time

Figure 3 graphically depicts the calculated changes in selected attributes of the LBK's pot decoration over computed time; table 2 presents the figures. As noted above, the House Generations that have been established for the Aldenhovener Platte LBK cannot be derived from the (aggregated) Dutch material. Together with the arbitrary nature of the factor scores, this is the reason that the chronological scale has been divided arbitrarily into twenty

phase	technique			components				rim decoration		
	simple	double	multi	lines	points	st-&-dr	hatch	none	1 row	≥2 rows
1	100	0	0	88	12	0	0	100	0	0
2	100	0	0	77	23	0	0	100	0	0
3	100	0	0	63	37	0	0	96	3	1
4	100	0	0	55	45	0	0	88	10	2
5	100	0	0	52	48	0	0	74	22	4
6	100	0	0	50	50	0	0	59	35	6
7	100	0	0	48	52	0	0	47	46	7
8	100	0	0	45	55	0	0	36	54	11
9	100	0	0	43	55	2	0	25	65	11
10	100	1	0	36	60	3	1	17	69	14
11	99	2	0	25	70	4	1	13	62	25
12	98	1	0	18	73	6	3	7	51	42
13	99	0	1	14	66	16	4	2	34	64
14	94	2	4	10	58	28	4	0	16	84
15	84	3	13	8	48	38	6	0	9	91
16	71	7	22	7	43	40	10	0	7	93
17	58	12	30	7	30	50	13	0	13	97
18	43	12	45	6	17	61	16	0	1	99
19	24	5	71	4	11	71	14	0	0	100
20	9	1	90	2	8	73	7	0	0	100

Table 2 Attributes of pottery decoration *vs.* chronological factor, percentages per variable (st-&-dr: stab-and-drag).

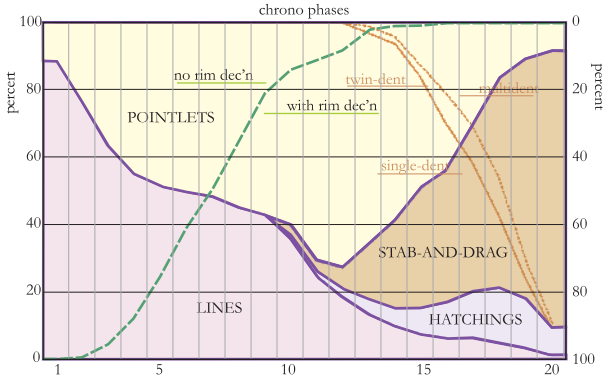

Figure 3 Attributes of pottery decoration *vs.* chronological factor, percentages per variable.

'phases', equivalent each to a fixed interval in the scores, i.e., a mathematical construct. The trends in the variables of the decoration are clear, yet the alignment to a 'true' chronology may compress or stretch parts of the graph. Specifically, the green interrupted line separates off the early pottery decoration, which was restricted to the potbellies only, a style already starting to decline quite early in the succession, to disappear about halfway the time factor scale. This is very much in line with Modderman's observations: in his scheme, undecorated rims occur until phase LBK-2a (Modderman 1970, 199). Regarding the separate components, the decline of the lines attribute (purple field) is conspicuous though possibly misleading. This is because both the graph and the table are given in percentages that are relative to the total counts; the raw counts of the lines may very well be approximately constant per decorated pot, it is only the number of points (yellow field), stabbed-and-dragged points (l. brown field) and hatchings (violet field) that really soar in the later part of the LBK period. Hatchings, the fourth component of the decoration depicted in figure 3, starts to appear slightly before the demise of the pots with no rim decoration, by the looks of the graph hatching has never been very popular in the Southern Netherlands. Modderman's account, however, puts the first appearance of this component later, by phase LBK-2c, also in use right to the end of the Dutch LBK (his ribbon types A-III / 30, B-III / 32, and C-II / 37; Modderman 1970, 122, 199). The double-dented spatula (brown line) appears two or three arbitrary factor chrono-phases later than the emergence of hatched ribbons in the LBK's decorative repertory, and quickly replaces its single-dented predecessor – in Modderman's scheme, multi-dented spatulas ("gezahnte Spatel") (interrupted brown line) are reported only when occurring in the rim decoration, in the final sub-phase of the Dutch LBK.

As a summary of the above and a lead to further research, table 2 presents the smoothed percent values of the attributes in LBK pottery decoration that are most sensitive to the course of time – counts will be off by less than five percent, provided a sufficient number of sherd families (say, at least ten per case) is incorporated. Within this pottery decoration's evolution, the main difference occurs around phase 9, best visible in figure 2 in the dip in the counts of the finds. It is not a break as all series are continuous, and some remain stationary around this phase (all technique attributes, also components more or less) as illustrated by the columns of table 2. Before this divide, the pottery decoration is executed exclusively with single dented spatulas, with lines and points only, lines counting for at least 45% of the sum of the components; also, pots without rim decoration are mostly restricted to the first half of the time range accompanied by an increasing number of pots with rim decoration. After the divide, nearly all pots have decorated rims, all types of spatula are in use (with increasing counts of double and multi-dented spatulas), hatching and increasingly stab-and-drag do occur, replacing points; the relative number of lines decreases to a few percents at the end.

It does not seem stretching the evidence too much to suggest that the first nine of the calculated phases equate with the first LBK period as defined by Modderman and Dohrn-Ihmig, and the group of eleven ceramic phases following to the second period. This suggests an investigation of further similarities between the two schemes. For the LBK-1 period Modderman's periodization rests mainly upon developments in the architecture of the houses[2] (Modderman 1970, 195-200), which are emphatically not considered in the present text: any subdivision here is exclusively based upon the behaviour over time of the various attributes of the pottery decoration. Thus a first split may be applied between the phases 2 and 3 (refer to table 2), leaving finds with exclusively pottery without rim decoration as a defining feature for a possible parallel to the customary LBK-1b phase. In my calculated phases 3-6 a minority of pots feature decorated rims, and their belly decoration shows small numbers of points (less than 50% of this variable's count) – not too different in description from Modderman's LBK-1c phase. My phases 7-9 equate readily with Modderman's LBK-1d ("emphatically a transitional phase towards the Younger LBK"; Modderman 1970, 196) in that there are more points than lines in the decoration (Modderman's D-II ribbon type) sometimes together with a little more complex (than a simple line of points) rim decoration.

The LBK-2a phase is described by Modderman as "clearly transitional" (as was the preceding 1d phase), he lists many characteristics pertaining to the LBK-1 that have disappeared altogether by then, with the occasional absence of rim

decoration on the pots as an exception. Added here are the still exclusive use of simple spatulas, and (negatively) the (near) absence of hatching or stab-and-drag ribbon fillings – my chrono-phases 10-12. Phases 13-15 of table 2 seem to group into the LBK-2b phase, with "many new variations in the way the ribbons are filled": stab-and-drag, and rarely hatched components, all rims decorated, and off and on a twin-dented spatula are the distinctive characteristics. Modderman's definition of the LBK-2c phase points to the rapidly increasing use of multi-dented spatulas, and hatched ribbon fillings, to which the almost explosive increase in the application of stab-and-drag points should be added to bring my chrono-phases 16-18 under this heading. The remainder, chrono-phases 19-20, of necessity equates with Modderman's LBK-2d phase, defined indirectly (through his ribbon types C-II, D-III, F-II) by the manifold use of the multi-dented spatula, almost exclusively employed I would add, as are complex rim decorations.

It will be observed that the first and last Modderman-phases equate with two ceramic phases as defined here, while the other LBK-phases in between are equivalent to three such phases each. Several reasons can be invoked, most important among which is the purely qualitative nature of Modderman's descriptions as opposed to my fully quantified definitions. Also and just as consequential, statistical methods are based on the equivalence of calculated differences between numbers, which implies that rapid change is spread over more intervals than is stagnation. Therefore, the two ceramic 'phases' 1-2 computed from the differences in pottery decoration (LBK-1b) might span even more chronological time than e.g., the phases 16-18 equivalent to the 2c phase. Given the unreliable nature of ^{14}C-determinations for the LBK period, only dendrochronological measurements can point a sure way out, with probably sociological assumptions as especially the concept of House Generation a good approximation. In other words, ceramic phases can be used for relative dating purposes only.

Even so, the table above may provide a lead to further research, such as which LBK settlement was last to be abandoned (or, rather, where did they stop making LBK-type decorated pottery). Conversely, which sites in this area did LBK-decorating people settle first? Similarly, were the Belgian Hesbayan LBK sites an offspring of the early Dutch sites on the left bank of the Meuse? It might also serve in an investigation of the different LBK trajectories on both banks of the Meuse River with intensification on the right bank and dispersion on the left, yet both followed by societal collapses. Internal settlement histories will also profit from sharper relative chronologies through application of the table's values, which then may result (or not!) eventually in a definition of House Generations in this part of the NW-LBK. There may be more …

8 By way of conclusion: a ceramic chronology is but that

The 'old' generalized Modderman-Dohrn-Ihmig LBK-chronology can be specified and refined through the analysis and quantification of the pottery decoration of that culture, at least in Dutch Limburg Province. The 'new' Stehli LBK-chronology of 15 House Generations spanning the LBK period on the Aldenhovener Platte in Germany, only forty kilometres to the east, did not show up in the present data (consisting of 13,355 decorated sherds from 4547 sherd families, counted in 649 find units from 23 excavations). Statistical ordering of characteristics of pottery decoration by means of abstract/numerical intervals instead of counts in years or decades may be one cause of this, as will be the probably subtle differences between the regional cultures of Limburg and Platte (Van de Velde 1995). However, in my analysis of the Geleen-Janskamperveld settlement (Van de Velde 2008b), such entities could well be established – four such "HG"s in the first and one "HG" in the second occupation of the site – which suggests that the concept of House Generation may be applicable to individual sites rather than to a region like Dutch Limburg in its entirety. This latter hypothesis is supported by an argument I made above in another context: houses and House Generations apply to the built-up environment; pottery decoration is a very distinct field of discourse, only remotely coupled through the social. Houses are relatively long-lived entities occurring in relatively low numbers, whereas decorated pottery is relatively short-lived and occurs in relatively large numbers; demographic incidents will have different outcomes in both fields. Consequently, the net result was likely to be a divergence between the two series, and House Generations do not always map onto pottery decoration sequences. It is therefore that in regional comparisons the Modderman/Dohrn-Ihmig periodization of the north-western LBK is to be preferred over the House Generations count by Stehli and his successors. The latter may and will have its use in individual settlement analyses, perhaps even within settlement clusters – but should not be applied in a strict sense to a region.

Notes

1 "Wir haben sehr bewußt keine typologische Chronologie aufstellen wollen. Wenn sich herausstellt, daß die Verzierungen sich typologisch entwickeln, so betrachten wir das höchstens als eine Stütze für die relative Chronologie, wie diese sich aus den Ergebnissen der Grabungen ablesen läßt" (Modderman 1970, 121).

2 In that he assumes homogeneous types per sub-phase without allowing for conservatism or innovation in house construction this background is methodically invalid.

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APPENDIX: Counting LBK pottery decoration

To establish the chronological position of a set of decorated LBK sherds, only a limited set of variables has to be evaluated: the instrument with which the decoration has been applied, the existence or not of rim decoration and if so its complexity, and the several components of the decoration. On the assumption that all pots that have gone into a stratigraphical unit/pit are equally important in a chronological perspective, this counting is best done separately per "sherd family" (i.e., all sherds remaining from a pot), afterwards to be averaged per find unit. Of course, less reliable results will be achieved when all sherds from a pit are treated jointly. To demonstrate the counting procedure, below three sherd families will be analysed accordingly.

The first sherd family consists of four sherds remaining of a pot from the Maastricht-De Waal site (MW-122, # 072). They have been coded as follows: 45 cm^2 surface area, multi- (5-) dented spatula, independent rim decoration in five rows, belly decoration consisting of 2 lines, 2 pointlets, and 335 stabbed-and-dragged pointlets.

The single sherd from Maastricht-De Klinkers (MK-059, #520) depicted second here, has been coded as 30 cm^2 surface area; it has been decorated by means of a single-dented spatula, there is no separate rim decoration (rather a secondary motif between the main motifs on the potbelly), from the belly decoration only four lines and four pointlets remain.

The third example, 5 sherds of a pot also from Maastricht-De Klinkers (MK-015, #508), with an area of 85 cm^2, has been coded as: decorated by means of a single-dented spatula, with an independent rim decoration consisting of a single row of pointlets, the belly being decorated by 5 pointlets and 23 hatched lines.

The second analytical step is the conversion of the counts into percentages per variable per pot. These percentages are presented in the accompanying table; it is the basis for the third step, a comparison with table 2 in the main text. The first row (MW-122, #072) of this table easily agrees with the bottom row of the 'master table', indicative of a very late (phase 20) position in time. The second row (MK-059, #520) is less clear –if only because of the small size of the referent sherd. Here, the absence of rim decoration suggests a relatively early date, whereas the lines and the pointlets of the components variable are suggestive of phases 6 and 7; this is not contradicted by the other figures. Finally, the sherd family decorated with hatches (MK-015, #508) should apparently be placed in phase 10 at the earliest because of this component, while the other percentages for this decoration pose no objection to this 'date'.

Figure A1 Maastricht-De Waal. Sherd family no. 072, part of find MW-122.

Figure A2 Maastricht-De Klinkers. Sherd family no. 520, part of find MK-059.

Figure A3 Maastricht-De Klinkers. Sherd family no. 508, part of find MK-015.

find	ref	n (shds)	area cm^2	1-dent	2-dent	m-dent	lines	pntlets	st&dr	hatch	no row	1 row	2 row	>2 row
MW-122	072	4	45	0	0	100	1	1	98	0	0	0	0	100
MK-059	520	1	30	100	0	0	50	50	0	0	100	0	0	0
MK-015	508	5	85	100	0	0	0	18	0	82	0	100	0	0

Table A1 Percentage counts of decoration of pottery in Appendix figs 1-3.

The examples presented here are restricted to individual sherd families. Their counts demonstrate quite clearly that percentages (i.e. converted to counts per hundred) are suggestive of a much higher precision than ever can be justified: several variables are more of a qualitative than quantitative nature (consider the technique of decoration: *either* 1-, *or* 2-, *or* multi-dent; similar to the complexity of rim decoration with only four alternatives). That is, the chronological positioning of individual sherd families/pots is quite problematic, and only the combination of the variables (as here) poses some counterweight to this objection. Find complexes such as the pottery derived from a single pit are methodically better in this respect as higher total counts allow for more precision in the averaged percentages.

One final remark: The methodological background of the present analysis can be found in Van de Velde 1979, where many more variables of the decoration are considered, and where some non-chronological (mainly sociological) correlates of aspects of it are established.