Skills, scaling, and the role of youngsters in adaptation during the Northern European Final Palaeolithic

Mathilde Vestergaard Meyer [1], Jesper Borre Pedersen [2], David Nicolas Matzig [3], Felix Riede [1]

1. Department of Archaeology and Heritage Studies, Aarhus University. Moesgård Allé 20, 8270 Højbjerg, Denmark. Email: Meyer: mathilde.meyer@cas.au.dk; Riede: f.riede@bio.au.dk
2. The Role of Culture in Early Expansions of Humans, Heidelberg Academy of Sciences and Humanities, Tuebingen. Germany. Email: jesper-borre.pedersen@ifu.uni-tuebingen.de
3. AU Library, Aarhus University. Bartholins Allé 9, 8000 Aarhus C, Denmark. Email: dnma@kb.dk

Abstract:

At any one time in the Palaeolithic, children constituted the largest group of individuals in a given community. While not many objects ascribed to children are known from these remote periods, it is beyond doubt that children participated in many aspects of daily life, including knapping. These youngsters played a vital role in generating technological variation and in societal adaptation. We here focus on the role of children in Northern European Final Palaeolithic societies that experienced markedly different climatic regimes in order to better understand how youngsters and their playful, exploratory learning may have contributed to adaptation. Using a mixed-methods approach we study inexperienced knappers with emphasis on three distinct groups of flintwork: blades, cores, and projectile points. We apply 2D geometric morphometrics coupled with technological attributes, quantitative and qualitative analyses to interrogate the variability within these groups with the aim of tracing the possible work of children through notions of skill level and artefact scaling. The purpose of this analysis is to investigate (i) how we can identify the signatures of children knapping flint, and (ii) how children's participation in flintwork varied between inventories from periods characterised by distinctly different climates. Finally, to better understand the role of children in innovation and adaptation, we discuss how children's knapping relates to the generation of technological variability, innovation, and differences in adaptation. The combined analytical focus on blades, points and cores allow us to more securely identify evidence for children, allowing us to compare their contributions to cultural variability across the two time periods.

Keywords: flint; children; Final Palaeolithic; knapping; skill

1. Introduction

In Palaeolithic communities, children constituted the largest group of individuals (Langley 2018; Nowell 2021). Not many objects specifically ascribed to children are known from these very remote periods, but it is safe to assume that children participated in many aspects of daily life, not least in stone knapping (Shea 2006). As a consequence of the

Journal of Lithic Studies (2025) vol. 12, nr. 1, 35 p. DOI: https://doi.org/10.2218/jls.10853

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

growing populations during the Upper Palaeolithic, this period also saw an increase in the number of children, arguably boosting their visibility in the archaeological record (French 2021; Nowell 2015; Roveland 2000). Notably, rates of innovative transformations also rise in the Upper Palaeolithic (Flas 2014), and children may have played a vital part in this process (*cf.* Riede *et al.* 2021). Human childhood is characterised by exploration, play and learning, all promoting cognitive skills and cultural innovation within society (Gopnik 2020; Leca & Gunst 2023; Pellegrini 2013). Especially object play and social learning play a major part (Samuelsson 2023; Stout 2021), as they are central to the particular object-focused adaptability and innovativeness of humans (Lew-Levy *et al.* 2023; Riede *et al.* 2018). Social learning is particularly strong in childhood peer learning and play, as learning and playing with peers can provide variation that can lead to innovation (Lew-Levy & Amir 2024). This is because children are more likely to employ trial-and-error learning, which can generate novel variants (Tomasello 2019).

Unskilled knappers are identifiable by recurring errors and inefficiencies reflecting limited technical knowledge, poor motor control, and physical constraints. Common indicators include mis-strikes, excessive or insufficient force, poor core maintenance, hinge and step terminations, and repeated and uncorrected failures (Audouze & Cattin 2011). Conversely, if the presence of raw material is not a constraint, knappers might choose to adopt simpler and more wasteful core technologies, as maximizing core productivity would not be an advantage relative to the necessary investment in time and energy (Centi *et al.* 2023). This can lead to the flintwork seeming simpler and, literally, child-like. Ferguson (2003; 2008) has investigated how the presence of embedded learning, or scaffolding, can blur the differences between unskilled and skilled knappers. In such settings, pedagogically motivated expert interventions may erase evidence of novice knapping by correcting the mistakes and errors produced (Milne 2005; 2012), which complicates the tracing of unskilled knappers archaeologically.

The groundbreaking studies at the exceptionally well-preserved sites of Pincevent (Ploux 1984; 1989) and Étiolles in the Paris Basin (Pigeot 1987; 1990) succeeded in the identification of knapping novices through refitting. Since then, and with the help of experimental (*cf.* Eren *et al.* 2011; Ferguson 2003; Finlay 2008; Geribàs *et al.* 2010; Pargeter *et al.* 2023; Shelley 1990; Stahl 2008; Sternke & Sørensen 2009; Stout *et al.* 2009) and ethnoarchaeological work (*e.g.*, Stout 2002; Weedman 2002), the signatures of novice knappers have been identified in a number of sites around the world.

Although sites with traces of novice knapping from the Lower Palaeolithic are rare, Qesem Cave in Israel (Assaf 2021a; 2021b; Assaf *et al.* 2016; 2023), Hadar in Ethiopia (Hovers 2009) and Boxgrove in England (Leroyer 2018) have all revealed evidence of lithic pedagogy and variable skill levels. Equating lower skill levels with early age, these studies simultaneously suggest the presence of children at these sites. Similar analyses of individuals and their relative skill levels have been conducted at Middle Palaeolithic sites such as El Cañaveral in Spain (Baena *et al.* 2019), Nesher Ramla in Israel (Centi *et al.* 2023), and at the Grotte du Renne in France (Bodu 1990), again suggesting the presence of children as learners. The number of sites where individuals of varying competence can be identified increases in the Upper Palaeolithic. Here, studies have been conducted in a broad range of environments, including Alaska (Coutouly *et al.* 2021), Switzerland (Audouze & Cattin 2011), Japan (Takakura 2013; Takakura & Naoe 2019), Denmark (Fischer 1990a), Britain (Roberts & Barton 2021), the Netherlands (Stapert 2007), Poland (Mugaj 2015), as well as Italy (Cattabriga & Peresani 2024; Cattabriga *et al.* 2024), and several sites in the Paris Basin (Audouze & Cattin 2011; Bodu *et al.* 1990; Grimm 2000; Pigeot 1990). While fewer in number, relevant studies have also been conducted in assemblages from the Early Holocene, for instance, in Norway (Dugstad 2010; Viken & Darmark 2019), Denmark (Sternke &

Sørensen 2009), Scotland (Mithen & Finlay 1993), and southern Brazil (Neubauer 2018). Middle Holocene sites from Sweden (Högberg 1999), Norway (Viken & Darmark 2019), the Paris Basin (Augereau 2019), Spain (Castañeda 2018), and southern Kenya (Goldstein 2019) have yielded evidence of child knappers, as have more recent North American prehistoric sites in the Great Basin (Cunnar 2015), in New Mexico (Roth & Romero 2024), and the Mojave Desert (Walsh 2011), as well as in the Arctic (Milne 2005; 2012).

Despite this increasing wealth of information on the presence of children in the archaeological record our knowledge about their importance in terms of societal adaptability remains scarce. We here focus on the role of children in Final Palaeolithic societies that experienced markedly different climatic regimes in order to better understand how youngsters (*i.e.*, all individuals who have not fully developed motorically and cognitively) and their playful, exploratory learning may have contributed to adaptation or otherwise. To this end, we have selected a sample of sites from Final Palaeolithic Northern Europe, spanning across the Bølling/Meiendorf and Allerød chronozones (~14.7 - 12.9 kyr BP), where the presence of children has previously been proposed on the basis of lithic analyses, as well as control sites where such arguments have not been made. We deploy a mixed-methods approach to the study of inexperienced knappers in flint production. With emphasis on three distinct groups of flintwork - blades, cores, and projectile points - we interrogate the variability within these groups with the aim of tracing the possible work of children. The analysis consists of three steps where we conduct (1) a 2D geometric morphometric analysis on the outlines of complete laminar blades, coupled with technological attributes in order to relate blade morphology with attributes usually contributed to unskilled knappers, (2) a quantitative analysis of projectile point metrics, and (3) a qualitative assessment of selected laminar blade cores. The purpose of this analysis is (i) to comparatively investigate if and how we can confidently identify Final Palaeolithic children through their flint-work, and (ii) to track children's lithic signatures in the Allerød and the Bølling assemblages respectively. Identifying trends in youngsters' participation in these foundational craft activities leads us to discuss the degree to which they contributed to the overall pool of cultural variation and so to the adaptive capacities of these communities.

1.1. Youngsters and adaptation to the environment in the Northern European Final Palaeolithic

Throughout the Late Pleistocene, wide-ranging and short-term climatic shifts occurred rapidly, with both lower temperatures and sea levels (Shea 2017). The size and distribution of the human population in Europe was strongly influenced by climatic conditions. Following the Late Glacial Maximum, improvement in conditions were moderate at first, but at the onset of the Greenland Interstadial (GI) 1e it became considerably warmer, which allowed for the re-peopling of central and north-western Europe (French 2021). The arrival of humans in Northern Europe is linked to the Hamburgian technocomplex (~ 14.7-14.0 kyr BP), a variant of the Late Magdalenian (Weber 2012). This initial settlement took place during the Bølling/Meiendorf chronozone, corresponding to GI-1e, and was likely short-lived (Pedersen *et al.* 2018; 2023; Riede & Pedersen 2018). Separated by the short but cold GI-1d, a subsequent and somewhat longer-lasting dispersal is associated with the so-called Federmessergruppen during the Allerød chronozone, corresponding to GI-1a-c (Grimm & Weber 2008; Pedersen *et al.* 2018; Rasmussen *et al.* 2014; Riede 2014b; Wygal & Heidenreich 2014).

The people of these two discrete dispersal processes lived out their lives in different environments. During the Bølling/Meiendorf, the Northern European landscape possibly comprised a single ecotone that resembled an arctic tundra-like environment of primarily pioneer vegetation and dwarf shrub communities, which was well-suited for arctic and tundra fauna; reindeer (*Rangifer tarandus*) were plentiful (Aaris-Sørensen *et al.* 2007). The Hamburgian technocomplex is linked to groups of people who employed a highly selective hunting strategy focused on reindeer (Bokelmann 1991; Bratlund 1991; Grønnow 1985). During the Allerød, warmer, more humid conditions coupled with more developed soils allowed for sporadic patches of open woodlands dominated by birch trees. Within these environments reindeer was probably less common while elk (*Alces alces*) became a more common inhabitant (Krüger *et al.* 2020; Mortensen *et al.* 2011).

The lithic repertoires of the Hamburgian and Federmesser associated groups are markedly different. While Hamburgian lithic technology reflects rather normative knapping behaviour with strong Magdalenian affinities, lithic inventories associated with the Allerød chronozone appear to be more idiosyncratic in knapping choices. The lithic assemblages associated with the Federmessergruppen display a wider variety of knapping strategies within and between assemblages, and the resulting flakes, blades, and tools are less standardised (De Bie & Caspar 2000; De Bie & Vermeersch 1998; Kotthaus 2019; Pedersen *et al.* 2022; Riede 2014a; Sobkowiak-Tabaka 2020). Differences in material culture between the Hamburgian and Federmessergruppen reflect broader contrasts in population structure and mobility. Although the two groups faced comparable environmental changes, their responses were different. This is partly reflected in the lithic repertoires, as described above. These differences are rooted in fundamentally different ways of organizing society, and they are relevant for the study at hand because this might allow us to infer knowledge about the role of children in these groups. Drawing on research in developmental psychology (Gopnik 2020; Riede *et al.* 2018; 2021) and its extension to cognitive and cultural evolution, we hypothesise that societies that allow for a greater degree of experimental play in key technological domains have greater adaptive capacities. Play generates variation in a manner guided by play object provisioning, allowing youngsters to more effortlessly acquire expertise in these domains, and in turn catalysing salient innovations.

2. Materials and methods

Our analysis focuses on seven sites from the Northern European Final Palaeolithic (Figure 1). The data for the present analysis have been obtained directly from relevant collections, and from illustrations of published lithic assemblages. We have specifically targeted assemblages from our focus periods for which it has earlier been proposed that the work of children or novice knappers has contributed to their formation (n= 4), and control assemblages (n= 3) which have no such interpretation attached to them (Table 1).

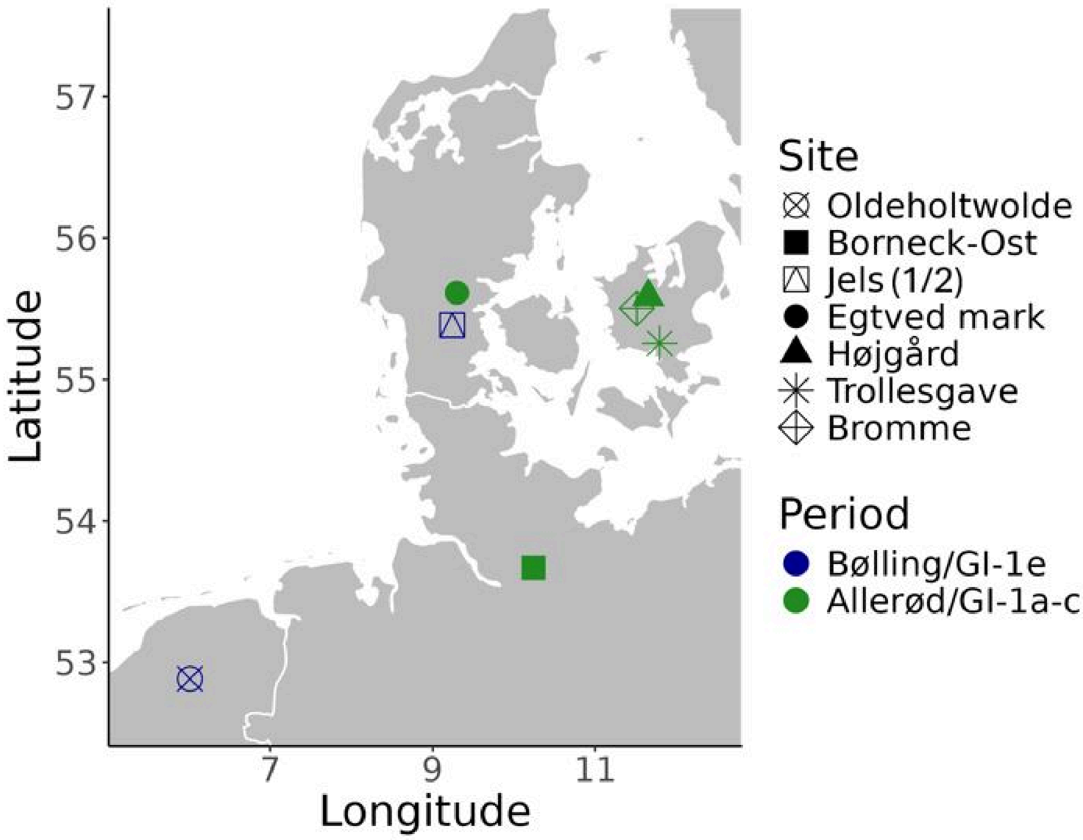

Figure 1. Distribution map showing the locations of the seven sites used in this study. Blue are sites from the Bølling/GI-1e. Green are sites from the Allerød/GI-1a-c.

Table 1. The sites represented in the present analysis, with their respective artefact classes and references. The numbers represent the sample size used in this study.

		Artefact classes analysed			Child	
	Site	**Blades**	**Cores**	**Points**	**knappers**	**References**
Bølling/GI-1e	Oldeholtwolde	22	2	2	X	(Johansen & Stapert 2004; Stapert 1982)
	Jels (1/2)	7	-	22		(Holm & Rieck 1992; Pedersen *et al.* 2022)
Allerød/GI-1a-c	Borneck-Ost	4	1	11	X	(Kotthaus 2019; Rust 1958; 1962)
	Egtved mark	30	-	-		(Fischer 1988)
	Bromme	14	-	45		(Fischer & Nielsen 1987; Mathiassen 1946)
	Trollesgave	37	1	4	X	(Donahue & Fischer 2015; Fischer 1990a; 1990b)
	Højgård	38	-	10	X	(Ballin 1991)

The most common way of identifying unskilled knappers consists of identifying indicators of less-than-perfect skill levels as well as errors. The knapping performed by unskilled individuals leaves a characteristic suite of defects related to the lack of know-how and motor control (Bleed 2008; Torres & Preysler 2020). As strength and hand-eye coordination increases with age, these characteristics are often attributed to children (Bamforth & Finlay 2008). Yet, not all errors and variation in a lithic assemblage can be explained by the presence of inexperienced flintworkers, as even expert knappers may make mistakes and exhibit variation in their work (Centi *et al.* 2023; Eerkens 2000; Eerkens & Bettinger 2001; Pargeter *et al.* 2023; Torres & Preysler 2020) - due to its inherent and idiosyncratic properties, stone is a difficult material to consistently manipulate. A key characteristic that sets the errors of adults apart from those of children, however, is the former's ability to overcome and solve such problems. Errors that are repeated many times, therefore, may indicate an inability to understand and correct these (Goldstein 2019; Shelley 1990). Moreover, small untrained child knappers also leave certain error traces at higher frequences that relate to physical limitations (Sternke & Sørensen 2009). Table 2 summarises the key attributes and operational chain characteristics used to infer skill levels from lithic remains. That said, it is important to note that the distinction between child and adult is not a categorical one. Children gradually grow into adulthood and while not fully synchronised, cognition and strength also develop over time. In relation to our ability to recognise flintworkers of different ages, we must consider a continuum of skill, variability, and errors.

The characteristics catalogued in Table 2 have been argued to be commonly produced by unskilled flintknappers and they can be linked to various forms of flintwork. Some characteristics can be linked to the specific production of blades, cores, and formal tools, respectively and these are listed in Table 3. Intersecting these specific traits with the larger suite of characteristics provides a canvas against which to evaluate skill levels and discuss the presence of beginner of intermediate knappers in any given assemblage.

Skill level alone does not provide direct evidence of child knappers, however. Object size is, taken at face value, the most straightforward index of user size and, by inference, user age (Losey & Hull 2019; Park 1998). Of course there are also other reasons for small size, such as raw material and the task at hand, but if these are accounted for, size is a good indicator for children. Kaaronen *et al.* (2023) have demonstrated that body-based measurement is a cross-cultural feature of measurement systems. Body-based units are commonly used in artefact design to ensure the right fit between the individual and the technology in question. Equipment scaling is the process of acquiring skills through the use of technology reduced in size to fit the individual using it, thus making it easier to master the implements (Buszard *et al.* 2016). While children clearly also play with adult-sized objects and with objects never intended to be played with (Crawford 2009; Lancy 2016), equipment scaling can be used to infer evidence for the enskillment via qualifier object provisioning. Losey and Hull (2019) discuss examples of such equipment scaling for atlatls based on examples from the first-millennium CE Par Tee site on the Oregon Coast. Here, reduced grip size is used as an argument for the use of individuals with smaller hands, *i.e.*, children. There are also other cases in the archaeological record where such qualifier toys can potentially be identified, such as some very small Early Upper Palaeolithic arrowheads from Grotte Mandrin (Klaric *et al.* 2024), a possible child-sized spear from Schöningen (Milks *et al.* 2023), and some smaller and less symmetric dart-points from the Final Palaeolithic of Northern Europe (Riede & Lombard 2024). Common to these is that the small size within a given functional group of artefacts is used as an indicator for user body size. We here build on these approaches by investigating the sizes of projectile points from our focus sites in relation to size ranges from the Final Palaeolithic at large and metric data from ethnographic collections. This two-pronged approach considering both knapping errors and equipment scaling facilitates a more robust identification of young knappers and also provides insights into different aspects of children and childhood in the past: Knapping errors provide evidence of child presence and involvement in knapping activities, while equipment scaling indexes the presence of children and the provisioning of equipment to children from other members of these communities. Combined these proxies may offer novel insights into past lifeways and the role of children in adaptation.

Table 2. Characteristics commonly connected with unskilled and, by inference, youngster flintknapping.

	Characteristic	**Reference**
Raw material	Choice of raw material (often poorer quality)	(Baena *et al.* 2019; Bamforth & Finlay 2008; Castañeda 2018; Cattabriga *et al.* 2024; Centi *et al.* 2023; Coutouly *et al.* 2021; Ferguson 2003; 2008; Finlay 1997; 2015; Goldstein 2019; Grimm 2000; Hikade 2005; Högberg 1999; 2008; Klaric 2018; Knight 2017; Pigeot 1987; Roberts & Barton 2021; Shea 2006; Torres & Preysler 2020; Viken & Darmark 2019; Walsh 2011)
	Availability of raw material	(Centi *et al.* 2023; Cunnar 2015; Ferguson 2003; 2008; Karlin & Julien 1994; Klaric 2018; Milne 2005; 2012; Takakura & Naoe 2019)
Exploitation	Lack of maintenance	(Assaf *et al.* 2023; Centi *et al.* 2023; Fischer 1990a; Grimm 2000; Klaric 2018; Milne 2012; Sternke & Sørensen 2009; Takakura & Naoe 2019; Viken & Darmark 2019)
	Lack of striking platform or edge preparations	(Assaf *et al.* 2016; Baena *et al.* 2019; Centi *et al.* 2023; Coutouly *et al.* 2021; Fischer 1990a; Goldstein 2019; Klaric 2018; Milne 2012; Pigeot 1987; Shelley 1990; Stahl 2008; Takakura & Naoe 2019; Walsh 2011)
	Use of incorrect surfaces and angles	(Baena *et al.* 2019; Finlay 2008; Geribàs *et al.* 2010; Klaric 2018; Torres & Preysler 2020)
	Constant changes in holding position	(Baena *et al.* 2019; Torres & Preysler 2020)
	Chaotic exploitation	(Cattabriga & Peresani 2024)
	Platform failure	(Eren *et al.* 2011)

	Characteristic	**Reference**
Production	Few or no final products	(Baena *et al.* 2019; Bodu *et al.* 1990; Klaric 2018; Walsh 2011)
	Irregular negatives	(Castañeda 2018; Cattabriga & Peresani 2024; Grimm 2000; Klaric 2018; Stout *et al.* 2009; Torres & Preysler 2020)
	Small size	(Castañeda 2018; Cunnar 2015; Hikade 2005; Klaric 2018; Knight 2017; Knutsson 1983; 1986; Neubauer 2018; Shea 2006; Stapert 2007; Stout 2002; Walsh 2011)
	More simple core technology	(Centi *et al.* 2023; Högberg 1999; Neubauer 2018; Walsh 2011)
	Lack of symmetry	(Coutouly *et al.* 2021; Cunnar 2015; Darmark 2010; Neubauer 2018; Stahl 2008; Torres & Preysler 2020; Walsh 2011)
	Lack of multidimensional control/two-dimensional knapping	(Darmark 2010; Högberg 2008; Neubauer 2018; Stapert 2007; Sternke & Sørensen 2009)
	High width thickness ratio	(Cunnar 2015; Darmark 2010, Ferguson 2003; Klaric 2018; Neubauer 2018; Walsh 2011)
	Technically poorly execution/imitation	(Apel 2001; Finlay 2015; Fischer 1990a; Goldstein 2019; Grimm 2000; Högberg 1999; 2007; Neubauer 2018; Roberts & Barton 2021; Shea 2006; Sternke & Sørensen 2009; Stout 2002; Torres & Preysler 2020)
	Large bulbs of percussion	(Grimm 2000; Takakura & Naoe 2019)
Precision	Inadequate angles of impact blows	(Assaf *et al.* 2016; Castañeda 2018; Coutouly *et al.* 2021; Grimm 2000; Klaric 2018; Stapert 2007; Takakura & Naoe 2019)
	Double or multiple impact cones	(Baena *et al.* 2019; Coutouly *et al.* 2021; Torres & Preysler 2020)
	Impact scar concentrations	(Baena *et al.* 2019)
	Mis-strikes	(Eren *et al.* 2011; Roberts & Barton 2021; Viken & Darmark 2019)
Force	Platform and flake fractures	(Baena *et al.* 2019; Torres & Preysler 2020)
	Crushing	(Baena *et al.* 2019; Coutouly *et al.* 2021; Ferguson 2003; Klaric 2018; Milne 2012; Torres & Preysler 2020; Viken & Darmark 2019)
	Disproportional/inadequate use of force	(Assaf *et al.* 2016; Goldstein 2019; Shelley 1990; Stapert 2007; Takakura 2013; Takakura & Naoe 2019; Walsh 2011)

	Characteristic	**Reference**
Accidents	Hinge terminations/flakes	(Assaf *et al.* 2016; Baena *et al.* 2019; Bamforth & Finlay 2008; Cattabriga & Peresani 2024; Cunnar 2015; Darmark 2010; Dugstad 2010; Eren *et al.* 2011; Finlay 2015; Goldstein 2019; Grimm 2000; Hovers 2009; Klaric 2018; Milne 2012; Shelley 1990; Stapert 2007; Sternke & Sørensen 2009; Takakura & Naoe 2019; Torres & Preysler 2020; Viken & Darmark 2019)
	Stacked steps	(Bamforth & Finlay 2008; Cattabriga & Peresani 2024; Coutouly *et al.* 2021; Cunnar 2015; Darmark 2010; Dugstad 2010; Eren *et al.* 2011; Ferguson 2003; Finlay 2008; 2015; Goldstein 2019; Grimm 2000; Hovers 2009; Milne 2012; Shelley 1990; Stapert 2007; Takakura 2013; Takakura & Naoe 2019; Torres & Preysler 2020; Viken & Darmark 2019)
	Overshoot flaking	(Baena *et al.* 2019; Eren *et al.* 2011; Goldstein 2019; Takakura & Naoe 2019)
	Repetition of accidents/errors	(Baena *et al.* 2019; Centi *et al.* 2023; Ferguson 2003; Finlay 1997; 2015; Grimm 2000; Knight 2017; Milne 2005; Sternke & Sørensen 2009; Torres & Preysler 2020; Walsh 2011)
	Continued striking in areas that show previous accidents	(Castañeda 2018; Goldstein 2019; Shelley 1990; Walsh 2011)
	Split cores	(Goldstein 2019)
Insistence	Battering marks on core face	(Bamforth & Finlay 2008; Darmark 2010; Finlay 2008; 2015; Fischer 1990a; Klaric 2018; Milne 2012; Roberts & Barton 2021; Shelley 1990; Stapert 2007; Sternke & Sørensen 2009; Takakura 2013; Viken & Darmark 2019)
	Reiteration of accidents	(Centi *et al.* 2023; Finlay 2008; Goldstein 2019; Grimm 2000; Klaric 2018; Neubauer 2018; Shelley 1990; Takakura 2013; Torres & Preysler 2020)

	Characteristic	**Reference**
Productivity	Discontinuity in reduction	(Baena *et al.* 2019)
	Wasteful / inadequate / unsuccessful / ineffective reductions	(Baena *et al.* 2019; Castañeda 2018; Cattabriga & Peresani 2024; Dugstad 2010; Klaric 2018; Milne 2012; Neubauer 2018; Shea 2006; Shelley 1990; Stapert 2007; Takakura 2013; Takakura & Naoe 2019; Viken & Darmark 2019; Walsh 2011)
	Incomplete sequences	(Baena *et al.* 2019)
	Inadequate percussion tool	(Castañeda 2018; Klaric 2018; Torres & Preysler 2020)
	Low productivity	(Cattabriga & Peresani 2024; Cattabriga *et al.* 2024; Centi *et al.* 2023; Grimm 2000; Klaric 2018; Takakura 2013)
	Large variability/lack of standardization	(Finlay 2015; Högberg 2008; Klaric 2018; Knight 2017; Neubauer 2018; Shea 2006; Shelley 1990; Sternke & Sørensen 2009; Takakura 2013)
	No sign of use	(Bodu *et al.* 1990; Högberg 2008; Karlin & Julien 1994; Neubauer 2018; Pigeot 1990; Takakura 2013; Takakura & Naoe 2019; Walsh 2011)
Abandon	Severe/repeated accidents	(Cattabriga & Peresani 2024; Cattabriga *et al.* 2024; Finlay 2008; Goldstein 2019; Grimm 2000; Hikade 2005; Shelley 1990)
	Exhausted core	(Milne 2012; Takakura & Naoe 2019)
Location	Located where flint is abundant (*e.g.,* flint mines, quarries, *etc.*)	(Audouze & Cattin 2011; Castañeda 2018; Finlay 1997; Klaric 2018; Milne 2005; 2012; Walsh 2011)
	Spatial segregation	(Assaf 2021b; Bodu *et al.* 1990; Coutouly *et al.* 2021; Finlay 2015; Grimm 2000; Högberg 1999; 2008; Neubauer 2018; Pigeot 1990; Roberts & Barton 2021)

Table 3. Characteristic errors and defects for unskilled production of blades, cores, and formal tools.

Group	Characteristic	Reference
Blades	Lack of motor skills	(Coutouly *et al.* 2021)
	Poor understanding of the basic rules of conchoidal fracture	(Coutouly *et al.* 2021)
	Management of the volume to be reduced	(Coutouly *et al.* 2021)
	Failure to maintain proper platform angle	(Grimm 2000)
	Failure to differentiate the striking platform and the blade production face	(Grimm 2000)
	No systematic attention to core maintenance	(Grimm 2000)
	No systematic attention to overall core organisation	(Grimm 2000)
	Hinges or steps	(Shelley 1990; Takakura & Naoe 2019)
	Irregularity of the form	(Takakura 2013)
	Overshoots	(Takakura & Naoe 2019)
Cores	Hinges and steps	(Cattabriga & Peresani 2024; Shelley 1990)
	Battering	(Cattabriga & Peresani 2024)
	Chaotic exploitation of surface	(Cattabriga & Peresani 2024)
	Irregular shaped removals	(Cattabriga & Peresani 2024)
	Exhausted core	(Shelley 1990)
Formal tools	Hinges and steps	(Cunnar 2015); Darmark 2010)
	Poor symmetry	(Cunnar 2015)
	Miniaturization	(Cunnar 2015)
	Poor width-thickness ratio	(Cunnar 2015)
	Battering	(Darmark 2010)
	Extreme edge sinuosity	(Darmark 2010)
	Triangular cross-sections	(Darmark 2010)

Working with three separate groups of flintwork entails different approaches. We first conduct an outline analysis on the blades, using the principles of Geometric Morphometrics (GMM), to measure and plot variability in shape. The efficacy of GMM to assess artefact shapes has been amply demonstrated (*e.g.,* Cardillo 2010; Matzig *et al.* 2021; Tsirintoulaki *et al.* 2023), and knapping techniques have previously been investigated based on 2D blade morphometry (Radinović & Kajtez 2021). The latter study's data are integrated here and aligned with the analytical protocol of Matzig *et al.* (2021) in an R-based protocol (The R Core Team 2024). We extracted a total of 148 outlines from the sites Oldeholtwolde (n=22), Jels 2 (n=7), Egtved Mark (n=30), Højgård (n=38), Trollesgave (n=37), and Bromme (n=14), and combined them with the 51 artefact outlines that were either directly (n=31) or indirectly (n=20) knapped by an experimental archaeologist, published in Radinović and Kajtez (2021). These experimentally produced blades and their outlines served as a baseline in terms of adult competence. Using the Momocs package (Bonhomme *et al.* 2014), all outlines were centered on their origin (using `Momocs:: coo_center()`, scaled by their centroid size (`Momocs::coo_scale()`), and their starting point was set to be at the top (`Momocs::coo_slidedirection()`). Using `Momocs::efourier()`, an Elliptical Fourier Analysis was conducted on the artefact outlines using 26 harmonics. We then applied a Principal

Components Analysis (`Momocs::PCA()`). The first six Principal Component axes were plotted in pairs using ggplot2 (Bonhomme *et al.* 2014; Wickham 2016). To quantify and compare the shape variation of the artefacts, all Principal Component scores of the complete dataset were used in a disparity analysis, calculating the sum of variances for each site, using the dispRity package (Guillerme 2018) with 1000 bootstrap iterations. The results were visualised using both boxplots and so-called half-eye plots using the ggplot and ggdist packages (Kay 2024). A PERMANOVA and Mann-Whitney U test, with p-value adjustment using the Bonferroni method, were conducted to test whether disparity values between sites differ, yielding statistically significant results ($p < 0.001$).

For analysing the technological attributes of the laminar blades, a correspondence analysis (CA) was conducted. This analysis only includes blades from the collections that were analysed in person and includes a wider range of attributes (*i.e.*, Egtved Mark, Højgård, Oldeholtwolde and Trollesgave) (see Figure 2). A CA is a multivariate approach that is similar to a PCA but summarises categorical data in a reduced number of dimensions. It is therefore well suited for analysing a multitude of observations such as technological attributes of laminar blades while keeping the relation to the original object. For the projectile points, metric measurements of their width were analysed and compared to the dataset compiled by Thomas (1978) and Shott (1997). Their studies on projectile-point variability and classification aimed to discriminate between arrowheads and dart-points; we here use their data to establish the boundary values for adult-sized projectile points classes against which our archaeological values can be evaluated. If points in our sample fall within the lower end of these measurements, some form of scaling may be in evidence. The cores were analysed from a qualitative perspective, where potential markers of children's knapping, such as stepped hinges and hammer marks, were recorded and discussed. Metric measurements of width and height of the cores were also recorded.

Figure 2. Some of the blades showing attributes commonly ascribed to being the work of children, such as strong hinging, hammer marks and pronounced bulbs. Højgaard (a: CX2062 13/15 SV, b: RU2062 H13/16 SV, c: KR2062 12/15 NØ, d: OG 2062 H11/14 NØ, e: UO2062 H12/14 NV, f: 41S13, g: 7S37, h: 107S21), Oldeholtwolde (i: 12_4978, j: 12_2382, k: 12:6:134, 12_3705, l: 12.5434), and Trollesgave (m: 100/100:2164, n: 107/99:1000, o: 100/100:2163, p: 90/120:2000, q: 115/90:2000, r: 101/101:1001, s: 104/105:1085).

For blades, different attributes together with measurements have been recorded in standardised spreadsheets for easy comparison between both artefacts and sites. For cores, attributes such as preparation, exploitation, and measurements have been recorded. For points, metric data, primarily width and length (in mm), have been recorded. The data on blades for the GMM analysis stem from various collections (Højgård, Oldeholtwolde, Trollesgave, Egtved Mark) and from published illustrations (Bromme, Borneck-Ost, Jels) (Fischer 1990a; Kotthaus 2019; Madsen 1992; Mathiassen 1946). The points for the metric analyses have been derived mainly from publications (Fischer 1990a; Fischer & Nielsen 1987; Johansen & Stapert 2004; Kotthaus 2013; Mathiassen 1946; Rust 1958), supplemented with a few artefacts from Højgård, Trollesgave and Jels 1-2. The qualitative analysis of cores has been carried out on a small selection of cores from both direct observations (Trollesgave, Oldeholtwolde) and the literature (Johansen & Stapert 2004; Kotthaus 2019).

3. Results

3.1. Blades

The GMM analysis for the blades shows a quite homogeneous sample without many outliers (see Figure 3). This could indicate that the different assemblages have been knapped by only one individual. When comparing our data to the data collected by Radinović and Kajtez (2021), it is evident that some variation can be expected in assemblages produced by a single knapper. However, some sites seem to differ more than the others, namely Egtved Mark and Trollesgave.

Looking at the disparity plot (Figure 4), the two assemblages from Bølling/GI-1e seem to be more normative than the assemblages from Allerød/GI-1a-c. This is very much in line with the common conception of the flint technologies of these periods (*e.g.,* Pedersen *et al.* 2022). If we assume an indirect technique was primarily used at the Hamburgian sites, both Oldeholtwolde and Jels 2 suggest that several knappers were at work (interpreted against the indirect comparison data). In that light, especially Oldeholtwolde shows quite a lot of variation, possibly indicating the presence of an unskilled child knapper, as proposed in the literature (Johansen & Stapert 2004). Regarding the Allerød assemblages, Trollesgave is the site showing most variability, again indicating the presence of a possible child knapper, as also suggested previously (Fischer 1990a; 1990b). The Bromme site shows surprisingly little variation, which could be an effect of the sample size. Another interesting result is that Egtved Mark has a higher disparity value, as this site is commonly thought to be the work of a single knapper. This result could be explained by the considerable variation in artefacts within the assemblage, none of them being ‘less skilled’ versions, only variations, of the same kind of artefact.

In the multivariate space of the CA, blades stemming from Bølling/GI-1e and Allerød/GI-1a-c respectively orientate themselves differently from one another (Figure 5A). This reinforces the observation that Hamburgian knapping is more normative while knapping during the Allerød is more idiosyncratic. Hamburgian style knapping involves more trimming and abrasion and produces a high degree of lip formation as well as small and at time punctiform butts. During the Allerød/GI-1a-c, there appears to be greater variability, but also a tendency to produce larger butts, pronounced bulbs and less preparation of the blades (Figure 5B). While the Hamburgian material concentrates in the lower right quadrant, there are some outliers in the upper right quadrant. These are most probably related to fracture mechanics. The various Allerød assemblages appear to concentrate in the centre of the plot and to the left along dimension 1. While the material from Egtved Mark appears to concentrate in the middle, Højgård and especially Trollesgave stick out. The outliers from Trollesgave could be related to more unskilled knapping as the left part of the plot describes novice related knapping traits such as hammer marks, large and unfaceted butts. The same is true for Oldeholtwolde.

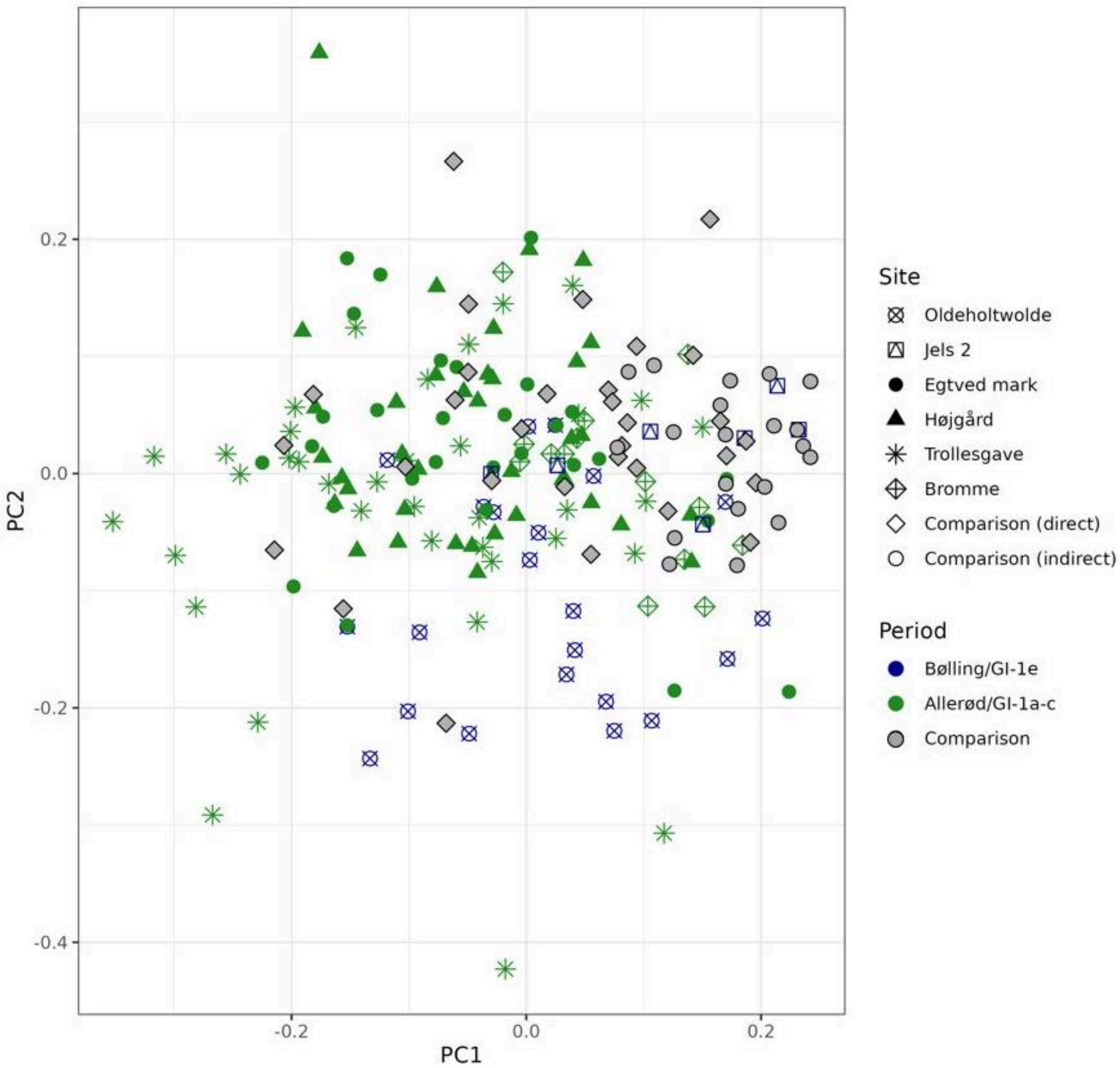

Figure 3. PCA-plot for the sites used in this study as well as the comparison data from Radinović and Kajtez (2021). As is evident from the plot, the samples are all quite heterogeneous with only a few outliers. Blue are sites from the Bølling/GI-1e. Green are sites from the Allerød/GI-1a-c. Grey are the comparison data.

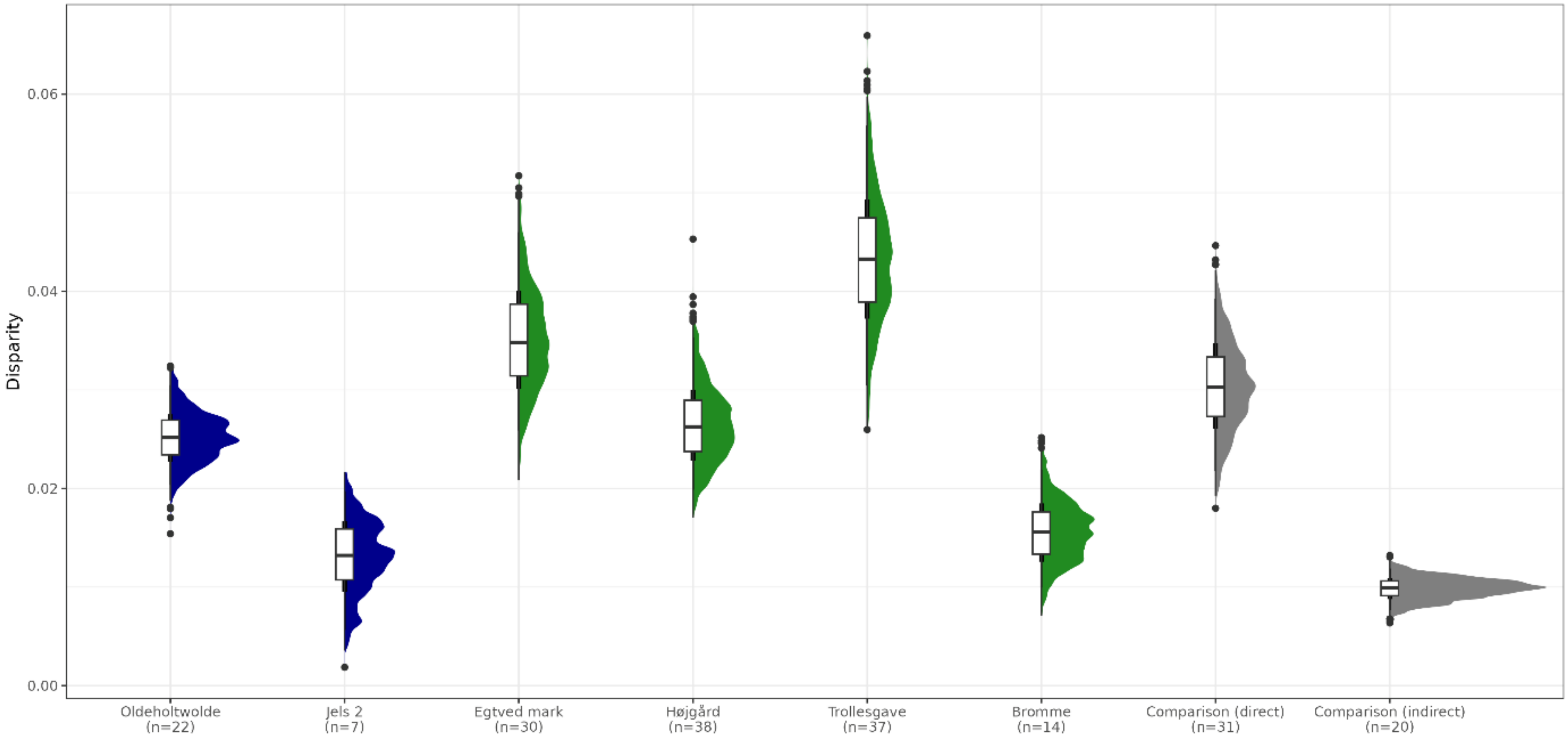

Figure 4. Disparity plot for the sites used in this study as well as the comparison data from Radinović and Kajtez (2021). The lower the disparity (here, the bootstrapped sum of variances), the more heterogeneous the assemblages, and the more they are likely to have been produced by only a single knapper. Blue= sites from the Bølling/GI-1e. Green= sites from the Allerød/GI-1a-c. Grey= comparative experimental data.

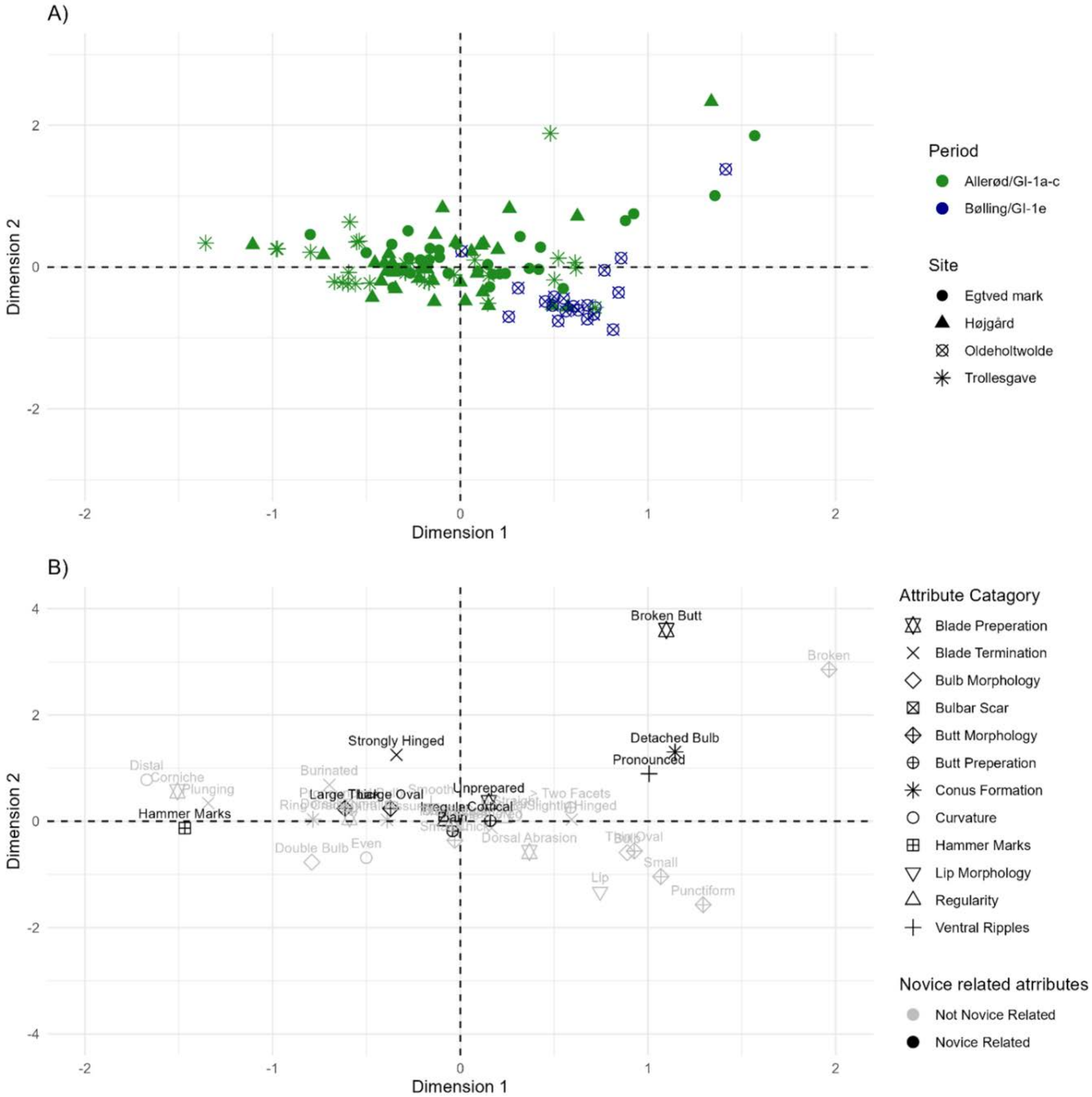

Figure 5. CA scatterplots. A) displays the distribution of laminar blades of various assemblages according to their technological attributes. B) displays the technological attributes with those attributes that are typically related to novice flint knappers highlighted.

3.2. Points

The analysed projectile points stem from several Hamburgian inventories, all related to the Havelte variant (*cf*. Pedersen *et al*. 2018), various inventories related to the Allerød/GI-1a-c, which mainly consists of large tanged points as well as arch backed points at the site of Borneck-Ost and ethnographic projectile point data of arrows and darts (Thomas 1978; Shott 1997).

Regarding projectile point function, Hamburgian points, due to their ballistic properties, are related to bow-and-arrow technology, although no archaeological remains of bow or arrow shafts are known from a Hamburgian context (Riede 2010; Weber 2009). For Allerød assemblages, it is suggested that arch backed points relate to bow-and-arrow technology, while the large tanged points would have served as dart- or javelin-tips (Riede 2009).

In terms of width, the present analysis aligns with these earlier findings. Both Hamburgian and arch backed points fall within the spectrum of the ethnographic arrows, while the large tanged points - notably variable - fit well with the ethnographic darts (Figure 6; Table 4). In the context of equipment scaling, it is the lower end of the width spectrum that is particularly pertinent. Overall, Hamburgian points are in the slimmer end of the arrowhead spectrum and quite uniform. However, within the inventory from Jels 2 there are points, which are far below the mean for Hamburgian point width. Some projectile points from Oldeholtwolde, a locale with prior arguments for the presence of children, are also slimmer than the mean. For the large tanged points, there are a few examples of points which are far below the mean width of both the bulk of the archaeological material as well as the ethnographic dart comparison. Interestingly, Borneck-Ost, another site with prior arguments for the presence of kids, is well represented here.

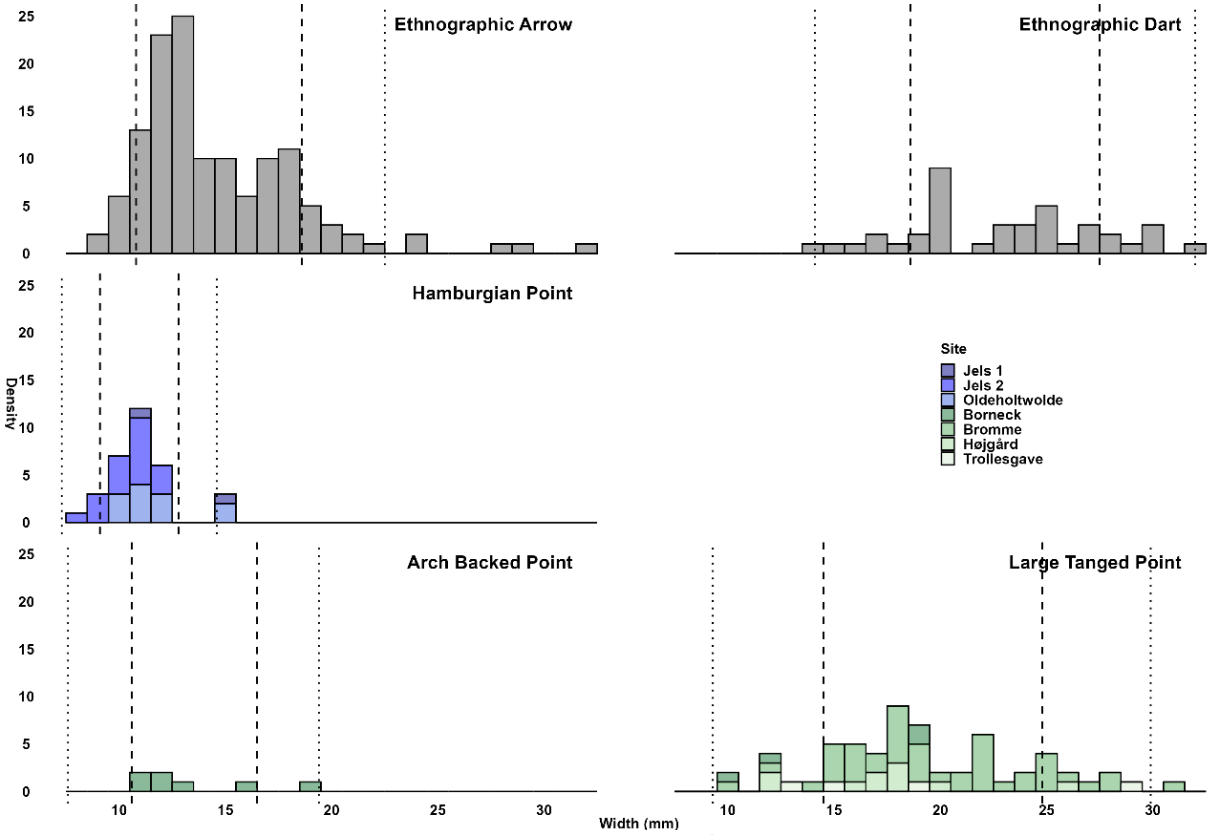

Figure 6. Histograms visualising the maximum width (in mm) of all analysed projectile points. Vertical dashed lines indicate ±1 standard deviation (σ) from the category mean, while dotted lines indicate ±2σ.

Table 4. Summary statistics for the maximum width (in mm) of projectile points in the study. For each category, the mean width and standard deviation are reported, along with the calculated ranges for one (±1σ) and two (±2σ) standard deviations from the mean. These values provide an indication of central tendency and variability in point morphology within each group.

Projectile point class		Mean	SD	Upper 1s	Upper 2s	Lower 1s	Lower 2s
Archaeological	Hamburgian	11	1.8	12.8	14.6	9.1	7.3
	Arch Backed	13.5	2.9	16.5	19.4	10.6	7.6
	Large Tanged	19.6	5.2	24.8	29.9	14.5	9.3
Ethnographic	Arrow	14.7	3.9	18.6	22.5	10.8	6.9
	Dart	23	4.5	27.5	32	18.6	14.1

3.3. Cores

From Oldeholtwolde, two cores have been suggested to have been handled by young, unskilled children. Both cores (refit-group 50 and 72) have been exploited from a single front and show prominent bulb negatives, hammer marks and series of hinges. For refit-group 72, a lack of platform preparation is also present (Johansen & Stapert 2004). From the Borneck-Ost material, only one core has been specifically mentioned as bearing characteristics of unskilled knapping. Core 53 is suggested to have been picked up by an unskilled individual after it has been exhausted by an experienced knapper. No successful objects have been knapped by the unskilled individual, only step breaks have been produced, arguably reflecting a knapper of limited knowledge and skill (Kotthaus 2019). The core from Trollesgave, core 115/95:2000, also shows many characteristics of unskilled knapping. Present on the cores are both stacked steps, series of hinges and hammer marks.

Common for the four cores are their smaller size. The core from Trollesgave is the largest with a maximum height of 99 mm and a maximum breadth of 58 mm. The smallest core is refit-group 50 from Oldeholtwolde with a maximum height of 62 mm and a maximum breadth of 27 mm. The two other cores lie in between these numbers, which places all the cores in the lower end of the scale for core sizes for the different sites (Figure 7).

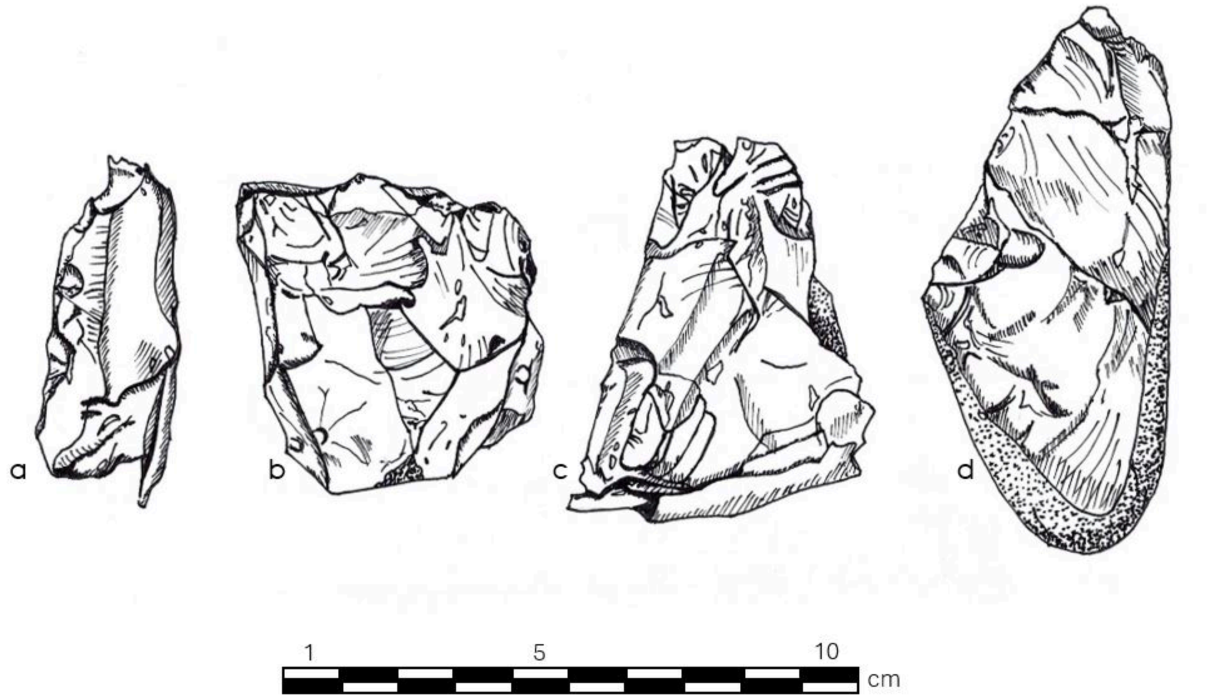

Figure 7. Drawing of the four cores that have traces of being worked by children, from smallest to largest. a: refit-group 50, Oldeholtwolde, b: core 53, Borneck-Ost, c: refit-group 72, Oldeholtwolde, d: core 115/95:2000, Trollesgave. All cores are small and have attributes such as stacked steps, series of hinges and hammer marks.

4. Discussion

Even considering multiple facets of flintwork, it is difficult to pinpoint children using lithic technological data alone. In the archaeological literature, there is a known tendency to preferentially depict regular and supposedly diagnostic artefacts, and so to set aside those objects perceived as less skilful or unusual (Hoggard *et al.* 2023; Lopes 2009; Saville 2009). Hence, many objects potentially reflective of unskilled or child knapping may not be reported. Moreover, considering skill proxies alone does not provide direct clues to children's stone handling as a myriad of other confounding but difficult-to-capture factors - time constraints, health status of the knapper, weather - may have impacted flint-working at any given time. Judiciously combining technological and scaling proxies for the identification of children does provide a more robust avenue to identifying both children actively engaging with stone-working and their enskillment via scaled-down qualifier toys.

The products of inexperienced knappers show more irregularity (*cf.* Table 2); their nonconformist and less-than-perfect craftwork introduces variability. This is partly because of children's less developed cognitive and motor skills, but also because of their more experimental trial-and-error based approach to knapping (Assaf 2021b). Such variability often leads to end products of low quality, but it also contributes to the generation of overall technological variability on which selection may act. From such variability, new technologies or variants of existing practices may arise (Assaf 2021a; Cattabriga *et al.* 2024).

Our quantitative analyses of the blades confirm the notion that the knapping protocols from the Bølling/GI-1e (Hamburgian) were more normative than those from the Allerød/GI-1a-c. By the same token, our analyses do also reveal assemblage homogeneity, indicating that these - with the exception of Trollesgave - were probably knapped by a single person. Our morphometric analysis indicates that the Trollesgave assemblage was knapped by more than one person, and outlier blades do show attributes commonly related to more unskilled knapping (*i.e.*, hammering and hinging). This supports the previous claims of the Trollesgave assemblage being knapped by more than one person, one of these probably being a child (Donahue & Fischer 2015; Fischer 1990a; 1990b).

Larger butts, more pronounced bulbs, and limited preparation are attributes related to unskilled knapping. These attributes are amply present in the Allerød/GI-1a-c assemblages considered in this study. While arguments for children knapping have been made for both Borneck-Ost (Kotthaus 2019) and Højgård (Ballin 1991), the overall variability and ad hoc nature of the flint-work at these sites and in this period do not allow us to use such criteria as strictly child-diagnostic.

Scaled-down miniatures that play an important role in child development (Riede *et al.* 2018) and aid the transmission of technological knowledge across generations of learners and users (Meyer *et al.* 2025) provide a different insight into the presence of multiple generations at these Late Pleistocene sites. Our projectile point analysis that compares Final Palaeolithic lithic armatures against adult-produced ethnographic standards - suggests that scaled-down qualifier toys may have been present at some of the sites under study. Note, however, that these standards are derived on a moderate sample of North American specimens originally introduced by Thomas (1978) and Shott (1997), which have come under some criticism (see Lombard *et al.* 2024 for a review).

For the blades, we chiefly considered signs of children actively knapping. For the points, we concentrated on identifying tools falling outside of standard ranges, especially values below these, as this could point to qualifier tools. According to our analysis, some points from Oldeholtwolde are substantially slimmer than the mean width for the period (Bølling/GI-1e). The same holds true for the points from Borneck-Ost (Allerød/GI-1a-c) - both the arch backed points and the large tanged points, several of which fall well below the core width range of arrow- and dart-heads respectively. Taking the arguments of qualifier tools being smaller (Dawe 1997; Losey & Hull 2019; Park 1998) as they are fitted to the measurements of the individual using them (Buszard *et al.* 2016; Kaaronen *et al.* 2023), these smaller points could be indicators of the provisioning of miniatures to children in order to foster their acquaintance with the technologies of their respective societies. With the two sites belonging to each their period, it is hard to say if any of these assemblages support that children should be more present in one period over the other.

Regarding the cores in focus here, it should be noted that we have focused only on those cores that have previously been suggested to have been produced by children (Fischer 1990b;

Johansen & Stapert 2004; Kotthaus 2019). These all exhibit several of the attributes supposedly diagnostic of the work of children, such as hammer marks and small size. To more securely assign such cores to the work of children, however, it would have been fruitful to combine the technological analysis with spatial analyses (see *e.g.*, Bodu *et al.* 1990; Mugaj 2015; Pigeot 1990), yet this was not possible given the resolution of our target sites.

Notably, our detailed technological analysis demonstrates that there are elements of poorer knapping in almost all assemblages under study, but that this cannot be confidently ascribed to the work of children. Triangulating between multiple proxies, however, we are able to point at the sites where the evidence for children is more convincing (Table 5).

Table 5. Presentation of the evidence of children for each category analysed in the article. -3 is no evidence, +3 is strong evidence. The overall evidence for children being involved in flintknapping at the site is scored on a scale from +++ (very strong evidence) to --- (no evidence).

		Score			Overall
	Site	Blades	Points	Cores	evidence
Bølling/GI-1e	Oldeholtwolde	+3	+2	+2	+++
	Jels (1/2)	-1	+1	-3	-
Allerød/GI-1a-c	Borneck-Ost	0	+3	+2	++
	Egtved mark	+1	-3	-3	--
	Bromme	-3	-3	-3	---
	Trollesgave	+3	-2	+2	++
	Højgård	+2	-3	-3	--

The scores we assign to each assemblage, based on our analyses above, point at strong evidence for children being present at several sites, especially Oldeholtwolde, with positive evidence for children found in both the analyses of the blades, the points and the cores. At Borneck-Ost, because of the small sample size, no analysis could be conducted on the blades. Nonetheless, there is strong evidence for children being present when looking at both the points and the cores. For Trollesgave, there were no clear signs of object scaling in the points, but there were clear indications of children knapping in both the blades and the cores. These results are all consistent with the previous claims of children being present at these three sites (Fischer 1990a; 1990b; Kotthaus 2019; Johansen & Stapert 2004).

At Højgård, it has previously been suggested that several knappers were present at the site, one of them being a child (Ballin 1991). Our analyses provide rather strong evidence for children in the blades, but for the points and cores, the evidence was non-existent. Therefore, the evidence for children being present at Højgård can only be said to be quite weak. Our analyses also showed some very weak evidence for children might being present at Jels (1/2) and at Egtved Mark. We suggest that this evidence relates to the inherent variation in the lithic assemblages, rather than indications of children being present. The only site that showed absolutely no evidence for children was Bromme, which may be said to be surprising given the relatively large size of this particular site.

Our study was motivated by the hypothesis that there may have been a greater presence and involvement of children in those societies that left a greater and long-lasting legacy, *i.e.*, the Federmessergruppen of the Allerød/GI-1a-c. Our analyses have revealed evidence for the presence of children at some albeit not all sites from both periods. Tentatively, we may point to a shift towards a greater involvement of children in both practice knapping and in the handling of scaled-down weapons and instruments as attested to by the cores and blades on the one hand and the smaller points on the other. This change in behaviour possibly allowed for a more playful, experimental approach to technological enskilment. This playful experimentation, in turn, may have boosted youngsters' ability to swiftly acquire the necessary skills and to innovate within these specific technological domains, not least as climate changed (Meyer & Riede 2025; Riede *et al.* 2018; 2021;). As proposed by Gopnik (2020), exploration and experimentation chiefly occurs during childhood. This will later allow individuals to better exploit their environment - including the technologies of their specific cultural niche - as adults. During childhood, play is a way to explore a broad range of affordances, also beyond the norm, which can become beneficial in periods of rapid environmental change (Lew-Levy & Amir 2024). Children's playful experimentation is thus helpful for adapting to climatic changes, arguably a major driver of evolution of human culture more broadly.

5. Conclusion

The archaeology of Stone Age children has matured substantively in the past decades (*cf.* Nowell 2021) as an increasing number of scholars seek to identify the traces of children in the often poorly preserved record from these very remote periods. While we wholeheartedly support this endeavour, our analysis has demonstrated just how difficult it is to robustly pinpoint children in lithic data alone. Often, sites do not offer the resolution required for such detailed analyses. Without extensive spatial analyses and refitting, it is challenging to say much about the presence of different individuals and skill levels - multiple competing interpretations remain equally likely (*cf.* Perreault 2019). Future use-wear analyses of the assemblages under study here could further help illuminate the presence of children. Determining how the flint objects were used can help us better understand technological skills and the possible involvement of children. Certain tacit assumptions further complicate matters. While it is often assumed that stone tools were produced by healthy, skilled individuals striving for efficiency and precision, this overlooks the reality of individual variation in ability, experience, and physical condition. Such variation is especially evident in smaller assemblages, where the actions of one or a few individuals may disproportionately shape the archaeological signal. However, in larger assemblages, these individual-level differences tend to average out, allowing more representative insights into group-level technological practices. Nonetheless, attention to anomalous patterns remains important, as they may reveal the presence of novices, children, or individuals with impairments.

That said, we have here shown that the combined analytical focus on blades, points, and cores may allow us to more securely identify evidence for children at a given locale. Our analyses support previous interpretations of children being present at the sites of Oldeholtwolde (Johansen & Stapert 2004), Borneck-Ost (Kotthaus 2019) and Trollesgave (Fischer 1990a; 1990b), but not at Højgaard. Tracking the lithic signatures of children in the Final Palaeolithic of southern Scandinavia has demonstrated that children were indeed present in both periods. Moreover, we suggest that children became more involved, and hence more visible, in the lithic record during the Allerød period. In this period, children arguably contributed more substantially to the overall cultural variability in their communities. This variability provided the grounds for tacit mastery, increased creativity, innovation and thus for adaptation.

Acknowledgements

This work was supported by Aarhus University as part of Mathilde Vestergaard Meyer's PhD grant. The contributions of Felix Riede, David Nicolas Matzig and Jesper Borre Pedersen to this paper are part of CLIOARCH, an ERC Consolidator Grant project that has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No. 817564). We would like to thank the Rijksmuseum van Oudheden in Leiden, Museet Sønderskov, Moesgaard Museum, VejleMuseerne and The National Museum of Denmark respectively for granting access to the various assemblages included in the study.

Data accessibility statement

The data that support the findings of this study is available on GitHub with the following link: https://github.com/JesperBorrePedersen/palaeo-youth-skills

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Færdigheder, pbjekt-skalering og børns rolle i tilpasning i nordeuropæisk senpalæolitikum

Mathilde Vestergaard Meyer [1], Jesper Borre Pedersen [2], David Nicolas Matzig [3], Felix Riede [1]

1. Afdeling for Arkæologi og Kulturarvsstudier, Aarhus Universitet. Moesgård Allé 20, 8270 Højbjerg, Danmark. Email: Meyer: mathilde.meyer@cas.au.dk; Riede: f.riede@bio.au.dk
2. The Role of Culture in Early Expansions of Humans, Heidelberg Academy of Sciences and Humanities, Tübingen, Tyskland. Email: jesper-borre.pedersen@ifu.uni-tuebingen.de
3. AU Library, Aarhus Universitet. Bartholins Allé 9, 8000 Aarhus C, Danmark. Email: dnma@kb.dk

Resumé:

Børn udgjorde på et hvilket som helst tidspunkt i palæolitikum den største gruppe af individer i et givet samfund. Selvom der ikke kendes mange genstande tilskrevet børn fra disse fjerne perioder, er der ingen tvivl om at børn deltog i mange aspekter af dagligdagen, herunder flintslagning. I slutningen af palæolitikum ser vi en stigning i de innovative transformationer, og det er meget sandsynligt at børn spillede en afgørende rolle i at generere teknologisk variation samt i tilpasningsdygtigheden. I dette studie fokuserer vi på børns rolle i nordeuropæiske samfund i den senpalæolitiske periode, hvor markant forskellige klimatiske regimer herskede, for bedre at forstå, hvordan børn og deres legende, udforskende læring kan have bidraget til tilpasning. I denne periode fandt to adskilte spredningsprocesser sted, hvilket resulterede i to adskilte flintkulturer – Hamburgkulturen og Federmessergruppen. De to gruppers litiske repertoirer er meget forskellige, hvor Hamburgkulturen reflekterer en meget normativ flintslagning imens Federmessergruppen udviser større variation af strategier, både i og imellem inventarerne. Disse forskelle reflekterer en bredere kontrakt i befolkningsstruktur og mobilitet. Vores analyse fokuserer på syv pladser fra den nordeuropæiske senpalæolitikum, hvoraf fire af disse tidligere har været postuleret som indeholdende spor af uerfarne flintsmede. Uerfarne flintsmede kan identificeres ved gentagne fejl og en ineffektivitet i behandling af flinten der reflekterer en begrænset teknisk viden, ringere motoriske færdigheder samt fysiske begrænsninger. Selvom disse kan bruges til at pege på uerfarne flintsmede, giver disse ikke direkte bevis for tilstedeværelsen af børn. Genstande i miniature kan være tegn på objektskalering, hvis brug i oplæringen af børn er bevist i flere etnografiske og moderne studier. Ved hjælp af en blanding af metoder studerer vi uerfarne flintsmede med vægt på tre forskellige grupper af flintarbejde: flækker, kerner og projektilspidser. Dette gøres for at undersøge variationen inden for ed tre grupper med de formål at spore børns mulige arbejde gennem begreber om færdigheder og skalering. Dette vil tillade os at undersøge hvordan vi kan identificere signaturerne hos børn der hugger flint og hvordan børns deltagelse i flintarbejde varierede mellem perioder præget af forskellige klimaer.

Omridsanalyse af flækkerne ved hjælp af 2D geometrisk morfometri (GMM) tillader os at spore variabiliteten i deres form. Denne variation sammenligner vi ved hjælp af en Principal Component Analysis (CPA). Til sidst udfører vi en Correspondence Analysis (CA) til at analysere de teknologiske attributter for flækkerne. For pilespidserne analyserer vi metriske attributter og sammenligner disse med et etnografisk kontrolsæt for uld funktionsdygtige pilespidser brugt af voksne for at etablere grænserne for spidser i fuld størrelse. Spidser der falder under den normale størrelse kan være tegn på objektskalering. Kernerne undersøger vi fra et kvalitativt perspektiv, hvor potentielle markører for børns flintslagning fremhæves og diskuteres.

GMM for flækkerne viste meget homogene inventarer, hvilket er tegn på at genstandene er slået af en enkelt person. Dog ser inventarerne fra Hamburgkulturen – med undtagelsen af Oldeholtwolde – ud til at være mere normative end for Federmessergruppen, hvilket stemmer overens med den almene opfattelse af flintinventarerne fra disse perioder. Dette bekræftes også af vores CA for flækkerne. For spidserne ser vi beviser for objektskalering på nogle pladser. Igen skiller Oldeholtwolde sig ud. Analysen af kernerne viser også tegn på tilstedeværelsen af uerfarne flintsmede på Oldeholtwolde.

Selvom vi har kigget på flere facetter af flintslagning, er det stadig svært med sikkerhed at udpege børn på baggrund af litisk data alene. Triangulering mellem adskillige elementer kan dog hjælpe os med at pege på pladser der med stor sandsynlighed indeholder spor efter børns flintslagning. Vores kvantitative analyser af flækkerne bekræfter ideen om mere normativ flintslagning for Hamburgkulturen end for Federmessergruppen. Vores analyser af spidserne viser at nedskalerede objekter er til stede på flere pladser – især på Oldeholtwolde. Tilsammen peger vores analyser dog på en større involvering af børn i både flintslagning og håndtering af nedskalerede objekter mod slutningen af perioden. Denne større involvering betyder et større bidrag fra børn til den overordnede kulturelle variabilitet i samfundene fra den yngre tidsperiode.

Nøgleord: flint; børn; senpalæolitikum; flintslagning, færdigheder

Fertigkeiten, Objekt-Skalierung und die Beiträge von Kindern zur Anpassung im nordeuropäischen Spätpaläolithikum

Mathilde Vestergaard Meyer [1], Jesper Borre Pedersen [2], David Nicolas Matzig [3], Felix Riede [1]

1. Abteilung für Archäologie und Kulturerbestudien, Universität Aarhus, Moesgård Allé 20, 8270 Højbjerg, Dänemark. Email: Meyer: mathilde.meyer@cas.au.dk; Riede: f.riede@bio.au.dk
2. The Role of Culture in Early Expansions of Humans, Heidelberger Akademie der Wissenschaften, Tübingen, Deutschland. Email: jesper-borre.pedersen@ifu.uni-tuebingen.de
3. AU Library, Universität Aarhus, Bartholins Allé 9, 8000 Aarhus C, Dänemark. Email: dnma@kb.dk

Zusammenfassung:

Kinder stellten im Paläolithikum zu jedem Zeitpunkt den zahlenmäßig größten Teil der jeweiligen Gemeinschaften. Obwohl nur wenige Artefakte aus diesen urgeschichtlichen Perioden eindeutig Kindern zugeschrieben werden können, besteht kaum Zweifel daran, dass sie an zahlreichen Aspekten des alltäglichen Lebens beteiligt waren, einschließlich der Silexbearbeitung. Gegen Ende des Paläolithikums lässt sich ein deutlicher Anstieg innovativer Transformationsprozesse beobachten, und es ist sehr wahrscheinlich, dass Kinder eine maßgebliche Rolle bei der Erzeugung technologischer Variabilität und der kollektiven Anpassungsfähigkeit spielten.

Die vorliegende Studie befasst sich mit der Rolle von Kindern in den spätpaläolithischen Gesellschaften Nordeuropas, die stark divergierenden klimatischen Bedingungen ausgesetzt waren. Ziel ist es, besser zu verstehen, inwiefern Kinder und ihre spielerisch-explorativen Lernprozesse zur Anpassungsfähigkeit dieser Gruppen beigetragen haben könnten. In dieser Phase lassen sich zwei voneinander getrennte Ausbreitungsprozesse nachweisen, die mit zwei unterschiedlichen lithischen Traditionen einhergingen: der Hamburger Kultur und den Federmesser-Gruppen. Die lithischen Repertoires dieser Kulturen unterscheiden sich signifikant: Die Hamburger Kultur weist ein stark normatives Reduktionsschema auf, während die Federmesser-Gruppen eine deutlich breitere Variationsbreite von Strategien erkennen lassen, sowohl innerhalb als auch zwischen einzelnen Inventaren. Diese Unterschiede spiegeln kontrastierende demographische Strukturen und Mobilitätsmuster wider.

Unsere Analyse konzentriert sich auf sieben Fundplätze des nordeuropäischen Spätpaläolithikums, von denen vier zuvor als mögliche Fundorte mit Spuren unerfahrener Steinschläger postuliert worden sind. Unerfahrene Steinschläger lassen sich anhand wiederkehrender Fehlabschläge und einer ineffizienten Bearbeitung des Rohmaterials identifizieren, was auf begrenztes technisches Wissen, geringere motorische Fähigkeiten sowie physische Beschränkungen schließen lässt. Obwohl solche Merkmale auf unerfahrene Steinschläger hinweisen können, stellen sie jedoch keinen direkten Nachweis für die Anwesenheit von Kindern dar. Miniaturisierte Artefakte können Hinweise auf Objekt-Skalierung liefern, deren Einsatz in dem spielerischen Anlernen von Kindern in verschiedenen ethnografischen und modernen Studien nachgewiesen ist.

Unter Anwendung eines gemischten Methodenapparates untersuchen wir unerfahrene Steinschläger mit Schwerpunkt auf drei Gruppen lithischer Produkte: Klingen, Kerne und Projektilspitzen. Ziel ist es, die Variation innerhalb dieser drei Gruppen zu erfassen, um anhand von Konzepten wie Fertigkeiten und Skalierung mögliche Beiträge von Kindern sichtbar zu machen. Dies erlaubt es uns zu prüfen, wie sich die materiellen Signaturen von Kindern identifizieren lassen und wie sich die Beteiligung von Kindern an der Silexbearbeitung zwischen klimatisch unterschiedlichen Perioden unterschieden haben könnte.

Die Konturanalyse von Klingen mittels 2D-geometrischer Morphometrie (GMM) ermöglicht es uns, die Variabilität ihrer Form zu erfassen. Diese Variation vergleichen wir mithilfe einer Hauptkomponentenanalyse (PCA). Abschließend führen wir eine Korrespondenzanalyse (CA) zur Untersuchung der technologischen Attribute der Abschläge durch. Für die Projektilspitzen analysieren wir metrische Attribute und vergleichen diese mit einer Kontrollgruppe von Projektilspitzen, für die der Gebrauch durch Erwachsene ethnographisch belegt ist. Spitzen, die unterhalb der normalen Größe liegen, können Hinweise auf Objekt-Skalierung darstellen. Die Kerne betrachten wir aus qualitativer Perspektive, wobei potenzielle Marker kindlicher Silexbearbeitung erfasst und diskutiert werden.

Die GMM-Analyse der Klingen zeigte sehr homogene Inventare, was darauf hindeutet, dass die Stücke jeweils von einer einzigen Person hergestellt wurden. Allerdings erscheinen die Inventare der Hamburger Kultur normativer als jene der Federmesser-Gruppen, was mit der allgemeinen Auffassung über deren lithische Traditionen übereinstimmt. Die Klingen von Oldeholtwolde weisen jedoch eine bemerkenswert große Variation auf. Dies wird durch unsere CA-Analyse bestätigt. Auch bei den Projektilspitzen finden wir Hinweise auf Objekt-Skalierung an mehreren Fundplätzen. Wiederum sticht Oldeholtwolde hervor. Die Analyse der Kerne zeigt ebenfalls Hinweise auf die Präsenz unerfahrener Steinschläger an diesem Fundplatz.

Obwohl wir mehrere Facetten der Silexbearbeitung untersucht haben, verbleibt es schwierig, allein anhand von Lithik spätpaläolithische Kinder mit Sicherheit zu identifizieren. Die Kombination verschiedener Evidenzgruppen kann jedoch dabei helfen, Fundplätze zu bestimmen, die mit hoher Wahrscheinlichkeit Spuren kindlicher Silexbearbeitung enthalten. Unsere quantitativen Analysen der Klingen bestätigen die Annahme stärker normativer Silexbearbeitung in der Hamburger Kultur im Vergleich zu den Federmesser-Gruppen. Unsere Analysen der Spitzen zeigen, dass verkleinerte Objekte an mehreren Fundplätzen auftreten – besonders in Oldeholtwolde. Insgesamt deuten die Ergebnisse auf eine zunehmende Beteiligung von Kindern sowohl an der Flintbearbeitung als auch an der Handhabung verkleinerter Objekte gegen Ende des Untersuchungszeitraums hin. Diese verstärkte Beteiligung impliziert zugleich einen größeren Beitrag von Kindern zur kulturellen Variabilität der jüngeren spätpaläolithischen Gesellschaften.

Schlüsselwörter: Silex; Kinder; Spätpaläolithikum; Silexbearbeitung; Fertigkeiten