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BRILL

A Cultural Transmission Model for the Origins of Westerwanna: Four-Sided Dice in Northern Europe

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Abstract

Westerwanna are four-sided dice first produced among the Frisii people in the northern Netherlands and Germany during the late Iron Age and Imperial Roman period. We report analyses on a set of 27 Westerwanna and 15 oblong four-sided dice from this region to examine their cultural origin. While some attributes, such as Sevens configuration, conform strongly to patterns in Roman six-sided dice, others, such as pip orientation and layout, more closely resemble Celtic and Free Germania oblong dice. We argue in this article that Westerwanna dice reflect a blending of cultural information from different ancient cultures, resulting in a new form.

Keywords

dice – Frisii – games – Iron Age – Roman – Netherlands

1 Introduction

Dice have been a part of the archaeological record since at least the third millennium BCE (Dales 1968; Van der Heijdt 2001; Sajjadi et al. 2003). Their analysis has opened important windows on ancient game play (e.g., Depaulis 2020; Nifosi 2023), but also more broadly, contact and the transmission of technological information between ancient cultures (Artioli et al. 2011; De Voogt et al. 2015; Eerkens & De Voogt 2018).

During the later Roman Period (ca. 100 BCE–400 CE), astragals (knucklebones), oblong four-sided dice (sometimes called ‘stick’ dice), and cubic six-sided dice are

found in sites across a broad region in northwestern Europe (Fig. 1). Krüger (1982, 154) showed that sites in the western and southern part of this region were dominated by cubic dice, while those in the eastern part had more oblong dice. During this period, Frisii people, on the border of both Free Germania (to the north and east) and the Roman Empire (to the south), introduced a new and distinct type of four-sided dice, called the ‘Westerwanna’ die by Krüger (1982, 153), named after the type-site in northwestern Germany.

The Westerwanna die is not elongated as most other four-sided dice but has two opposite ends that are rounded, thereby contributing to a more spherical or ovular form (Fig. 2). Four flattened faces, in pairs opposite one another, contain the pips. When rolled, the die is only able to settle on one of the four faces. A subset of Westerwanna dice is made from hollow long-bone (Fig. 2, bottom-right) and is not rounded, but also does not have ‘sides’ on the ends with pips. While dice from this subset could potentially land on these sides/ends, given the elongated shape, such a result is very unlikely (Singmaster 1981; Mungan & Lipscombe 2013).

Krüger (1982) based his definition of Westerwanna on just six examples that showed little variation. He believed the type reflected blending of ideas from Celtic, Roman and Free Germania cultures, but his dataset was limited. More recently, Küchelmann (2017–2018, 116) proposed a more specific transmission pathway, speculating that Westerwanna were a derivative of oblong Celtic Iron Age dice and not related to Roman dice. Using Cultural Transmission theory, and an independent and previously unpublished data set of Westerwanna dice from the northern Netherlands, we compare Westerwanna

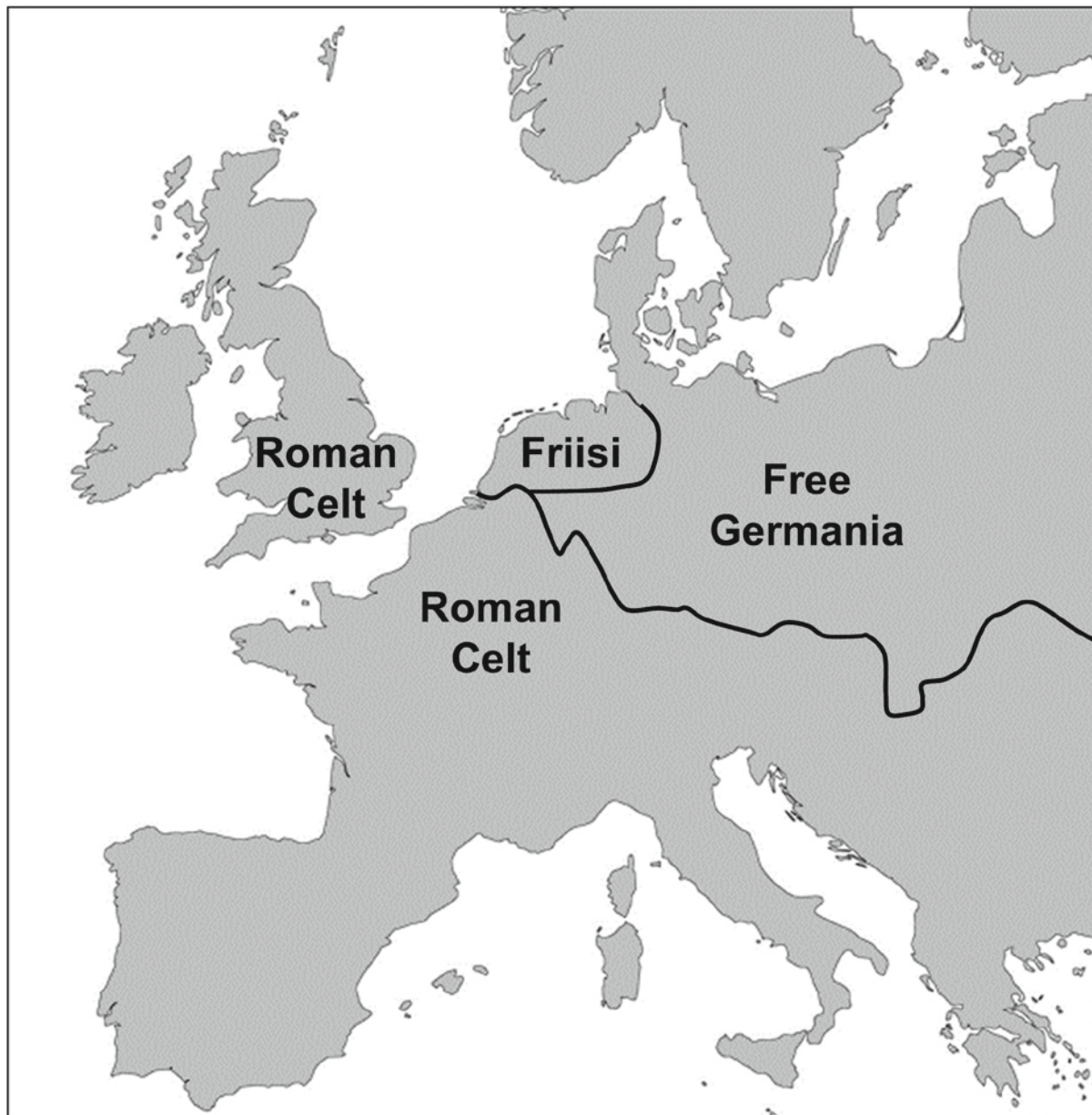


FIGURE 1 Map at approximately 1 CE, showing general cultural boundaries
MAP: AUTHORS

with oblong and six-sided dice from the same region to evaluate different transmission models and a likely origin for this die type. This model provides insight into ancient cultural interactions and information exchange.

2 Cultural Transmission of Games and Dice

Cultural Transmission (CT) theory explores how cultural information is transmitted between individuals. CT is useful because it provides discrete models on how 'packages' of information can be structured, biased or distorted during transmission. For example, *conformist*

transmission describes a process where individuals seeking to learn how to engage in some behaviour where there are multiple options (e.g., what types of clothing to wear) and choose to copy the most popular or common cultural variant. By contrast, *individual learning* describes a process where people will experiment with different variants or innovate new ones to find one that meets their needs. While archaeologists cannot typically see or reconstruct individual transmission events, such models are useful in their discipline to explain larger patterns in variation of material culture over space and/or time. These patterns provide insight into ancient transmission processes (Eerkens & Lipo 2007), such as

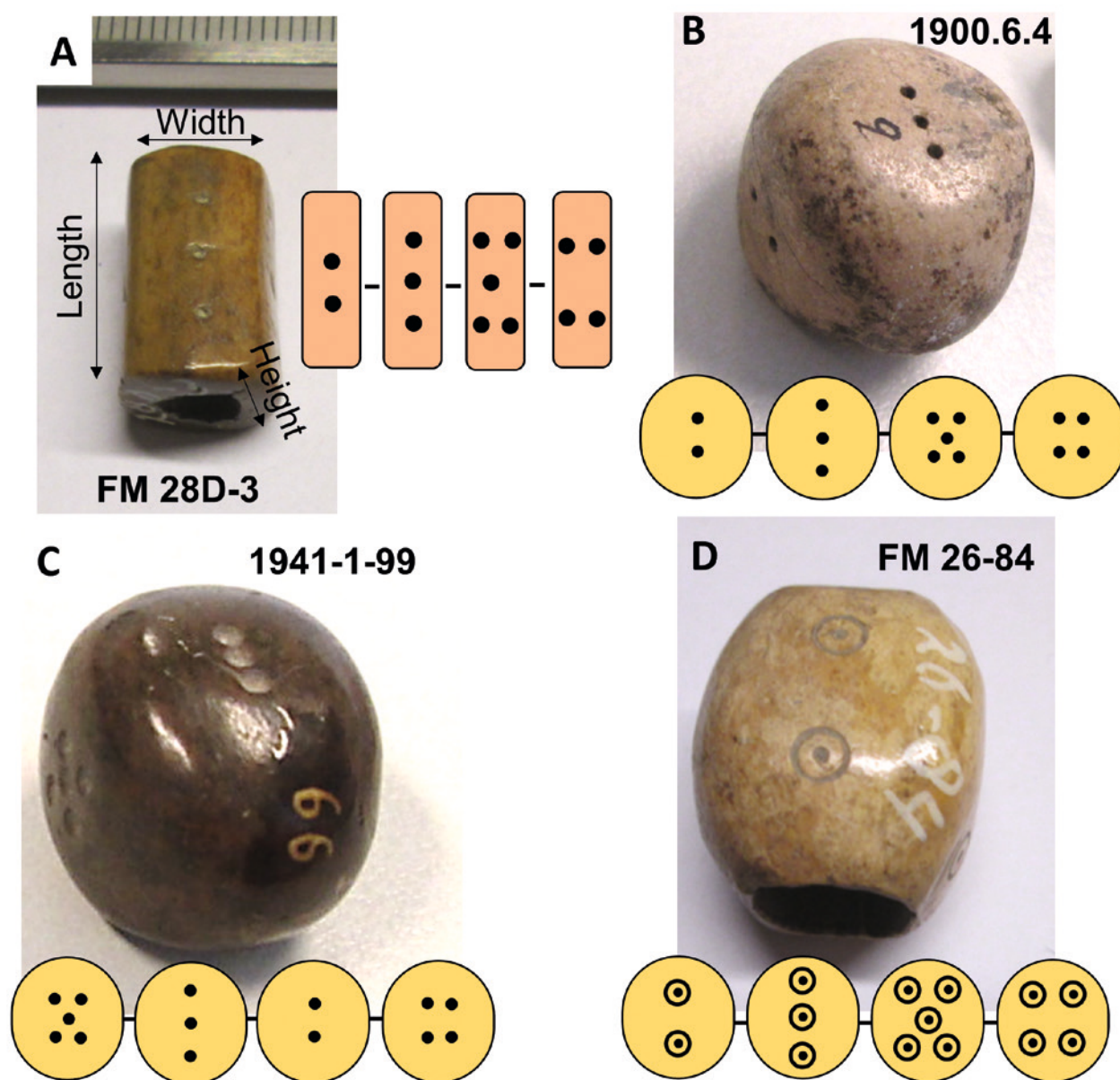


FIGURE 2 Oblong dice (A, C), typical solid Westerwanna die (B), and hollow Westerwanna die (D); figure also shows pip styles, with simple 'dots' (A, B, C) and 'dot-ring' (D)
PHOTOS: AUTHORS

how technological information about making pots or smelting iron spread across a region and over time.

Scholars generally agree that six-sided dice were introduced by the Romans to Germanic Frisii people in the northern Netherlands (Krüger 1982; Van der Heijdt 2001; Hall and Forsyth 2011; Eerkens & De Voogt 2022). Six-sided dice were common in Roman society, used in both gaming and divination (Swift 2017a; 2017b). Similarities in shape and configuration (i.e. how the pips are arranged onto the cube) of dice in the Roman Empire and Roman-period dice in the Netherlands leave little doubt that the Romans are responsible for introducing six-sided dice technology into the region.

Although formal Roman expansion stopped at the Rhine River, a northern boundary for the empire referred to as the *Limes Germanicus* (Wheeler 1954; Whittaker 2004, 7; Galestin 2010; Suharoschi et al. 2020), cultural interaction still occurred between Romans and those who lived north of the boundary (Wells 1999; Galestin 2010; De Bruin 2019; Suharoschi et al., 2020). For example, many Frisii were recruited into the Roman army, gained Roman citizenship and traded with Romans (Galestin 2007–2008; Kootker et al., 2022). Not all interaction was peaceful, of course, and as recorded in Roman documents, Frisii sometimes attacked Roman forts along the *Limes* (Goodyear 2004). As well, recent field

investigations reveal the presence of several temporary Roman military forts well north of the *Limes* (Driessen & Verschoof-Van der Vaart 2024).¹ These findings attest to cultural exchanges between Romans and Frisii, both in conflict and cooperation, and set the stage for the exchange of cultural information.

On the other hand, debate exists about how four-sided dice technology originated in northwestern Europe. Four-sided oblong dice are rare or absent in Roman contexts south of the *Limes* (Krüger 1982). While beyond the scope of this paper, possible exceptions may represent other exchanges of information and/or trade of actual dice. Thus, introductions of dice from Celts have been reported before, for instance, in Schädler (2019), who reports an exchange between Celtic and Etruscan peoples that also included four-sided dice technology. In any case, direct transmission of four-sided dice from Romans to Frisii is unlikely because this technology was not a regular part of the Roman material culture repertoire.

Instead, there are three likely models for the origins of Westerwanna dice in the Netherlands that we explore further. First, it is possible that the *concept* of dice was introduced to the Frisii, and that this model was adapted into Frisii culture with modification, a process known more generally as cultural ‘translation’ (Eerkens & Lipo 2007). Under such a model, we expect similar amounts of variation in both the translated population of objects (i.e. Westerwanna dice in this case) and the original donor population. This holds because if the transmission happened over a short amount of time, there is less time for experimentation and copying errors to build up in the receiving population. As well, the ideas about a technology should be transmitted together, leading to higher covariation between various attributes (e.g., the material used to make an object and its size, and perhaps how the object is used). Further, there should be direct and unambiguous analogues in the technology between donor and receiving populations.

Second, four-sided dice are found in other regions of northwest Europe around the same time as in the Netherlands (Clark 1970; Krüger 1982; Ramstad 2020). Thus, the transmission of four-sided dice technology to the Frisii may have been from multiple donor populations, each with a slightly different die style, as proposed by Küchelmann (2017–2018). This is a cultural ‘blending’

of information. In such a case, higher variation in the adopter population is expected, as multiple donor populations each contribute some amount of information, which can be mixed together in various ways. Further, we expect lower degrees of covariation between traits within the receiving population as different elements are borrowed from different donor populations.

Third, Westerwanna dice may have been independently invented among Frisii with little influence from other cultures. Such objects could have been present in low frequencies prior to Roman contact, but evidence for their existence has not yet been detected through archaeological excavation and careful dating. Under this model, we also expect high rates of variation since dice technology would be present for longer, and due to copying errors, variation would slowly accumulate over time. As well, we expect few direct analogues in the traits of dice between cultures.

We realise these models are idealised, and actual transmission of dice technology (or any technology) likely has a complex history that could have involved aspects of all three. However, below we intend to examine which of these models *best* explains empirical data within four-sided dice in the Netherlands.

3 Results and Discussion

We measured 27 Westerwanna dice (21 solid and six hollow) from the Dutch provinces of Groningen ($n = 6$) and Friesland ($n = 21$). For reference, we also collected data on 15 four-sided oblong dice from Friesland ($n = 10$), Groningen ($n = 3$), Utrecht ($n = 1$) and Zuid-Holland ($n = 1$). All dice are made of organic materials, and based on visual properties, they all appear to be made of bone, though additional biochemical analyses are necessary to verify this assertion.

3.1 Morphological Variation

Figure 3 plots the longest axis (length) against the second-longest axis (width) for dice complete enough to measure both dimensions. Figure 3 suggests clear differences in the shape of die types, where oblong dice are less wide than Westerwanna, especially hollow Westerwanna. A t-test comparing mean width for all Westerwanna (solid and hollow) vs. all oblong dice (including an anomalous oblong die from Utrecht) is significant ($p < 0.00001$). This points to likely differences in the types of bone used to produce dice, especially the hollow forms (i.e. thicker bones for Westerwanna, thinner for oblong).

1 For photos, see Geggel 2025. Roman army camp found in Netherlands, beyond the empire's frontier. *LiveScience*. <https://www.livescience.com/archaeology/romans/roman-army-camp-found-in-netherlands-beyond-the-empires-frontier> (July 23, 2025).

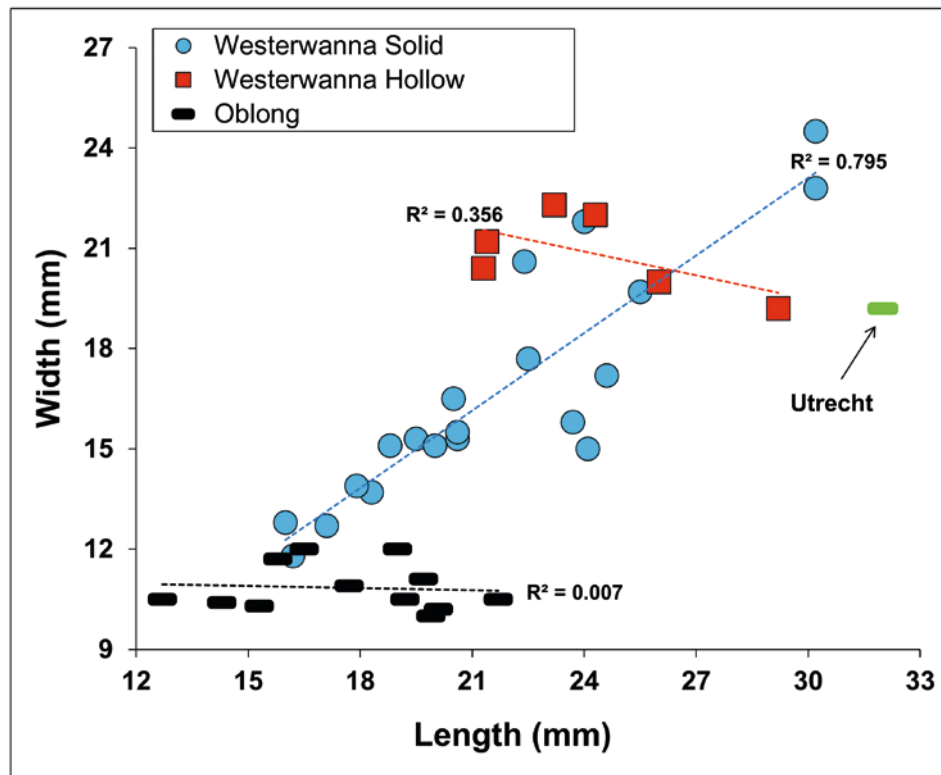


FIGURE 3 Length vs. width for four-sided die types in the Netherlands
PLOT: AUTHORS

Table 1 presents the average and the Coefficient of Variation (cv) for length, width and height for different die types, but removing the clearly anomalous Utrecht die. Oblong dice are less variable in width ($cv = 0.08$) and height ($cv = 0.11$) but approximately twice as variable on the longest axis ($cv = 0.15$). There is no correlation between length and width for this die type ($r^2 = .01$). Hollow Westerwanna dice show a similar pattern, with low variation for width and height ($cv = 0.06$ and 0.07 , respectively), higher variance in length ($cv = 0.12$) and have low correlation between length and width ($r^2 = .35$).

By contrast, solid Westerwanna dice are more variable on all three attributes ($cv = 0.19$, 0.21 and 0.18). As well, these dice show a stronger and positive correlation on length and width ($r^2 = .79$), with longer dice increasing linearly in width. Little regard for overall morphology (i.e. high metrical variation) is a characteristic of Roman period six-sided dice (see Eerkens & De Voogt 2022). In this regard, Westerwanna dice, especially solid ones, are much like Roman six-sided dice.

Bones for adults of particular animal species tend to have relatively standardised shapes and sizes. Thus, femurs of adult cattle will be similar from animal to animal but will be systematically larger than femurs of adult sheep. We argue that the difference in widths of hollow Westerwanna and oblong dice is from the

TABLE 1 Average and CV metrics for die types

	Length		Width		Height	
	Avg	CV	Avg	CV	Avg	CV
Oblong	17.7	.15	10.7	.08	10.4	.11
Westerwanna-solid	21.5	.19	16.6	.21	15.7	.18
Westerwanna-hollow	24.2	.12	20.9	.06	20.9	.07

Notes: CV = Coefficient of Variation (average / standard deviation)

systematic use of long bones from different animal species, for example, cows for Westerwanna and sheep for oblong. This hypothesis could be tested in the future by ZooMS (Zooarchaeology by Mass Spectrometry) or ancient DNA analysis. The one unusually wide oblong die from Utrecht is an exception, but since it is from outside the Friisi region, it may have been made under different production rules. It falls on the regression line of the hollow Westerwanna dice and seems to have been produced from the larger species.

3.2 Stylistic Variation

Table 2 reports Indices of Qualitative Variation (IQV) as a measure of variation in die configuration and pip style.

TABLE 2 Counts for different configurations and pip styles for four-sided dice and associated IQV

	Configuration				Pip style			
	Seven	Turn	Seq.	Unorth.	IQV	Dot	Dot-R	Dot-two-R
Oblong	7	1	1	3	0.78	11	2	1
Wester-solid	19	0	0	0	0	18	2	0
Wester-hollow	6	0	0	0	0	4	2	0

Notes: Turn. = Turned; Seq. = Sequenced; Unorth. = Unorthodox; Dot-R = Dot surrounded by a single ring; Dot-two-R = Dot surrounded by two rings

Configuration in Westerwanna dice is uniform (IQV = 0). Of the 25 Westerwanna dice with all four pips visible and present (both hollow and solid), all show the pips 2, 3, 4 and 5, and are in a configuration where the face of the 2 is opposite the 5, and the 3 is opposite the 4. This is referred to as the 'Sevens' configuration, as opposite sides total to seven. Roman six-sided dice from the Netherlands are nearly uniform in this configuration, especially those made from bone and antler (Eerkens & De Voogt 2022). By contrast, oblong dice from the Netherlands are in a much broader range of configurations (IQV = 0.78). Of twelve with visible pips, three are 'unorthodox' using either 3-4-5-6 (the unusual die from Utrecht), 3-6-5-12 (Friesland) or 5-5-5-5 (Friesland). As well, one is 2-3-4-5, which is called 'turned' because the numbers are placed successively on the object if it is turned through the four faces, and one is 2-4-3-5, called 'Sequenced' because the opposite sides are sequential (and do not add to seven).

Solid Westerwanna dice are also more standardised for pip style. Where visible, we recorded three different pip styles: simple dots ($n = 33$), dots with a single ring ($n = 6$ as in Fig. 2D), and dots with two surrounding rings ($n = 1$). While 90% of solid Westerwanna dice conform to simple dots (IQV = 0.27), hollow Westerwanna (IQV = 0.67) and oblong dice (IQV = 0.54) are more variable, with the latter showing all three pip styles. In this respect, Westerwanna and oblong both differ markedly from Roman six-sided dice, which are predominantly dot-ring or dot-two-ring.

Layouts of the dots follow a similar pattern. While there is near-conformity among all dice for the layout of the numbers 2, 4 and 5, the layout for 3 shows some variation. Most dice have three dots in a vertical line to indicate three (as in Fig. 1A), yet one die has the dots in a triangle shape, and three have the dots in a diagonal (as in Fig. 4, right side hollow Westerwanna). The IQV is lower for solid Westerwanna dice (0.15) than for oblong dice (0.45) and hollow Westerwanna (0.42). Again, all

three die styles differ from Roman period six-sided dice, which always have the three in a diagonal line.

4 Conclusions

Our analyses show that morphological attributes largely separate four-sided dice in the northern Netherlands. There is a statistically significant difference between Westerwanna and oblong dice, and further differences between solid and hollow Westerwanna forms. These findings highlight differences in the transmission of the idea of dice across cultures in antiquity and their subsequent production within Friisi culture.

Solid Westerwanna dice are more standardised in configuration, pip style and layout of dots than oblong dice in northeastern Netherlands. These patterns suggest a single short-term transmission event ~~for Westerwanna~~ and are less consistent with ~~cultural blending or an independent invention~~. Based on strict adherence to the Sevens configuration, a trait dominant among Roman six-sided dice, and little concern for overall die shape and size, a pattern also present in Roman dice, we argue that the idea for Westerwanna dice is more likely to emanate from interaction with Roman cultures. Adoption of such dice into Friisi culture involved a translation, wherein six-sided objects were rounded on two sides to create a four-sided die. However, the dot-ring or dot-two-ring pip style and a diagonal layout for the three were not adopted from the Roman model. These latter elements were likely borrowed from oblong Free Germania or Celtic four-sided dice.

Hollow Westerwanna dice likely represent a derivative of the solid form. Greater variation among these objects suggests either experimentation with pip styles and dot layout, or perhaps additional borrowing of attributes present in oblong dice. At the same time, clearly divergent widths for hollow Westerwanna vs. oblong

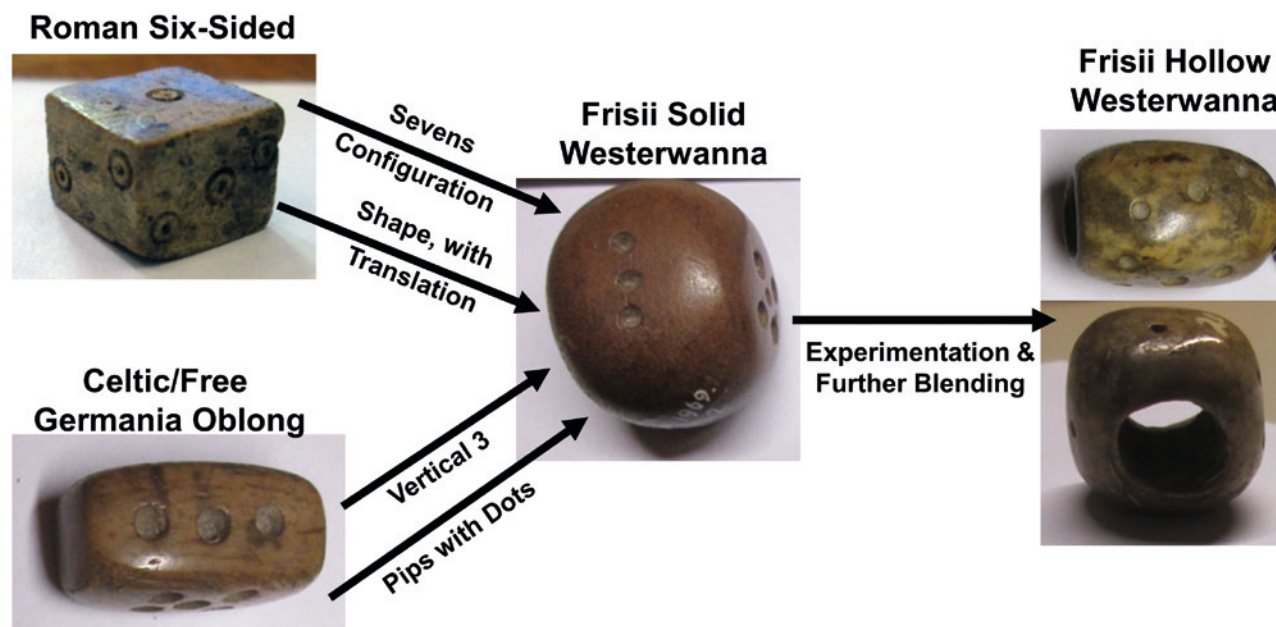


FIGURE 4 Blending process of cultural traits to create Westerwanna
DIAGRAM: AUTHORS

dice suggest a different and larger bone was systematically selected to produce the former vs. the latter. Figure 4 presents a schematic of our model for the origin of the Westerwanna die type.

Future research may include a more fine-grained analysis of local dice-making and dice-playing practices within Friisi society, particularly in light of future finds either in excavations or existing collections in additional curation facilities or repositories. As well, radiocarbon or other methods of dating individual items could help track changes within dice technology over time, perhaps refuting our hypothesis that hollow Westerwanna dice were derived from the solid form in which they should, on average, date later in time. Greater awareness of the significance of dice in the archaeological record may bring valuable contexts and additional insight in future research about ancient interactions between cultures.

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Appendix

Catalogue of Finds Used in the Article

Site	Region	Catalog	Sub cat	Type	Hollow/ solid	Length (1-4 edge), mm	Width (1-2 edge), mm	Height (2-3 edge), mm	Config- uration	Config. name	2	3	4	5	6	Ø of pip, mm	Pip style	Comments
Wijnaldum, Harlingen	Fryslan	W91-2664		O	Hollow		8.7	8.2	2-3-5-4	Sevens			::	X			Dot	See Prummel 2011
Wijnaldum, Harlingen	Fryslan	8014		O	Hollow	14.3	10.4	9.5	X-X-X-6								Dot	See Prummel 2011
Oosterwjitwerd, Loppersum	Groningen	G2008-II- 262B		O	Hollow	20.1	10.2		2-3-4-X							1.7	Dot	Broken in half (split)
Ezinge	Groningen	1930-IV.504		O	Hollow				2-3-5-4	Sevens							Dot	
Bullepolder	Fryslan	2003-XI-229		O	Hollow	19	12	9.5	2-3-5-4	Sevens			::	X			Dot	See Koopstra 2002
Unknown	Zuid Holland	TMS-1255	1403-14	O	Hollow	16.5	12	11.2	2-4-3-5	Sequenced			::	[			Dot	Interior diameter = 4mm
Hallum	Fryslan	FM 27A-187		O	Hollow	19.2	10.5	10.2	5-5-5-5	Unorth.				X			Dot	
Wanswerd	Fryslan	FM 28D-3		O	Hollow	12.7	10.5	10.8	2-3-5-4	Sevens			::	X		1.1	Dot	Interior diameter = 4.6
	Fryslan	FM 87-136		O	Hollow	19.9	10	10	3-6-5-12	Unorth.	\			X			Dot-ring	
Beetgum, bij bessebuten	Fryslan	46A-870		O	Hollow	21.7	10.5	10.4	2-3-4-5	Turned			::	X		1.3	Dot	Many of the dots are misaligned or off-center
Sneek	Fryslan	F2007-V-497	d4347; Sn	O	Solid	15.8	11.7	10	2-3-5-4	Sevens			::	X				
Joeswerd, Winsum	Groningen	1909-230		O	Solid	17.7	10.9	12	2-3-5-4	Sevens			::	X			Dot	
	Fryslan	FM 87-135		O	Solid	15.3	10.3	12.5	2-3-5-4	Sevens			::	X		2.6	Dot	
Unknown Terp	Fryslan	1934/11.13		O	Solid	19.7	11.1	10.8	2-3-5-4	Sevens			::	X		3.7	Dot-ring	May have been reworked with edges beveled. See Miedema 1983:207.4
Dorestad, Duurstede	Utrecht	WD 371.3.1b		O	Solid	32	19.2	19.1	3-4-5-6	Unorth.	\		::	X		5.3	Dot- ring-ring	Excavated by ROB in the 1960s-1980s
	Fryslan	FM 87-187		W	Hollow	26	20	19	2-3-5-4	Sevens			::	X		3.5	Dot	Deep holes

(cont.)

Site	Region	Catalog	Sub cat	Type	Hollow/ solid	Length (1-4 edge), mm	Width (1-2 edge), mm	Height (2-3 edge), mm	Config- uration	Config- name	2	3	4	5	6	Ø of pip, mm	Pip style	Comments
Stiens (De terp eigen aan de heer J.D. Bennema)	Fryslan	23-16		W	Hollow	29.2	19.2	20.1	2-3-5-4	Sevens		\	::	X		3-5	Dot	
Joeswerd, Winsum	Groningen	1909-II-29		W	Hollow	21.4	21.2	20.7	2-4-5-3	Sevens			::	X			Dot	
Ondersma-state onder Hallum	Fryslan	FM 26-84		W	Hollow	24.3	22	22.2	2-3-5-4	Sevens			::	X		3-9	Dot-ring	Interior diameter = 11.8
Jelsum	Fryslan	FM 20A-89		W	Hollow	21.3	20.4	20.5	2-3-5-4	Sevens			::	X		2	Dot	Interior diameter = 10.4 × 8.2
Almenum, Harlingen	Fryslan	FM 77-22		W	Hollow	23.2	22.3	23	2-3-5-4	Sevens			::	X		4.8	Dot-ring	Many of the rings eroded from dot-ring
Hallum	Fryslan	27B-189		W	Solid	24.1	15	15	2-3-5-4	Sevens			::	X		1.8	Dot	Found in 1900 in the terp south-east of Jousumburen under Hallum (mound no. 100), at a depth of 1.5–2 m
Waaixens	Fryslan	1964-X-69		W	Solid	24	21.8		2-3-5-4	Sevens			::	X		3	Dot	In sleuf z.o. zijde van kerk tijdens opgraving R.O.B.
Rasquert, Winsum	Groningen	1941-I-99		W	Solid	18.8	15.1	14.7	2-3-5-4	Sevens			::	X			Dot	Rounded edges
Joeswerd, Winsum	Groningen	1909-II-77		W	Solid	22.5	17.7	17.1	X-3-5-4	Sevens			::	X			Dot	One side gouged out – missing number
Toornwerd, Loppersum	Groningen	1900.6.4		W	Solid	19.5	15.3	14.9	2-4-5-3	Sevens			::	X			Dot	
Joeswerd, Winsum	Groningen	1909-II-68		W	Solid	24.6	17.2	16.9	2-3-5-4	Sevens		Δ	::	X			Dot	
Wijnaldum, Harlingen	Fryslan	144-30	d-3717	W	Solid	20.6	15.3	16.1										No pips visible
Ranum, Winsum	Groningen	1883-1-1		W	Solid	22.4	20.6	19.9	2-3-5-4	Sevens			::	X		4.4	Dot-ring	
Spannum	Fryslan	1912/3.102		W	Solid	20	15.1	15.6	2-3-5-4	Sevens			::	X		1.2	Dot	
Oldhove, Leeuwarden	Fryslan	FM 2007-IV-514		W	Solid	20.6	15.5	16.3	X-X-X-4				::			3-3	Dot-ring	Badly eroded – only one face still readable

(cont.)

Site	Region	Catalog	Sub cat	Type	Hollow/ solid	Length (1-4 edge), mm	Width (1-2 edge), mm	Height (2-3 edge), mm	Config- uration	Config- name	2	3	4	5	6	Ø of pip, mm	Pip style	Comments
Menaldumadeel	Fryslan	FM 45-134/135		W	Solid	16	12.8	12.3	2-3-5-4	Sevens			::	X		0.9	Dot	
Menaldumadeel, Beetgumermolen	Fryslan	FM 46-137		W	Solid	23.7	15.8	15.5	2-3-5-4	Sevens			::	X		2.6	Dot	Deep holes
Achlum, Franekeradeel	Fryslan	FM 74D-1		W	Solid	17.1	12.7	12.6	2-3-5-4	Sevens			::	X		1.5	Dot	
Kimsward, Wonseradeel	Fryslan	FM 121-63		W	Solid	18.3	13.7	13.2	2-3-5-4	Sevens			::	X		1.2	Dot	
Bartlehiem; Een van de drie terpen in Bartlehiem	Fryslan	39B-1		W	Solid	30.2	22.8	22.4	2-3-5-4	Sevens			::	X		2.6	Dot	Has a 1 an 4 on ends
Lekkuum	Fryslan	18-8		W	Solid	25.5	19.7	20.6	2-3-5-4	Sevens			::	X		3	Dot	Found during the construction of a new road through the Kanterland in July 1867
Stiens (Terp eigen aan de heer Kalma)	Fryslan	21A-319		W	Solid	17.9	13.9	13	2-3-5-4	Sevens			::	X		2.3	Dot	
Cornijum (Dekama- of stoomterp)	Fryslan	120-323		W	Solid	20.5	16.5	16.4	2-3-5-4	Sevens			::	X		2	Dot	
Winsum, Bruggeburen	Fryslan	53-34	W	Solid	18.5	13.5			2-3-5-4	Sevens			::	X		1.5	Dot	5 face is damaged/eroded, but still visible
Menaldum	Fryslan	45-134	W	Solid	16.2	11.8		12	2-3-5-4	Sevens			::	X		1.5	Dot	
Grou	Fryslan	1969-II-2	W	Solid	30.2	24.5			2-3-5-4	Sevens			::	X		3.5	Dot	Found during 'kielspitten' in a polder dike northeast of Grou. Finder: H. Broer, Grou, winter 1944/45

O = oblong, W = Westerwanna, Unorth. = Unorthodox