

PALAEOHISTORIA

*ACTA ET COMMUNICATIONES
INSTITUTI ARCHAEOLOGICI
UNIVERSITATIS GRONINGANAE*

59/60

(2017/2018)

University of Groningen / Groningen Institute of Archaeology

&

Barkhuis

Groningen 2018

Editorial staff

P.A.J. Attema, E. Bolhuis, R.T.J. Cappers, P.D. Jordan, F. Kramer (coordinator/editor),
M.A. Los-Weijns, D.C.M. Raemaekers, S. Voutsaki

Drawing office

S.E. Boersma, E. Bolhuis (coordinator), M.A. Los-Weijns, S. Tiebackx

Address

University of Groningen
Groningen Institute of Archaeology
Poststraat 6
9712 ER Groningen
The Netherlands
gia@rug.nl

Website

www.palaeohistoria.nl
DOI: <https://doi.org/10.21827/5beaafbcc2bf2>

Publisher's address

Barkhuis
Kooiweg 38
9761 GL Eelde
The Netherlands
info@barkhuis.nl
www.barkhuis.nl

Typesetting

Hannie Steegstra

Cover design

S.E. Boersma

Cover

Fibula from Tumulus 5, Celano (Abruzzo region, Italy). From d'Ercole 1998: La necropoli dell'età del Bronzo Finale delle "Paludi" di Celano (in: D'Ercole, V. & R. Cairoli (a cura di), *Archeologia in Abruzzo, Arethusa, Montalto di Castro (VT)*, 157-166).

ISSN 0552-9344

ISBN 9789492444752

Copyright © 2018 Groningen Institute of Archaeology, University of Groningen, the Netherlands.

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronical, mechanical, by photocopying, recording or otherwise, without prior written permission from the Groningen Institute of Archaeology, University of Groningen.

Although all care is taken to ensure the integrity and quality of this publication and the information herein, no responsibility is assumed by the publishers nor the authors for any damage to property or persons as a result of operation or use of this publication and/or the information contained herein.

Contents

Looking Sharp Dutch Bronze Age razors and tweezers in context <i>Stijn Arnoldussen & Hannie Steegstra</i>	1
Grafheuveld bij Arnhem Opgravingen op het landgoed Warnsborn 1947-'48 <i>L.P. Louwe Kooijmans</i>	49
Around 1000 BC. Absolute dates for the Final Bronze Age – Early Iron Age transition in Italy: wiggle-match ¹⁴ C dating of two tree-trunk coffins from Celano <i>J. van der Plicht & A.J. Nijboer</i>	99
Why 7? Rules and exceptions in the numbering of dice <i>Hans Christian Küchelmann</i>	109
Hellenistic Rural Settlement and the City of Thurii The survey evidence (Sibaritide, southern Italy) <i>Neeltje Oome & Peter Attema</i>	135
The Late Antique and Medieval settlement of Astura (Lazio, Italy) A synthesis of GIA investigations (2005-2014) <i>G.W. Tol, T.C.A. de Haas, P.A.J. Attema & K. Armstrong</i>	167
Where are the Shipwrecks of the Zuiderzee? A new version of the Shipwreck Database Flevoland (3.0), based on spatial and archaeohistorical research into wreck sites in the province of Flevoland <i>Y.T. van Popta & A.F.L. van Holk</i>	191

Why 7?

Rules and Exceptions in the Numbering of Dice

Hans Christian Küchelmann

Bremen, <http://www.knochenarbeit.de>

Abstract: A seldom questioned rule is that opposite sides of dice add up to seven. A look through history reveals that this numbering rule has prevailed for more than 2000 years, from the first millennium BC up to the present. Nevertheless, exceptions occur in all periods, 159 of which are presented here. This paper will discuss the development of the numbering rule, possible motives for this arrangement and possible reasons for exceptions.¹

Keywords: Dice, astragali, multi-period, gaming rules.

1. Introduction

In his study about the element of play in culture Johan Huizinga (1980: 1-27) argues that play is older than human culture, that it is inter-woven with the beginning of culture itself and that it may even be regarded as an essential element of culture in general.² Two central and interdependent aspects of playing are the repetition of an experienced reality and the creative change of it (Huizinga 1980: 8-10). These aspects are reflected in the objects used for playing, as well as in the rules and

concepts connected with their use.³ Such issues shall be discussed here using a specific type of game – the throwing of dice.

Dice have an extraordinarily wide distribution seen from a chronological as well as geographical point of view. They are a type of artefact with a rich and diverse archaeological record. From Antiquity onwards there are numerous literal and iconographic sources mentioning dice and dice games. Ethnographic data complete this rich evidence. Finally, mathematic approaches can be applied to dice. Combining these different traits

1 A previous version of this paper has been presented at the 5th meeting of the ICAZ Worked Bone Research Group (WBRG) in Veliko Turnovo, Bulgaria, on 30-8-2005.

2 'In culture we find play as a given magnitude existing before culture itself existed, accompanying it and pervading it from the earliest beginnings right up to the phase of civilization we are now living in. We find play present everywhere as a well-defined quality of action which is different from "ordinary" life.' (Huizinga 1980: 4). 'Play is older than culture, for culture, however inadequately defined, always presupposes human society, and animals have not waited for men to teach them their playing. [...] Here we have at once a very important point: even in its simplest forms on the animal level, play is more than a mere physiological phenomenon or a psychological reflex. It goes beyond the confines of purely physical or purely biological activity. [...] If we call the active principle that makes up the essence of play, "instinct", we explain nothing; if we call it "mind" or "will" we say too much. However we may regard it, the very fact that play has a meaning implies a nonmaterialistic quality in the nature of the thing itself.' (Huizinga 1980: 1).

3 'Here, then, we have the first main characteristic of play: that it is free, is in fact freedom. A second characteristic is closely connected with this, namely, that play is not "ordinary" or "real life". It is rather a stepping out of "real life" into a temporary sphere of activity with a disposition all of its own. [...]

Once played, it endures as a new-found creation of the mind, a treasure to be retained by the memory. It is transmitted, it becomes tradition. It can be repeated at any time, whether it be "child's play" or a game of chess, or at fixed intervals like a mystery. In this faculty of repetition lies one of the most essential qualities of play. It holds good not only of play as a whole but also of its inner structure. In nearly all the higher forms of play the elements of repetition and alternation (as in the refrain), are like the warp and woof of a fabric. [...]

Inside the play-ground an absolute and peculiar order reigns. Here we come across another, very positive feature of play: it creates order, is order. Into an imperfect world and into the confusion of life it brings a temporary, a limited perfection. Play demands order absolute and supreme. The least deviation from it "spoils the game", robs it of its character and makes it worthless.' (Huizinga 1980: 8-10).

of evidence dice are objects offering the rare opportunity to look beyond the artefact as such. They offer the possibility to infer social and cultural concepts and the change of these by comparing developments and changes in types of dice used in different regions, cultures and time periods. Thus, they are good examples to observe “behaviour behind bones” (Jones O’Day *et al.* 2003).

From today’s point of view, the rule of opposite sides of dice adding up to seven seems to be a general feature. It transcends cultures, times and geographical regions and at first sight it appears to be strict and never questioned. Research for this paper began in 2004 after discussions with colleagues about a die deviating from this rule, found at Leeste, Germany (Appendix 1, no. 18). In the course of the subsequent research qualities of archaeological dice and astragali were collected in a database, which at present contains data of more than 1,500 dice and nearly 37,000 astragali.⁴ In this article, after an outline of the history of dice and dice games, I would like to discuss the development of numbering rules, reasons for their consistency and the interpretation of exceptions.

2. Development and geographical distribution of dice and dice games

A problem in tracing the history of throwing games is the fact that almost any natural object, fitting into the palm of a hand – like nuts, shells, stones, etc. – can be

used for this type of game.⁵ But unless the player did modify the object, or in case of specific contextual information like *e.g.* grave deposits or hoards, we will never be able to recognise most of these objects as gaming pieces. Nevertheless, one natural object that has been used regularly for throwing games is the astragalus of even-toed ungulates.⁶

Archaeological, ethnographical and iconographical evidence shows that these bones were intentionally selected and received extraordinary attention. Finds of astragali from Neolithic sites in Europe and Asia, sometimes with drillings and traces of use-wear, make it probable that astragali were used as gaming pieces as early as the Neolithic period (Maier 1962: 216-220; Schmölcke & Rasran 2000: 361). Remarkable is the solid gold replica of an astragalus found in a tomb of the Aeneolithic (4500 – 4200 BC) necropolis at Varna, Bulgaria, exhibited in the Varna Archaeological Museum (Biegel 1986: 85). There are even a few older examples from Palaeolithic (Magdalenien) sites, indicating the long lasting significance of these bones.⁷ Yet, the purpose of these objects cannot be identified with confidence so far. From the Neolithic onward astragali, providing some kind of evidence for special significance, remain common archaeological finds throughout Eurasia.⁸ From the Greek pre-classical period onward astragali are frequently mentioned in literature⁹ and from Hellenistic times on there are iconographic sources (figs. 1-2).¹⁰ Some of these sources give details of utilisation and gaming rules. Mainly used were the

-
- 4 1.217 cubic dice, 300 stick-shaped dice, 36.682 astragali and 187 astragalus replicas (state October 2018). The database has been created by the author and can be sent on request.
- 5 See Fittá 1998: 10-14; Freeman & González Echegaray 2006: 164-167; Hills 1998: 11; Hojer 1996: 14-15; Ineichen 1996: 14, 56; Van der Heijdt 1990: 64.
- 6 Families Bovidae, Cervidae, Camelidae, Suidae etc.; *e.g.* sheep, goat, cattle, gazelle, red deer, roe deer, fallow deer, reindeer, camel, pig.
- 7 A polished astragalus from Remouchamps, Belgium; worn astragali from El Jouyo Cave, Cantabria, Spain (Freeman & González Echegaray 2006: 161) four reindeer (*Rangifer tarandus*) astragali from department Gironde, France (Guadelli, pers. com. 30-8-2005).
- 8 *E.g.* Bartosiewicz 1984; 1999; Bischof 2001: 76, 157, 216; Choyke 2005: 137, 147-152; De Grossi Mazzorin & Minniti 2013; Forstenpointner 1999: 56-62, 177-187; Herrmann *et al.* 1998: 62-63; Hampe 1951: 13, 16, 30, 32, 34-37, notes 4, 13, 28-36, 54, 58; Korzakova 2010; Kovács 1989; Krüger 1982; Kühl 1984: 211-219; Lehmkuhl 1984; Maier 1962: 216-220; Minniti & Peyronel 2005; Reese 1985; 2000; Röber 1994: 113-114; Schmölcke & Rasran 2000: 362-363; Tomé (pers. com. 26-11-2004); Van der Heijdt 1990: 15.
- 9 *E.g.* Aristoteles, II. XXIII, 88, *Historia animalium* 2,1; Asklepiades in *Anthologia Palatina* VI.308; Homer, *Ilias* XXIII.86-88; Lukian, *Theon dialogoi* IV.3, V.2; Martialis, *Epigrammata* XIV.14-16; Meleager in *Anthologia Palatina* XII.47; Ovidius, *Tristium liber* II.470-471; *Ars amatoria* II.203; Pausanias, *Description of Greece*, X.30,2; Plautus, *Miles gloriosus* 164; Plutarch, *Lysander* 8; Pollux, *Onomastikon* IX.126-127; Suetonius, *Augustus* 71, *Tiberius* 14,3; Theophrastos (characters) mentions the special value of gazelle astragali; for these and further antique references see Bartosiewicz 1999: 37; Fittá 1998: 15-16, 30, 108-109, 114, 120-129; Forstenpointner 1999: 56-60; Hampe 1951: 13-17, 20-22, 28, 36, note 56; Hojer 1996: 18, 27; Ineichen 1996: 23-30, 36-38, 63-65; 1999: 5; Lehmkuhl 1984: 245-246; Reese 2000: 400; Rohlf 1963: 6; Schmölcke & Rasran 2000: 362.
- 10 See Bartosiewicz 1999: 41; Dandoy 2006: 134-135; Fittá 1998: 15-18, 30, 109, 121, 186, 209, fig. 14-19; Grunfeld *et al.* 1975: 162-163; Hampe 1951: 11-23, 28, figs. 6-11, 13; Ineichen 1996: 24-25, 30, 37, 54, fig. 1; Pappalardo 2000: 117; Rieche 2004: 26; Rohlf 1963: 6, 25-26, 28, fig. 1-3, 5; Schmölcke & Rasran 2000: 361. Dandoy (2006: 134) mentions one older depiction from an Egyptian tomb dated to 3500 BC.



Fig. 1. Iconographic examples for astragalus games; judging the bearing of the hands dexterity games are illustrated in all cases.

a) Hellenistic terracotta from Capua, Italy, 3rd century BC (from Fittà 1998: 16, fig. 17).

b) Drawing from Herculaneum, Italy, 2nd-1st century BC (from Pappalardo 2000: 117).

c) Roman terra sigillata vessel from Arezzo or Pisa, Italy, c. 20 AD (from Rieche 2004: 26).

d) Detail of painting "Children's Games" by Pieter Bruegel the Elder, Netherlands 1560 (from Schmölcke & Rasran 2000: 361, fig. 4).

e) Detail of painting by F. J. Shields, England 1855 (from Grunfeld et al. 1975: 162).



Fig. 2. Roman marble sculpture; 2nd century BC, copy of a Hellenistic original; unlike the examples in fig. 1 the hand posture of the girl allows the interpretation of a game of chance (from Schmölcke & Rasran 2000: 361, fig. 2).

astragali of sheep (*Ovis aries*) and goat (*Capra hircus*). Games played with astragali can be divided into two major categories: dexterity games¹¹ (fig. 1) and games of chance (fig. 2).¹² Remarkably, the rules for dexterity games are similar crossing geographical, cultural and chronological borders. According to historic illustrations and literature sources mainly girls played dexterity games (fig. 1-2). Some names for these are Pentelitha (Hellenistic Greece), bikkels (Netherlands),

knucklebones, fivestones, checkstones, jacks (England), osselets (France), Fangsteine, Knöchelspiel, Kurbeln, Perducksteine, Unterhändchen (Germany), Pitziknochen (Siebenbürgen / Romania).¹³ For this paper I will leave out the dexterity games, because they are not related to the research question of the numbering rules, and proceed directly to the games of chance. Two different purposes can be observed in games of this latter category: ritual use of the astragalus as an oracle object

11 Dexterity games are documented from Hellenistic times onward throughout the centuries. They are still favourite games for children (or have been until the recent past) in various parts of the world, e.g. in Albania, Arabia, Armenia, France, Georgia, Germany, Greece, India, Iran, Iraq, Italy, Kyrgyzstan, Netherlands, New Zealand, Norway, Pakistan, Romania, Russia, South Africa, Spain, Syria, Turkey, Turkmenistan and Uiguria (Bartosiewicz 1999: 41; Bdoyan 1980: 145-156; Dandoy 2006; Haltrich 1885: 205; Hampe 1951: 35, note 47; Hojer, pers. com. 23-5-2006; Ineichen 1996: 26; Karsli, pers. com. 13-6.-2011; Lehmkuhl 1984: 247, 250-251; Rieche 2004: 26; Rohlf 1963; Schmölcke & Rasran 2000: 365-366; Smith, pers. com. 30-11-2004; Ter-Martirosov, pers. com. 29-9-2005).

12 Not within the scope of this paper, but worth to be mentioned, is another type of use: astragali symbolising miniature animal models, sometimes painted, which are known from 19th and early 20th century Switzerland (Grieshofer *et al.* 2004: 46, 142-143, 154; Iceland (exhibition Skogar Museum; see <https://www.wbrg.net/bonetool-of-the-month-archives/bonetool-archives-2017>, accessed 24-1-2018; Hungary (Bartosiewicz, pers. com. 30-8-2005) and South Africa (Dandoy 2006: 135).

13 See Grunfeld *et al.* 1975: 162-163; Fittá 1998: 16, 30; Hampe 1951: 35, note 47; Hills 1998: 11-14; Haltrich 1885: 205; Hojer 1996: 18, 27; Lehmkuhl 1984: 245-248, 251; Steinmeier 2004: 45-48.



Fig. 3. Modern astragalus oracle from Mongolia named Durvun Berh (foto: Tettenborn).

(astragalomancy; fig. 3)¹⁴ and its use as an everyday gambling item (Hojer 1996: 18-19, 27; Reese 2000; Schmölcke & Rasran 2000: 362-363).

Several astragalus finds show modifications of the original anatomical shape. Occasionally sides were marked with pits (fig. 4).¹⁵ Astragali were found with added holes, ground-down areas (fig. 5), with incised decoration or with metal fittings. The grinding-down of the lateral and medial sides with files or stones is reported from early 20th century Kyrgyzstan, and sometimes half of the bone was ground-down to increase the chance of the more valuable lateral and medial sides to appear upside (Schmölcke & Rasran 2000: 365-366). Another modification to “improve Fortunas failures”¹⁶ was the filling of the marrow cavity with lead.¹⁷ In early 20th century Kyrgyzstan the use of these manipulated dice lead to “heavy protests of the other gamblers” (Schmölcke & Rasran 2000: 365). Numerous astragalus replicas in various materials like ivory, gold, silver, bronze, brass, tin, lead, copper, glass, gemstone, marble, stone, amber, mother of pearl, clay or – in Modern Times even in plastic – prove again enduring significance (fig. 6).¹⁸ Baart

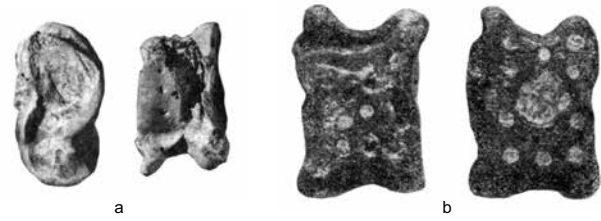


Fig. 4. Astragali with pittings.

a) From Tating, Germany, 8th – 10th century AD, Viking Period, sheep or goat; the pittings are arranged in two or three rows on the plantar surface (from Kühl 1984: 216-219, fig. 6.1).

b) From Szolnik fortress, Hungary, 16th – 17th century AD, Ottoman period, sheep; pittings are engraved on all four sides, represented are numbers between 1 and 12 (from Kovacs 1989: 107, fig. 4.1-2).



Fig. 5. Sheep astragalus with flattened lateral and medial side from Biskek, Kyrgyzstan, 20th century (from Schmölcke & Rasran 2000: 265, fig. 8)

et al. (1977: 452-453) detected a coincidence between the increase of metal astragalus replicas and the prohibition of home butchery in Amsterdam from the beginning of the 16th century onward. As numerous older metal replicas exist (see footnote 17), this is obviously no adequate explanation for such situations elsewhere.

14 Astragali are numerous in Mediterranean sanctuaries. Oracles using four or five astragali were common in Greece and Asia Minor (Forstenpointner 1999: 60-62, 177-187; Ineichen 1996: 63-65; Reese 1985; 2000). The Roman emperor Tiberius threw golden astragali in a well while visiting the oracle at Geryon near Patavium (Sueton, Tiberius 14.3; Fittá 1998: 122, 129; Hojer 1996: 18, 27). Oracles with four astragali are still a common practice in Mongolia (fig. 3, Table 1; Peterlunger 1998; Tettenborn, pers. com. 15-1-2006). In Armenia and Georgia one astragalus is thrown for future foreseeing (Ter-Martirosov, pers. com. 29-9-2005). See also Ineichen 1996: 63-65 and Hampe 1951: 20-21, 36, note 56 on astragalomancy.

15 See Bartosiewicz 1999: 40; Bdoyan 1980: 146; Kovács 1989; Kühl 1984: 216-219.

16 “*ut arte emendaturus fortuna*” (Horatius quoted by Ineichen 1996: 58; 1999: 6).

17 For examples of modified astragali see Bartosiewicz 1999: 40; Bdoyan 1980: 148-149, 152-154; Forstenpointner 1999: 56-62, 177-187; Kovács 1989; Krüger 1982; Maier 1962: 216-220; Reese 1985; 2000; Röber 1994: 113-114; Schmölcke & Rasran 2000: 365; Smith (pers. com 2-6-2006).

18 For examples of astragalus replicas see Baart et al. 1977: 452-453; Bartosiewicz 1999: 41, 44, 594, fig. 1.2; Bischof 2001: 216; Fittá 1998: 15, 30; Forstenpointner 1999: 56-62; Grunfeld et al. 1975: 163; Hampe 1951: 12-13, 16, 21, 30-31, 34-37, fig. 6, note 3-6, 8, 30, 36, 54, 57-58; Korzakova 2010: 155; Krüger 1982: 155; Reese 2000; Van der Heijdt 1990: 15; Verweij 2018: cat. nos. 60, 168, 206, 286, 350, 351.



Fig. 6. Astragalus replicas.

- a) Bronze astragalus of Darius I. from Susa, Iran, 5th – 6th century BC, length c. 40 cm (from Bartosiewicz 1999: 44, 594, fig 1.2).
 b) Bronze bikkels Netherlands 1800; these examples show 10 and 11 pittings on one side (from Grunfeld et al. 1975: 163).
 c) Modern French osselets of tin-alloy, size 22 x 14 x 13 mm (foto: C. Küchelmann).

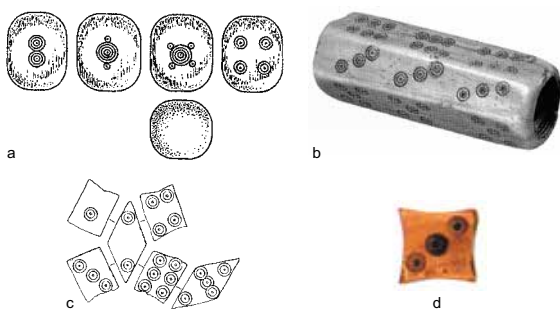


Fig. 7. Examples of bone dice deviating from the cubic shape.

- a) Westerwanna die from Kirchweyhe, Germany, 1st – 3rd century AD, size 16 x 13 x 13 mm (from Bischof 2001: 75, fig. 49.1).
 b) Prismatic die, Roman (British Museum London; from Fittà 1998: 116, fig. 197).
 c) Lozenge-shaped die from York, England, 16th – 17th century AD, size 16 x 10 x 7 mm (from MacGregor et al. 1999: 1982-1985, fig. 941.7980).
 d) Cubic die with concave sides from Konstanz, Germany, 14th – 15th century AD (from Planck 1994: 307).

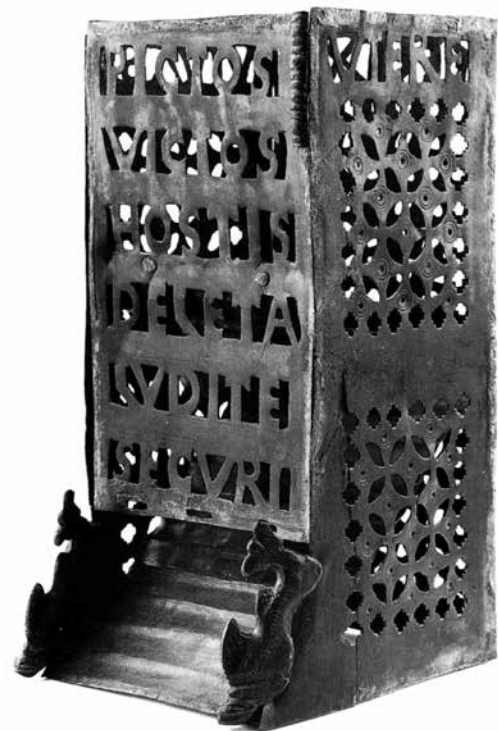


Fig. 8. Roman dice tower (turrucula) from Froitzheim, Germany, 4th century AD (from Fittà 1998: 117, fig. 203).

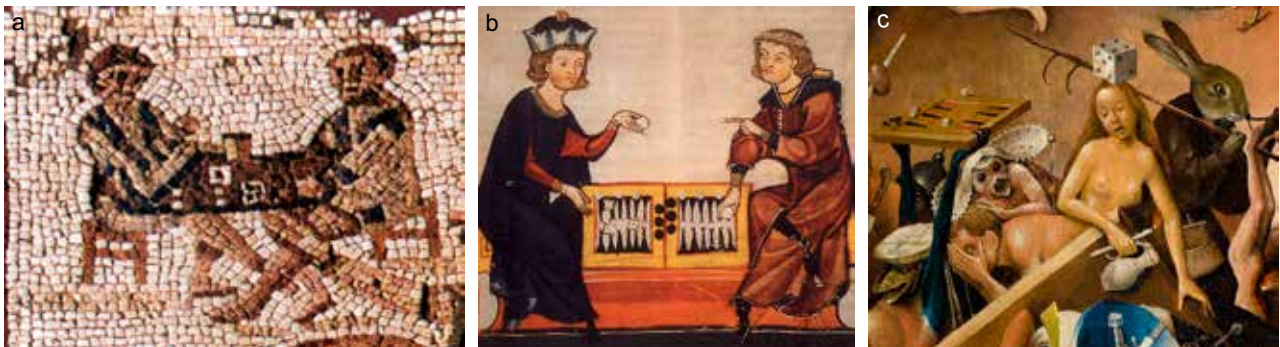


Fig. 9. Iconographic examples for dice games.

- a) Detail of tessellated pavement with dice and turrucula from Carthago, Tunisia (from Rieche 2004: 27).
 b) Tric-trac-players with concave dice in the medieval Codex Manese, 14th century AD (from Planck 1994: 293).
 c) Detail of painting “The Garden of Delights“ by Hieronymus Bosch, Netherlands, c. 1500 AD.

Table 1. Examples for names and valuing of the different sides of the astragalus.

a: Names and values attributed to the sides are not consistent in the historic sources. This confusion is mainly caused by inaccurate anatomic descriptions. Even Aristoteles (384 – 322 BC), being the oldest and giving the most accurate anatomic description, leaves room for interpretation. Dorsal and plantar side as well as medial and lateral side are sometimes swapped (see Dandoy 2006: 132-133; Fittá 1998: 121, 129; Forstenpointner 1999: 56-58).

b: Bdoyan (1980: 150-155) lists further names from different regions but their attribution to the anatomical sides is not exactly clear.

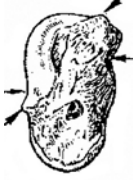


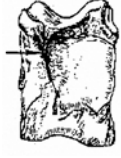
Region	Time	Name	Side				Reference
			medial	lateral	dorsal	plantar	
							
Greece ^a	1st mill. BC – 1st mill. AD	<i>astragalos</i> , <i>kybos</i>	<i>koon</i> , <i>kos</i> (dog) 6	<i>chion</i> , <i>chios</i> 1	<i>hyption</i> (belly) 3	<i>pranès</i> (back) 4	Dandoy 2006: 132-133; Fittá 1998: 120-122, 129; Forstenpointner 1999: 56- 58; Ineichen 1996, 26-27; Rohlf's 1963: 6, 9, 13-18
Roman Empire ^a	Roman	<i>talus</i> , <i>tax-</i> <i>illus</i>	<i>caesar</i> (emperor) 6	<i>canis</i> (dog), <i>vulturius</i> (vulture) 1	<i>suppus</i> (upright), <i>aquila</i> (eagle) 3	<i>planus</i> (plain), <i>vulcanus</i> (fire, firegod) 4	Fittá 1998: 120-122, 129; Forstenpointner, pers. com. 14-6-2006; Hojer 1996: 2, 18; Ineichen 1999: 4; Menge 1982: 514, 516; van der Heijdt 1990: 68
Hungary, Szolnik fortress	16th – 17th c. AD Ottoman	?	0 – 8	0 – 8	1 – 10	1 – 12	Kovács 1989: 104-107, fig. 1, 3-4
Mongolia	12th c. AD (?) until today	<i>durvun</i> <i>berh</i> , <i>shagai</i>	horse	camel	goat	sheep	Peterlunger 1998; Tetten- born pers, com. 15-1-2006
Nether- lands	Middle Ages until today	<i>bikkels</i>	<i>staantje</i> , <i>staander</i> , <i>stonderke</i> , <i>staander</i> (standing) 6	<i>essie</i> , <i>staander</i> , <i>esser</i> , <i>eske</i> , <i>essel</i> 1	<i>schijt</i> (shit), <i>kuil</i> , <i>kuilder</i> (hollow), <i>keerke</i> , <i>kuiltje</i> 3	<i>stoof</i> , <i>buik</i> (belly), <i>stoofke</i> , <i>stovert</i> , <i>rugge</i> (back) 4	Baart et al. 1977: 452-453; Tielens (no date); van der Heijdt 1990: 67
Armenia ^b	20th – 21st c. AD	<i>chan</i>	<i>taf</i> , <i>tav</i> , <i>kis</i> (advisor of king) 2 nd value 1	<i>chuk</i> <i>togavor</i> (king), highest value 2	<i>sal</i> , <i>sol</i> <i>sartsi</i> (farmer) 3 rd value 0	<i>kor</i> , <i>gol</i> (thief) lowest value 0	Bdoyan 1980: 150-155, 364, 369-370, 375; Mirzoyan pers. com. 8-6- 2006; Rohlf's 1963: 13-17
Georgia	19th – 20th c. AD	<i>astragal</i>	god, man, luck, good, highest value	goddess, woman, luck, good, 2 nd value	bad, lowest value	neutral, 3 rd value	Ter-Martirosov pers. com. 29-9- 2005
Greece	20th c. AD	<i>astragalos</i>	<i>wezir</i>	<i>vasilas</i> , <i>kigas</i> (king)	<i>kleftis</i> (thief)	<i>gáidaros</i> (don- key), baker	Hampe 1951: 18; Rohlf's 1963: 13-18
Romania	20th c. AD	<i>arsik</i>	<i>vizir</i> , <i>armas</i> (judge)	<i>imparat</i> (em- peror)	<i>om bun</i> (good man)	<i>om rau</i> (bad man)	Rohlf's 1963: 13-17, 21
Turkey	19th – 21st c. AD	?	<i>sultan</i>	<i>vizier</i>	<i>ekin-ci</i> (farmer), <i>bol</i> (honey), baker	Hirsiz (thief), servant	Dandoy 2006: 133; Rohlf's 1963: 13-17

Table 2. Examples for the ranking of combinations of multiple astragali

a: In Greek and Roman antiquity the side on which the thrown astragalus comes to rest scores, while in Armenia the side appearing upside was counted.

Region	Time	Name	Ranking of figures	Reference
Greece, Roman Empire ^a	1st mill. BC – 1st mill. AD	<i>astragalisis, talorum ludus</i>	1 st rank: <i>iactus Venerius</i> = 4 astragali in different positions intermediate ranks: <i>Stesichoros</i> = 2 x plantar, 2 x medial side <i>Alexandros, Antigone, Berenike, Darius, Ephebos, Euripides, iactus basilicus, Midas, Perses, Simon, Solon,</i> lowest rank: <i>canis</i> (dog) = 4 astragali on medial side	Fittá 1998: 121-122, 129; Ineichen 1996: 23, 29, 36-37; 1999: 5; Rohlf's 1963:9; Schmölcke & Rasran 2000: 362
Armenia ^a	19th – 20th c.	<i>shrjocik</i> (reversing), <i>chalu</i>	1 astragalus is thrown twice (<i>shrjocik</i>) or 2 astragali are thrown (<i>chalu</i>) 1 st rank: <i>chalu</i> = 1 x lateral up, 1 x medial up 2 nd rank: 2x lateral or 2 x medial up low ranks: plantar and dorsal sides up	Bdoyan 1980: 152, 154, game 369, 372; Mirzoyan pers. com. 8. 6. 2006
Kirgisia	1938 – 1946	<i>derchke</i>	1 st rank: 4 astragali in different positions 2 nd rank: 4 astragali same side 3 rd rank: 4 astragali “standing” (on lateral or medial side)	Schmölcke & Rasran 2000: 366

At present it is not certain if astragali are precursors of cubic dice or if they are an intermediate stage in the development of dice games. At least astragali stayed in use long after cubic dice developed. Geometrically shaped dice with numbered sides do appear for the first time in the 3rd millennium BC in Mesopotamia, India (Appendix 1, 1-2) and Egypt (Fasnacht, pers. com. 26-5-2006; Ineichen 1996: 41; Van der Heijdt 1990: 17). The regular hexahedric or cubic form was

common,¹⁹ but dice were not restricted to this shape (fig. 7; 9b; Appendix 1).²⁰ Almost certainly a derivative of the astragalus is the oblong die (Appendix 1, 19; 21; 32) named *talus* in Latin²¹ in distinction to the cubic *tessera* (Krüger 1982: 144; Menge 1982: 514, 521). Like in astragali only the four long sides were numbered. Through the centuries the majority of dice were manufactured from osseous material like bone, antler and ivory, but other raw materials like horn, wood, stone, marble,

19 For examples of archaeological finds of cubic dice with canonical numbering of various materials see e.g. Baart *et al.* 1977: 455; Barker 1986: 134, fig. 69a; Bernhauer 2007; Bräuning 2004: 30; Cilli *et al.* 2000: 45, 49, fig. 4; Deschler-Erb 1998: 147, 376, pl. 24.872-890; Falk 1983: 106-107, 126, fig. 1.4; Fittá 1998: 111-113; Goret 2004: 117; Gostencnik 2001: 384, 391, fig. 4.16-20; Gróf & Gróh 2001: 282, 284, fig. 3; Hojer 1996: 20; Ineichen 1996: 49-52, fig. 9-11; Kováts 2005: 299-300, fig. 11; Krüger 1982, with many additional references; Labner 2002; Lehmkuhl & Schäfer 2005: 362; Lehnert 1997: 58; MacGregor *et al.* 1999: 1982-1985; Neveux 2004; Pieler 2005: 799-800; Planck 1994: 307; Rieche 2004: 24; Rijkelijkhuisen 2008; Röber 1994: 114-116; Schmid 1968: 186, fig. 1d; 1972: 44-45, fig. 7; Seibt *et al.* 1990: 212; Stadler 1995: 234-238; Tamla & Maldre 2001: 373, 380, fig. 12; Van der Heijdt 1990; Van Vilsteren 1987: 47, fig. 68; Verweij 2018; von Buttel-Reepen 1927; Wegner 1982.

20 A common four-sided type is the Celtic Iron Age stick-shaped die (Appendix 1, no 4-10) (Krüger 1982; Ruß 2005: 771-773; Stäuble 2005; Verweij 2018: cat. no. 82, 184, 185, 205, 273, 296). Probably a derivative of this is the Westerwanna die (fig. 7a), a geographically restricted form, some dozen of which were found in Roman Iron Age and Migration Period contexts in Northern Germany and the Netherlands. This die is more oval than cubic in shape with rounded edges. Only four sides are decorated with numbers 2 – 5, numbers 1 and 6 are not represented. Opposites add to seven in all known cases (Bischof 2001: 74-75, 88-89, 216; Hermsen 2000: 140, fig. 5; Krüger 1982; Roes 1963: 53, pl. 44.4-14; Van der Heijdt 1990: 72, 146; Verweij 2018: cat. no. 127, 183, 193; von Buttel-Reepen 1927). A modified form of the cubic dice with concave sides has been found in 13th to 16th century German and Austrian contexts and on iconographic sources (fig. 9b) of the same period (Bernhauer 2007: 227-231). For further examples of non-cubic dice of different shapes see Fittá 1998: 113-116, 128; Ineichen 1996: 17, 53-54, 65-69; MacGregor *et al.* 1999: 1982-1985; Planck 1994: 307; Van der Heijdt 1990: 10, 15, 62-85, 105-107; Verweij 2018: cat. no. 76, 226.

21 The Latin word *talus* is a synonym for the astragalus and thus for this type of die (Ineichen 1996: 23; Menge 1982: 514).

clay, amber, gemstone, gold, bronze, lead or glass were also employed.²² Dice are especially common in Roman military contexts.²³ Numerous finds of gambling related items like dice beakers (*fritillus*), funnels (*phimus*) or towers (*turricula*) (fig. 8, 9a)²⁴ as well as iconographic²⁵ (fig. 9) and literary sources²⁶ complete the picture of the popularity of dice games under Roman soldiers.

3. The development of the numbering rules

The characteristic morphology of the astragalus with its four different and easily distinguishable sides (Table 1) suggests the designation of specific values to each side. Table 1 gives examples of such names and values. Usually four or five astragali were thrown together and the combination of the sides counted. Table 2 contains three examples for rankings of different combinations.

Evidently, astragali have only four sides on which they can fall and that thus may be valued. Yet, only the values 1, 3, 4 and 6 are known for these four sides from the Greek and Roman era; in finds from other contexts no numbers are attributed to the sides or the numbering does not follow a recognisable system. The location of the numbers in Greek and Roman contexts is regularly 3 : 4 and 1 : 6 opposite to each other (Table 1).

A cubic die offers 30 different possibilities to arrange the numbers 1 – 6 (Ineichen 1996: 42). But, as already mentioned, the arrangement of the numbers on archaeological dice is far from random, the vast majority of the finds display opposite sides adding up to seven. At first sight the rule appears to be affected neither by

material or shape nor by time period or cultural or geographical origin of the die. Keeping this in mind I would like to address the question “why?”. Why is this the only allowed possibility? Why was this rule invented?

A look back in time reveals that in 3rd millennium BC dice there was no fixed rule for the arrangement of the numbers (Appendix 1, 1-2). Opposite sides adding up to seven appear for the first time on Egyptian dice dating back to the 16th century BC, but there was not any standardised system during the time of the Egyptian New Kingdom (1550 – 1080 BC; Ineichen 1996: 41, 146). The Greeks apparently standardised the now called canonical or conventional numbering system in the 1st millennium BC. In addition to archaeological finds there are literary sources reporting this configuration.²⁷ Unfortunately such sources do not answer the question “why?”. From Greek antiquity onward the rule appears to remain consistent. It was obviously transmitted with the spreading of dice games itself – probably intensified by the expansion of the Roman Empire and culture.

In a first approach towards explanation we may look at a simple condition of astragalus games: the broad dorsal and plantar sides will occur more often upside than the narrow lateral and medial sides because of their morphology.²⁸ Consequently, the less often occurring narrow sides are more valuable from a statistical point of view. This is expressed in the ranking of the combinations (Table 2). A strict application of this fact would mean to attribute the highest values – 5 and 6 – or maybe even 3 and 4 in case of only four existing sides – to the lateral and medial sides and the lowest values (1 and 2) to the dorsal and plantar sides. This is obviously

22 For examples of dice made out of other materials than bone, antler or ivory see e.g. Bischof 2001: 74-78, 216, fig. 45.2, 49.3, 51; Cas-savoy 2006; Fittá 2000: 112-113, 115, 128, fig. 190, 196; Hermsen 2000: 139-140, 142, 144, fig. 2-3, 5-6; Ineichen 1996: 41-44, 49-50, 53, fig. 5-6, 9; 1999: 4; Krüger 1982: 141-154, 224, 240, 292, 311, 314-315, 317-318, fig. 29.14-15, 32.11-21, 33.1-10, 34.1-2, 4-6, 45.1-2, 14, 46.4; Lehmkuhl & Schäfer 2005: 362; Van der Heijdt 1990: 16-18, 130; Verweij 2018; von Buttel-Reepen 1927: 288-289; Vogt 2012: 13-15, 19, 56-57; Wegner 1982: 34.

23 See e.g. Barker 1986: 134, fig. 69a; Deschler-Erb 1998: 147, 376, pl. 24.872-890; Gostencnik 2001: 384, 391, fig. 4.16-20; Hermsen 2000: 142-143; Ineichen 1996: 49-52, fig. 9-11; 1999: 4; Krüger 1982: 138, 141-154, 214, 241, 306, 312-318, fig. 37.9, 46.2, 5-10; Pieler 2005: 799-800, fig. 96; Schallmayer 1994: 73, fig. 2; Schmid 1972: 44-45, fig. 7; Van der Heijdt 1990: 44-47; Wegner 1982: 34.

24 For examples of gambling related items see Fittá 1998: 112; 115-120; 128; Ineichen 1996: 45-46; fig. 7; Rieche 2004: 24-25; Van der Heijdt 1990: 36-37.

25 For examples of iconographic evidence see Fittá 1998: 117-119; 128; Rieche 2004: 27; Van der Heijdt 1990: 35-38) and Vogt 2012: 16, 26, 34, 62.

26 Most well-known is Caesar's saying “*iacta alea est*” (the dice is thrown) when crossing the river Rubicon (Sueton, Gaius Iulius Caesar 32; according to Plutarch (Pompeius 60) Caesar said “*anerrypho kybos*” quoting the Greek writer Menander; Roman soldiers gambling for the skirt of Jesus in the New Testament of the bible (Markus 15.24; Matthäus 27.33-36; Psalm 22.19); Tacitus (Germania, chapter 24, paragraph 2) reporting ruinous gambling habits of Germanic men; Apollonius, Cicero, Eustathius of Thessaloniki, Herodot, Horatius, Ovidius, Pausanias, Plato, Plinius, Pollux, Seneca, Sophocles, Suetonius, Vergil and numerous other antique authors are quoted in Fittá 1998: 108-120, 128; Ineichen 1996: 40-50, 59-60; 1999: 4, and Van der Heijdt 1990: 16, 18, 109-117.

27 Anthologia Graeca (14, 8; Eustathius of Thessaloniki (12th century AD); see Fittá 1998: 112, 128; Ineichen 1996: 41-44; Van der Heijdt 1990: 17.

28 According to empirical tests the probability of the dorsal and plantar side to appear upside is 35 – 48 %, while that of the lateral and medial side is 7 – 15 % (Dandoy 2006: 133; Ineichen 1996: 31; Rohlf 1963: 12-13; Schmölcke & Rasran 2000: 362).

not the case in Greek and Roman astragalus games. For a cubic dice, where each side has the same probability to appear upside,²⁹ there is no necessity for any specific arrangement from this point of view.

Another often suggested reason (*e.g.* Ineichen 1996: 42, 146; Lehmkuhl & Schäfer 2005: 362; Stäuble 2005) is the magical belief connected with the number seven. In accordance to the fact that astragali and dice were used in ritual practises this assumption seems not unreasonable. The number seven received extraordinary appreciation in Sumerian, Babylonian, Egyptian, Assyrian, Persian, Greek, Roman and other cultures, probably originating from astronomic observations.³⁰ But, while there is no lack of sources for the ties between the value seven and religious beliefs in other instances (*e.g.* the seven biblical days of creation), I could not find any reasonable direct evidence for the relationship between magical beliefs and the arrangement of the numbers on dice. Further, the significance of seven was well established in the Sumerian, Babylonian and Egyptian society, but according to the finds from Tepe Gawra (Appendix 1, no. 1) and Egypt (Ineichen 1996: 42-44, 146) in these cultures no rule for the numbering of dice related to the seven has been developed. At least all rituals in which dice might have been employed seem to have worked equally well with different numbering systems.

Maybe the reason was just a preference for mathematical symmetry? Grouping 1 : 6, 3 : 4 and 2 : 5 is the only possibility to arrange the numbers 1 to 6 in pairs symmetrically. Any other arrangement will result in different sums for the opposite sides. And, of course, seven is a prime number and thus of special mathematical significance. But apart from the well-known fact that mathematics was highly appreciated and developed in Greek and Roman antiquity, there is yet no evidence to verify or falsify this assumption. Ineichen (1996: 35-36; 1999) discussed the idea of harmony as a value in Greek philosophy. While in today's dice games the least probable combination is the most valuable, in antique times the most harmonic combination (*iactus Venerius*) was the highest valued. Maybe this applies also to the numbering system.

Finally, returning to Huizinga's (1980: 8-10) consideration of the nature and implicit characteristics of play (see footnote 3), the cause may be sought in the dichotomy of creation and tradition in play. An unknown person back in Greek Antiquity created the canonical design of dice, it became a rule and a tradition, the violation of which would have been regarded as an offense to the order of the game. Ineichen (1996: 32) discusses the possibility of a convention as reason for the assignment of numeric values to combinations of specific sides of astragali. He regards this option as possible but unlikely, referring to several historical Greek scientists³¹ developing elaborated philosophical texts dealing with probabilities and mathematics.

4. Exceptional finds

As every rule has its exceptions so has the numbering of dice. Appendix 1 assembles 159 examples of dice from 54 sites³² with an exceptional arrangement of numbers from a variety of chronological, geographical and cultural contexts not following the canonical numbering. Surprisingly exceptions are less rare than expected and the ones listed are not the only ones.³³

Taking a closer look at the assembled exceptions changes the picture of the uniform numbering rule remarkably and provokes questions about the origin of and reason for the canonical rule as well as for exceptions. Comparing rules and exceptions in dice offers the possibility to track "behaviour behind bones", as Jones O'Day *et al.* (2003) have put it. A cultural comparison shows that very few exceptions occur in Greek and Roman contexts regardless whether the dice are of the oblong or cubic type (Appendix 1, nos. 3, 12-13, 23-24). In contrast the rule of 7-sum placement is less strictly adhered to in Etruscan (Fitta 1998: 113) and in Celtic (Appendix 1, nos. 4-5, 8-10) contexts. On the majority of the four-sided Celtic stick-shaped dice the represented numbers range from 1 to 6, but the combination of seven is just one of a great variety of other combinations (including exceptional numbers like 10 or 19; Appendix 1, nos. 6-7; Krüger 1982: 149-153). Etruscan dice

29 At least theoretically, leaving manufacturing inaccuracies out here.

30 For a summary see <http://de.wikipedia.org/wiki/Sieben>. The author relies mainly on von Andrian (1901) and Paneth (1952).

31 Ineichen 1996: 32 refers in particular to the school of skeptical philosophy of Pyrrho of Elis (c. 360-270 BC) and to Carneades of Cyrene (c. 213-128 BC).

32 Plus "some hundred" specimen from the Czech Republic (Appendix 1, no. 8).

33 Additional finds of more than 198 irregular dice are reported from Boge in Denmark (Fittá 1998: 113; Egypt (Ineichen 1996: 42, 50, 146; England (Gloucester, Evans, pers. com 10-6-2005; Vogt 2012: 12, 21; France (Bordeaux, n=143, Neveux 2004; Boves, n=5, Chan-deveau, pers. com. 8/2007); Germany (Van der Heijdt 1990: 69-70; Wallen: von Buttel-Reepen 1927: 288); Greece (Ineichen 1996: 44; fig. 6); Italy (Fitta 1998: 113); Lebanon (Verweij 2018: cat. no. 204; Vogt 2012: 14); Syria (Verweij 2018: cat. no. 162; Vogt 2012: 13, 18) and uncertain provenances (n=42, Verweij 2018: cat. nos. 4-5, 38, 58-59, 63, 66-67, 75, 163, 169, 193, 210, 256-257, 261, 273, 296, 330, 357, 386, 389, 412, 586-587, 607, 1217-1218, 1831-1832; Vogt 2012: 13-21). They are excluded from Appendix 1 because of insufficient or uncertain data for provenance or dating at time of writing.

are mainly cubic but the numbering is not restricted to the canonical rule (Fittá 1998: 113). An example from the Phrygian capitol Gordion (9th-6th century BC) in Turkey (Appendix 1, no. 66) also does not apply to the rule. Interestingly, all known finds of the oblonged and oval-shaped Germanic Westerwanna dice follow the canonical numbering rule, while the style of the dot arrangement is closer to Celtic dice and the shape is a mixture between Roman cubic and Celtic stick-shaped dice. Krüger's (1982: 190-191) hypothesis is that this is a result of the melting of Celtic and Germanic traditions mediated through Roman contacts. This is supported by Krüger's comprehensive work about Iron Age games, who found that Roman military sites produced exclusively cubic and Celtic *oppida* exclusively stick-shaped dice, while in Germania Libera both types appear alongside each other (Krüger 1982: 184-191).

Searching for recurrent numbering patterns reveals one configuration, which occurs in higher than expected frequencies apart from the canonical numbering. In this configuration, following numbers are set opposite to each other (1 : 2, 3 : 4, 5 : 6; Appendix 1, nos. 37-42, 45-47, 49-50, 58, 61, 64).³⁴ Dice of this type are found in high and late medieval contexts (11th - 15th century) beside conventionally numbered ones (Eerkens & de Voogt 2018: 165; MacGregor *et al.* 1999: 1982-1985; Van der Heijdt 1990: 122). Apart from this no other recurrent pattern in the numbering of exceptional dice could be recognized so far.³⁵

Extraordinarily peculiar are the specimen with numbers represented twice (Appendix 1, nos. 10, 13-14, 20, 22, 24-25, 36, 38, 44, 52-56, 62-63, 65). Here, in all but two cases (Appendix 1, nos. 22, 44, 65) the numbers occurring twice are arranged opposite to each other. Very rare are dice with numbers higher than 6 (Appendix 1, nos. 6-7, 22-23, 27, 30, 59). In particular, there are three with 7, one with 9, four with 10, one with 12 and one with 19.

A chronological analysis shows a lack of numbering patterns for the earliest dice (Appendix 1, nos. 1-2), suggesting that no system had been developed at the origin of dice. Despite the generally strict numbering rule in Greek and Roman antiquity there are several exceptions (Appendix 1, nos. 3, 12-13, 24-25) but they do not follow a set alternative system. In the Late Middle Ages the already mentioned alternative pattern has been developed. In Early Modern Time the medieval numbering system disappears again and the canonical

numbering becomes the exclusive rule, resulting in our modern day perception of a generality.

Hermesen (2000: 140) suggests that people outside of the direct influence sphere of the Roman Empire tried to copy Roman dice but were not aware of the exact pattern. While this cannot be ruled out for individual examples, the sheer amount of exceptional dice makes this unlikely as a general hypothesis. Further, exceptions do also appear in Roman contexts, albeit not very frequently (Appendix 1, nos. 12-13; 24-25). Another interpretation is that the strict rule became less important after the decline of the Roman Empire. Reasons for this could be a shift in the significance or the purpose of the dice. This could have been a shift from an object attributed to magic beliefs to a solely gambling item or the utilisation in different types of games (Hermesen 2000: 141).

A more manufacture oriented approach might assign the exceptions to artisans' mistakes implying that the bone-worker intended to follow the rule but failed. Judging by the amount of preserved exceptional finds my impression is that this is not the case at least not for all examples. Assuming that the numbers were deliberately arranged in the exceptional ways allows two scenarios. Either the artisan did not care about the arrangement of the numbers, because there was no need to follow a rule, or he did deliberately develop an individual or group style for some reason (*e.g.* as expression of social identity; see for instance Choyke *et al.* 2003). An argument for artisans' failures are seven unfinished dice from the St. Jakobs-Platz in Munich (Bernhauer 2007), which display various fabrication defects like splintered edges, merged points, etc. These have been discarded together with large amounts of dice manufacturing waste. None of these specimen shows an irregular numbering. However, the artisan's failure hypothesis seems to be a reliable interpretation for particular specimen like one die from Konstanz (Appendix 1, no. 62) or the die from Aschaffenburg (Appendix 1, no. 36). In case of the former, a double five has been drilled opposite to the 6. This die also has been discarded together with dice production working waste, making it likely that it was regarded as a failed specimen. In case of the latter, the numbering is similar to the late medieval pattern of following numbers, but the four and the six have probably accidentally been swapped. The dice from Mahlstedt (Appendix 1, no. 20), Trier (Appendix 1, nos. 24-25) and Didam (Appendix 1, no. 30) are suggested to

34 Eerkens & de Voogt (2018: 165) call this configuration „Primes“.

35 Eerkens & de Voogt (2018: 165) recognise one more pattern they call “Turned” (1 : 3, 2 : 4, 5 : 6). According to them this pattern is “found in ancient dice worldwide in higher-than-expected frequencies”. However, within the sample of 1.215 cubic dice analysed for numbering patterns in this study, the “Turned” pattern appears only ten times: one time on a Roman die from Aislingen, Germany (Appendix 1, cat. no. 12), twice on medieval dice from Genf (Appendix 1, cat. no. 57) and on seven probably Roman dice of unknown provenance from the collection of Verweij (2018: cat. nos. 67, 163, 256-257).

be toys made by children because of their uneven shape, simple manufacturing techniques and the fact that one of the Trier dice was found in a child's grave (Hermsen 2000: 141; Wegner 1982: 34). Here again the manufacturing child could have been unaware of the numbering rule or it intended to create something individual. My objections against this explanation is that a bone die is not manufactured in a couple of minutes and the clay pieces from Mahlstedt and Didam are burnt.

Another idea, which has been put forward is that dice with exceptional numbering were intended for cheating (Erath 1999: 98; Labner 2002; Wegner 1982: 34). Cheating is evident directly (e.g. by dice filled with lead) or indirectly (e.g. by anti-cheating devices like *turriculae* or *fritilli*; fig. 8, 9a). Nonetheless this assumption seems unlikely, because the deviating numbering alone does not increase the chance of specific numbers to appear. All known examples for cheating are related to mechanical modifications or throwing manipulation, but not to the numbering (Fittà 1998: 116-118; Van der Heijdt 1990: 35-47). In case of missing or double represented numbers one might also wonder whether the intention to cheat is not too easy to discover (see also Van der Heijdt 1990: 40-43; Wegner 1982: 34). However, the painting "Garden of Delights" by Hieronymus Bosch (fig. 9c) shows a die with a double 4, which may be related to cheating taking into account the context of the illustration, which is shown on the right side of the tryptychon representing the hell.

For the Serce Limani bronze cube (Appendix 1, no. 59), showing exceptional numbers ten, fourteen and two times seven, a use as a weight has been suggested (Cassavoy 2006) and thus the similarity to a die may be a matter of coincidence.

At least the shift from the two existing numbering systems in the Late Middle Ages towards the exclusive use of the canonical numbering pattern from Early Modern Time onwards can be backed with some stout evidence. On the 30th of July 1297 the city council of

Toulouse issued a law advising the artisans of the city and the surrounding districts (*suburbium*) dealing with the manufacture of dice to produce them in a strictly predetermined way. Amongst other regulations on dice production it is declared in the so called *statutum taxillorum* that "no inhabitant of the city of Toulouse is allowed to manufacture dice except for when the upper and lower side add to seven like for example VI points on one side and on the inferior side one point, likewise on another side V points and on the inferior side two points, likewise on that side of the named dice IIII points and on the inferior side III points."³⁶ A law with similar content, the *parole des Deciers de Paris*, has survived from 13th century Paris (Boileau 1879: 149-151; Neveux 2004: 126-127). These documents allow the hypothesis that the disappearance of non-canonical numberings may be related to regulations by authorities. The question if these restrictions are confined to the areas of Toulouse and Paris must remain open so far, but the existence of such official documents plus the fact that alternative numberings of dice have completely disappeared adds weight to the possibility that those regulations were more general and geographically widespread.

5. Conclusion

In their analysis of three worked pieces of a cervid metapodium found in the Upper Palaeolithic (Magdalenian) cave site of El Jouyo (Cantabria, Spain) suggested to be gaming or divinatory devices, Freeman & González Echegaray (2006) argue that dice games serve an important socio-cultural function within a social system by strengthening social cohesion as well as being a means of coping with potentially troubling, uncontrollable natural phenomena.³⁷ Strategies against the unpredictability of nature are a general feature of socio-cultural interaction and can be traced back to the beginning of mankind. Trying to predict things that are otherwise unpredictable maybe a reason for the invention

36 '4. Item statuerunt ordinaciones que secuntur quod aliquis homo hujus ville Tholose non sit ausus facere taxillos seu daczs nisi septennos inter partem superiorem et inferiorem videlicet de VI punctis in una parte et in alia inferiori de uno puncto, item in alia parte de V punctis et in alia inferiori de duobus punctis, 5. Item in illa parte dicti taxilli de IIIIor punctis et in illa parte inferiori de III punctis.'

The *statutum taxillorum* is documented in the appendix of Fagniez (1898: 321-323, doc. 272). Translation with the help of Dirk Schmitz, Römermuseum Xanten.

37 'Bone artifacts can reflect other seemingly intangible dimensions of the psychic development of prehistoric people, and their functions can be plausibly interpreted. In the specific cases to be discussed here, bone artifacts seem to reflect game-playing and/or divination and to attest to early attempts by Upper Paleolithic humans to deal with chance: to cope with the seemingly "uncontrollable" randomness of natural phenomena. Modern human beings (and Upper Paleolithic people belonged to the same species as we do) find it hard to understand that many natural phenomena are simply random, a fact that is at least perplexing if not troubling, and that leads us to invent various means of coping with this randomness. [...] Such attempts to cope with randomness are, as much as graphic art, an important hallmark of fully modern, fully elaborate, socio-cultural systems. They permeate our belief systems, and play a large part in magico/religious ideas. [...] Games, particularly those in which skill plays little or no part, serve to strengthen social cohesion as they divert and entertain. In difficult times, they may provide important alternative means of gratification. Simple dice games are among the most widespread of these.' (Freeman & González Echegaray 2018: 160, 174).

of throwing games. To put it the other way round, dice take the burden from man to make decisions in a state of uncertainty (Ineichen 1996: 36, 61-63). Or, to say it with Huizinga (1980: 10), the play creates order: “*Into an imperfect world and into the confusion of life it brings a temporary, a limited perfection.*” This desire for perfection and order, recognisable as one essential and important aspect of play, may also be related to the step-by-step development from two-sided natural objects to geometric forms and towards a symmetry in numbering.

The considerations in this paper show first of all that the canonical numbering system for dice was by far less general than it appears from today's point of view. Instead, the canonical numbering system is a secondary development appearing two millennia after the invention of cubic dice in the 3rd millennium BC. The first cubic dice with the canonical numbering system appeared in the Egyptian New Kingdom, in the 16th century BC. The Greek adopted it in the 1st millennium BC. While being followed relatively strictly in Greek and Roman culture other rules existed in contemporary other cultures like Celtic or Etruscan. In the High Middle Ages even a competing numbering pattern (1 : 2, 3 : 4, 5 : 6) came into use widespread over Europe, which lasted for several centuries (from the 11th to the 15th century). The late medieval shift towards the canonical numbering was possibly induced by law.

The question “Why 7” remains unsolved. While the possibility of one design option becoming a convention and a subsequent traditional rule cannot be ruled out, a relation to a meta-level seems more likely. Given the facts and deductions outlined above, Greek values of aesthetics, beauty and symmetry seem more convincing than religious or magical beliefs connected with the number seven.

In their publication on the development of cubic dice Eerkens & de Voogt (2018) discuss qualities, patterns, differences and developments of dice from Roman to Early Modern Time by analysing material type, numbering configuration, style of the dots (pip style), shape and size of 312 dice from the Netherlands and the UK. In their introduction they write “*Although we shy away from larger interpretations regarding the context and use of dice in ancient human societies, the paper sets a stage for such an analysis.*” (Eerkens & de Voogt 2018: 164). Hopefully, my paper may help to push the research on rules and exceptions in the numbering of dice.

6. Acknowledgements

I am very grateful to the numerous colleagues and friends who contributed ideas and valuable information, in particular László Bartosiewicz, Edith Bernhauer, Cordula Brand, Frédéric Chandevau, Alice Choyke, Dieter Bischof, Jasmine Dum-Tragut, Walter Fasnacht, Gerhard Forstenpointner, Mirya Gerardu, Jean-Luc

Guadelli, Martin Höpfner, Sabine Hojer, Tom Jacobs, Ana Khechoyan, Ines Koenen, Sigrid and Hans Walter Küchelmann, Günther Karl Kunst, Lilit Mirzoyan, Marloes Rijkelijkhuisen, Dirk Schmitz, Uli Schmölcke, Walter Schwarze, Karin and Hans Seibet, Ian Smith, Felix Ter-Martirosov, Heiner Tettenborn, Monica Tielens, Manuel Thomas, Lena Wöhlke, Petar Zidarov. Alice Choyke, Alasdair Jardine and Lena Wöhlke lectured the manuscript. Further, I would like to thank my reviewers Stijn Arnoldussen and Wietske Prummel for their valuable comments. Last but not least I would like to express my gratitude to Milena Petrova and Petar Zidarov for the organisation of the wonderful conference.

References

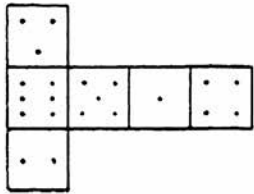


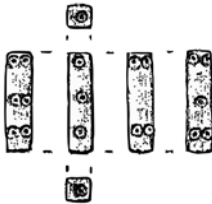
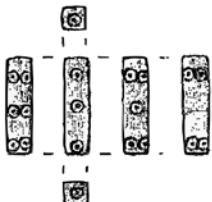
- BAART, J., W. KROOK, A. LAGERWEIJ, N. OCKERS, H. VAN REGTEREN ALTENA, T. STAM, H. STOEPKER, G. STOUTHART & M. VAN DER ZWAN, 1977. *Opgravingen in Amsterdam - 20 jaar stadskernonderzoek*. Amsterdam, Fibula-van Dishoeck.
- BARKER, P., 1986. *Understanding Archaeological Excavation*. London, Batsford.
- BARTOSIEWICZ, L., 1984. Reconstruction of Prehistoric Cattle Represented by Astragali in a Bronze Age “Sacrificial Pit”. In: C. Grigson, & J. Clutton-brock (eds.), *Animals and Archaeology: 4. Husbandry in Europe*. British Archaeological Reports International Series 227, Oxford, Archaeopress, 67-80.
- BARTOSIEWICZ, L., 1999. *A Systematic Review of Astragalus Finds from Archaeological Sites*. In: A. Vaday, (ed.), *Pannonia and Beyond*, Antaeus Communicationes ex Instituto Archaeologico Academiae Scientiarum Hungaricae 24, 37-44, 594, Budapest.
- BERNHAEUER, E., 2007. Herstellungsabfall eines Würfels vom St.-Jakobs-Platz in München. *Bericht der Bayerischen Bodendenkmalpflege* 47/48, 223-232.
- BIEGEL, G., 1986. *Das erste Gold der Menschheit*. 2nd printing, Freiburg, Schillinger.
- BISCHOP, D. 2001. *Die römische Kaiserzeit und frühe Völkerwanderungszeit zwischen Weser und Hunte*. Oldenburg, Isensee.
- BISCHOP, D. 2005a. Erster Vorbericht über die Grabungen auf dem historischen Bremer Marktplatz. *Bremer Archäologische Blätter Neue Folge* 6, 39-54.
- BISCHOP, D., 2005b. Am Rande der Domburg. Vorbericht über die Grabung 2002 auf dem historischen Marktplatz von Bremen. In: H. Eilbracht, V. Brieske, & B. Grodde (eds.), *Itinera Archaeologica. Vom Neolithikum bis in die frühe Neuzeit. Festschrift für Torsten Capelle zum 65. Geburtstag*. Internationale Archäologie - Studia honoraria 22, Rahden, Marie Leidorf, 9-23.
- BISCHOP, D., 2006. Mit Knochen gepflastert. Die archäologischen Beobachtungen am historischen Bremer Markt. *Zeitschrift für Archäologie des Mittelalters* 34, 215-230.
- BDOYAN, V., 1980. *Hay zolovrdakan xaler*. Hayakan SSH Gitut'yunneri akademia, [*Armenian National Games II*. Acade-

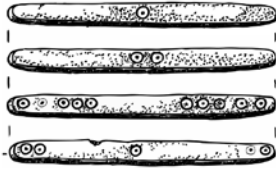
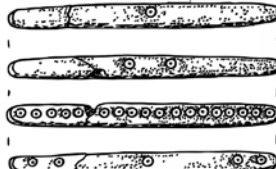
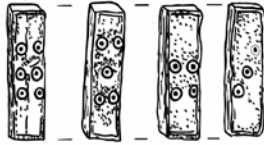
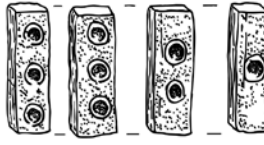
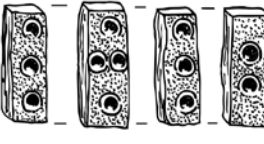


- my of Sciences of the Armenian Soviet Socialistic Republic], Yerevan.
- BOILEAU, E., 1879. Le Livre des Métiers. In: R. de Lespinasse & F. Bonnardot (eds.), *Histoire Générale de Paris*. Paris, Imprimerie Nationale.
- BRÄUNING, A., 2004. Adelsspiele, Ritterkämpfe, Volksvergnügen. *Archäologie in Deutschland* 1/2004, 28-35.
- CASSAVOY, K.A., 2006. *Serce Limani – The “Gaming Pieces”*, Institute of Nautical Archaeology, Bodrum, online at: <http://www.diveturkey.com/inaturkey/serce/gaming.htm>, accessed 21. 4. 2006; <http://ina.tamu.edu/SerceLimani.htm>, accessed 30. 5. 2006
- CHOYKE, A.M., M. VRETEMARK & S. STEN, 2003. Levels of social identity expressed in the refuse and worked bone from Middle Bronze Age Százhalombatta-Földvár, Vátya culture, Hungary. In: S. Jones O’Day, W. van Neer, & A. Ervynck (eds.), *Behaviour Behind Bones – Proceedings of the 9th ICAZ-Conference, Durham 2002*, Volume 1, Oxford, Oxbow, 177-189.
- CHOYKE, A.M., 2005. Bronze Age bone and antler working at the Jászódsza-Kápolnahalom tell. In: H. Luik, A.M. Choyke, C.E. Batey, & L. Lőugas (eds.), *From Hooves to Horns, from Mollusc to Mammoth – Manufacture and Use of Bone Artefacts from Prehistoric Times to the Present – Proceedings of the 4th Meeting of the ICAZ Worked Bone Research Group at Tallinn, 26th-31st of August 2003*, Muinasaja Teadus 15, Tallinn, Tallinn Book Printers, 129-156.
- CILLI, C., G. GIACOBINI & M. PAGANO, 2000. Dalla macrofotografia al microscopio elettronico a scansione: lo studio delle tracce presenti sui manufatti in osso e avorio. In: M. Pagano (ed.), *Gli Antichi Ercolanesi – Antropologia, Società, Economia*. Napoli, Elemond Editori Associati, 45-50.
- DANDROY, J.R., 2006. Astragali through Time. In: M. Maltby (ed.), *Integrating Zooarchaeology – Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham, August 2002*. Oxford, Oxbow, 131-137.
- DE GROSSI MAZZORIN, J. & C. MINNITI, 2013. Ancient use of the knuckle-bone for rituals and gaming piece. *Anthropozoologica* 48(2), 371-380.
- DESCHLER-ERB, S., 1998. *Römische Beinartefakte aus Augusta Raurica – Rohmaterial, Technologie, Typologie und Chronologie*, Band 1: Texte und Tafeln, Forschungen in Augst 27/1, Augst, Römermuseum
- DOLL, M., 2007. Speisereste, Sondermüll und Sägespuren – Archäozoologische Untersuchungen an den Funden aus der Hansestadt Soest. In: W. Melzer (ed.), *Handel, Markt, Haustiere – zur Geschichte von Markt und Tiernutzung in Soest*. Soester Beiträge zur Archäologie 7, Soest, Stadtarchäologie Soest, 83-205.
- EERKENS, J.W. & A.J. DE VOOGT, 2018. The Evolution of cubic Dice from the Roman through Post-Medieval Period in the Netherlands. *Acta Archaeologica* 88(1), 163-173.
- ERATH, M., 1999. Gute und gezinkte Würfel. In: R. Röber & G. Wesselkamp (eds.), *Von Schmieden, Würfeln und Schreibern. Städtisches Handwerk im Mittelalter*. ALManach 4, Stuttgart, Theiss, 88-99, T. 4.
- FAGNIEZ, M.G., 1898. *Documents relatifs a l’Histoire de l’Industrie et du Commerce en France*. Paris, Alphonse Picard et Fils.
- FALK, A., 1983. Knochengeräte des späten Mittelalters und der frühen Neuzeit, Bodenfunde aus Lübeck. *Zeitschrift des Vereins für Lübeckische Geschichte und Altertumskunde* 63, 105-128.
- FITTÀ, M., 1998. *Spiele und Spielzeug in der Antike – Unterhaltung und Vergnügen im Altertum*. Stuttgart, Theiss.
- FORSTENPOINTNER, G., 1999. *Untersuchungen zur osteologischen Manifestation des Tieropfers im ägäischen Raum anhand der Tierknochenfunde aus dem Artemision von Ephesos*. habilitation thesis, Veterinärmedizinische Universität Wien.
- FREEMAN, L.G. & J. GONZÁLEZ ECHEGARAY, 2006. Coping with chance: animal bones and the aleatory. In: K. Mariezkurrena (ed.), *Homenaje a Jesús Altuna*. Munibe 57, volume II, San Sebastian, Aranzadi, 159-176.
- GORET, J.-F., 2004. Os, bois de cervidés et ivoire – Le mobilier en matières dures d’origine animale à Saint-Denis. *Dossiers d’Archeologie* 297, 116-117.
- GOSTENCNIK, K., 2001. Pre- and Early Roman Bone and Antler Manufacturing in Kärnten, Austria. In: A. Choyke & L. Bartosiewicz, László (eds.), *Crafting Bone: Skeletal Technologies through Time and Space – Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group Budapest*, British Archaeological Reports International Series 937, Oxford, Archaeopress, 383-397.
- GREFEN-PETERS, S., 2005. Knochenarbeit ... – aktuelle Beispiele für Haus- und Handwerk in Stadt und Dorf. *Archäologie in Niedersachsen* 8, 50-53.
- GRIESHOFER, F., K. PALLESTRANG & N. WITZMANN, 2004. *Ur-Ethnographie – Auf der Suche nach dem Elementaren in der Kultur – Die Sammlung Eugenie Goldstern*, Kataloge des Österreichischen Museums für Volkskunde 85, Wien, Österreichisches Museum für Volkskunde.
- GRÓF, P. & D. GRÓH, 2001. The Remains of medieval Bone Carvings from Visegrád. In: A. Choyke & L. Bartosiewicz (eds.), *Crafting Bone: Skeletal Technologies through Time and Space – Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group Budapest*, British Archaeological Reports International Series 937, Oxford, Archaeopress, 281- 286.
- GRUNFELD, F. V., L. VIE, P. VAN DELFT, G. WILLIAMS & R.C. BELL, 1975. *Spelletjes uit de hele wereld*, Amsterdam, Kosmos.
- HALTRICH, J., 1885. *Zur Volkskunde der Siebenbürger Sachsen*, Wien, Carl Graeser.
- HAMPE, R., 1951. *Die Stele aus Pharsalos im Louvre*, Winkelmannsprogramm der Archäologischen Gesellschaft zu Berlin 107, Berlin, Walter de Gruyter.
- HEIJDT, L. VAN DER, 1990. *Oog in Oog – 5000 jaar dobbelsteen en dobbelstel*, Flevolaan-Naarden, Strengholt.
- HERRMANN, G., K. KURBANSAKHATOV & S.J. SIMPSON, 1998. *The International Merv Project. Preliminary Report on the sixth Season (1997)*. Iran 36, 53-75, pl. 6-10.
- HERMSEN, I., 2000. Een opmerkelijke dobbelsteen uit Didam (Gld.). *Westerheem* 49, 138-144.
- HILLS, J., 1998. *Das Kinderspielbild von Pieter Bruegel d. Ä. (1560)*, Veröffentlichungen des Österreichischen Museums für

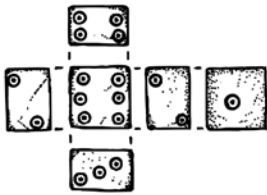

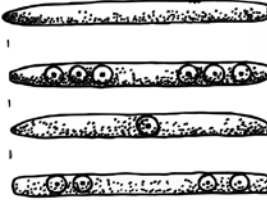

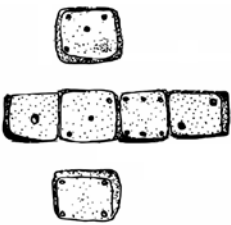

- Volkskunde X, 2. Auflage, Wien, Österreichisches Museum für Volkskunde.
- HOJER, S., 1996. *Antike Spiele*, München, Museumspädagogisches Zentrum.
- HUIZINGA, J., 1980. *Homo ludens – A Study of the Play-Element in Culture*, reprint, London, Routledge & Kegan Paul.
- INEICHEN, R., 1996. *Würfel und Wahrscheinlichkeit – Stochastisches Denken in der Antike*, Heidelberg, Spektrum.
- INEICHEN, R., 1999. Zufall und Wahrscheinlichkeit – einst ganz getrennt, jetzt eng verbunden. *Elemente der Mathematik* 54, 1-14.
- JONES O'DAY, S., W. VAN NEER & A. ERVYNCK, 2003. *Behaviour Behind Bones – Proceedings of the 9th ICAZ-Conference, Durham 2002*, Oxford, Oxbow.
- KORZAKOVA, H.B., 2010. Astragali. In: A. Kloner, E. Eshel, H.B. Korzakova & G. Finkielsztejn (eds.), *Maresha Excavations Final Report III. Epigraphic Finds from the 1989–2000 Seasons, Israel Antiquities Authority Reports* 45, 155-157
- KOVÁCS, G., 1989. Juh Astragalos-Játékkockák a Szolnoki Vár Területéről [Astragali aus dem Gebiet der Burg von Szolnok]. *Archaeologiai értesítő* 116, 103-110.
- KOVÁTS, I., 2005. Finds of worked bone and antler from the Royal Palace of Visegrád. In: H. Luik, Heidi, A.M. Choyke, C.E. Batey & L. Löugas (eds.), *From Hooves to Horns, from Mollusc to Mammoth – Manufacture and Use of Bone Artefacts from Prehistoric Times to the Present – Proceedings of the 4th Meeting of the ICAZ Worked Bone Research Group at Tallinn, 26th–31st of August 2003*, Muinasaja Teadus 15, 293-304, Tallinn, Tallinn Book Printers.
- KRÜGER, T., 1982. Das Brett- und Würfelspiel der Spätlatènezeit und römischen Kaiserzeit im freien Germanien. *Neue Ausgrabungen und Forschungen in Niedersachsen* 15, 135-324.
- KÜHL, I., 1984. Animal Remains in Cremations from the Bronze Age to the Viking Period in Schleswig-Holstein, North Germany. In: C. Grigson & J. Clutton-Brock (eds.), *Animals and Archaeology: 4. Husbandry in Europe*, British Archaeological Reports International Series 227, Oxford, Archaeopress, 209-220.
- LABNER, I., 2002. Ein gezinkter Würfel aus Lienz in Osttirol. *Archäologie Österreichs* 13, 47-48.
- LEHMKUHL, URSULA, 1985. Archäozoologische Betrachtung über Astragalusfunde aus Brandgräbern der römischen Kaiserzeit in Mecklenburg und ihr Brauchtum. *Jahrbuch Bodendenkmalpflege in Mecklenburg* 32, 241-251.
- LEHMKUHL, U. & H. SCHÄFER, 2005. Spiele für Jung und Alt. In: H. Jöns, F. Lüth, & H. Schäfer (eds.), *Archäologie unter dem Straßenpflaster – 15 Jahre Stadtkernarchäologie in Mecklenburg-Vorpommern*, Schwerin, 316-364.
- LEHNERT, S., 1997. *Beinverarbeitung im mittelalterlichen Bremen*, unpublished MA-thesis, Universität Bamberg.
- MACGREGOR, A., A.J. MAINMAN, & N.S.H. ROGERS, 1999. *Craft, Industry and Everyday Life: Bone, Antler, Ivory and Horn from Anglo-Scandinavian and Medieval York*, The Archaeology of York 17: The Small Finds, Fascicule 17, York, York Archaeological Trust.
- MAIER, R.A., 1962. Neolithische Tierknochen-Idole und Tierknochen-Anhänger Europas. *Bericht der Römisch-Germanischen Kommission* 42, 171-305, pl. 36-54.
- MENGE, H., 1982. *Langenscheidts Taschenwörterbuch der lateinischen und deutschen Sprache*, 31. Auflage, Berlin, Langenscheidt.
- MINNITI, C. & L. PEYRONEL, 2005. Symbolic or Functional Astragali from Tell Mardikh-Ebla (Syria). *Archaeofauna* 14, 7-26.
- NEVEUX, MARCEL, 2004. Un lot de dés en os du Moyen Age découvert sur le site de la place Camille-Jullian à Bordeaux. *Revue Archéologique de Bordeaux* 45, 115-130.
- NIEUWENBOURG-BRON, A., 1996. *Gegevens over beenbewerking*, Hilversum.
- PANETH, L., 1952. *Zahlensymbolik im Unbewußtsein*, Zürich.
- PAPPALARDO, UMBERTO, 2000. La casa ercolanese e le sue decorazioni. In: M. Pagano (ed.), *Gli Antichi Ercolanesi – Antropologia, Società, Economia*. Napoli, Elemond Editori Associati, 116-119.
- PETERLUNGER, D., 1998. *Durvun Berh – Ein Orakel aus der Monoglei*, unpublished gaming instruction, Murten (Switzerland).
- PETERS, E., 2002. Die Ausgrabungen auf der Beningaburg in den Jahren 1999 und 2000. In: H. Haßmann (Hrsg.), *Die Burg der Beninga zu Wirdum*, Wegweiser zur Vor- und Frühgeschichte Niedersachsens 23, Oldenburg, Isensee, 14-54.
- PIELER, F., 2005. Rettungsgrabung im Bereich des westlichen Vicus von Favianis in Mautern, Melkerstr. In: B. Wewerka (ed.), *Bericht über die Ausgrabungen des Vereins ASINOE im Projektjahr 2004*, Fundberichte aus Österreich 43, Wien, Berger & Söhne, 794-806.
- PLANCK, D., 1994. *Archäologie in Baden-Württemberg – Das Archäologische Landesmuseum, Außenstelle Konstanz*, Stuttgart, Theiss.
- PRILLOFF, R.-J., 2009. Würfel, Hohlkörper. In: M. Puhle (ed.), *Aufbruch in die Gotik. Der Magdeburger Dom und die späte Stauferzeit*. Band II: Katalog, Mainz, Philipp von Zabern, 463-465.
- RECH, M., 2004. *Gefundene Vergangenheit – Archäologie des Mittelalters in Bremen*, Bremer Archäologische Blätter Beiheft 3/2004, Bremen, Schintz-Druck.
- REESE, D., 1985. The Kition Astragali. In: V. Karageorghis (ed.), *Excavations at Kition V*, part 2, Nicosia, 382-391.
- REESE, D., 2000. Worked Astragali. In: J.W. Shaw & M.C. Shaw (eds.), *Kommos IV – The Greek Sanctuary, Part 1*, Princeton, Princeton University Press, 398-401.
- REKKAVIK, I., 2018. *Unusual medieval dice found in Bergen*, online publication: <https://niku.no/en/2018/03/uvanlig-terning-middelalderen-funnet-bergen>; accessed 16. 4. 2018.
- RIECHE, A., 2004. Von Astragalen, Nüssen und Würflern. *Archäologie in Deutschland* 1/2004, 24-27.
- RIJKELIJKHUIZEN, M.J., 2008. Dobbelen in Amsterdam. *Westerheem* 57(1), 21-23.
- RÖBER, R., 1994. Das Mittelalter: Hauswerk, Handwerk, Hohe Kunst. In: M. Kokabi, B. Schlenker & J. Wahl (eds.) (1994), *“Knochenarbeit” – Artefakte aus tierischen Rohstoffen im Wandel der Zeit*, Archäologische Informationen aus Baden-Würt-

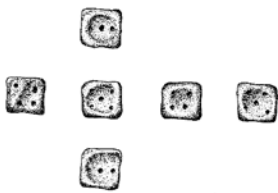
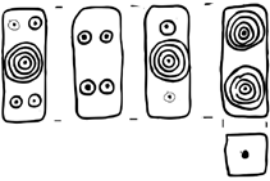



- temberg 27, Stuttgart, Landesdenkmalamt Baden-Württemberg, 110-120.
- ROHLFS, G., 1963. *Antikes Knöchelspiel im einstigen Grossgriechenland*, Tübingen, Max Niemeyer.
- ROES, A., 1963. *Bone and antler objects from the Frisian terpmounds*, Haarlem, H. D. Tjeenk Willink.
- RUß, D., 2005. Ein mehrphasiger Siedlungs- und Bestattungsplatz auf der Trasse der Ortsumfahrung Jetzelsdorf (B303), Niederösterreich. In: B. Wewerka (ed.), *Bericht über die Ausgrabungen des Vereins ASINOE im Projektjahr 2004*, Fundberichte aus Österreich 43, Wien, Berger & Söhne, 752-774.
- SCHALLMAYER, E., 1994. Die Verarbeitung von Knochen in römischer Zeit. In: M. Kokabi, B. Schlenker & J. Wahl (eds.), *„Knochenarbeit“ - Artefakte aus tierischen Rohstoffen im Wandel der Zeit*, Archäologische Informationen aus Baden-Württemberg 27, Stuttgart, Landesdenkmalamt Baden-Württemberg, 71-82.
- SCHMID, E., 1968. Beindrechsler, Hornschnitzer und Leimsieder im römischen Augst. In: E. Schmid, L. Berger & P. Bürgin (eds.), *Provincialia - Festschrift für Rudolf Laur-Belart*, Basel, Schwabe & Co., 185-197.
- SCHMID, E., 1972. *Atlas of Animal Bones for Prehistorians, Archaeologists and Quaternary Geologists*, Amsterdam, Elsevier.
- SCHMÖLCKE, U. & M.A. RASRAN, 2000. Vom Reiz eines Knochens - Talusspiele einst und jetzt. *Offa* 57, 361-367.
- SCHÜTTE, S., 1978. Das Haus eines mittelalterlichen Knochenschnitzers an der Johannisstraße in Göttingen. *Göttinger Jahrbuch* 26, 55-66.
- SCHÜTTE, S., 1979. Spielzeug aus Göttinger Bodenfunden. *Göttinger Jahrbuch* 27, 55-62.
- SEIBT, F., G. GLEBA, H.T. GRÜTTER, H. LORENZ, J. MÜLLER & L. TEWES, 1990. *Vergessene Zeiten - Mittelalter im Ruhrgebiet*, Essen, Peter Pomp.
- STADLER, H., 1995. *Ausgrabungen auf der Burgruine Flaschberg bei Oberdrauburg in Kärnten*. *Nearchos* 3, 137-331.
- STÄUBLE, H., 2005. Spielhölle oder Beinschnitzerwerkstatt?. *Archäologie in Deutschland* 1/2005, 55.
- STEINMEIER, K., 2004. *Komm, wir spielen Pitziknochen! - Eine Kindheit in Siebenbürgen*. Sibiu, Honterus.
- TACITUS, P.C., 1st c. AD / 1975. *Germania. Bericht über Germanien*. Translation Josef Lindauer, München, dtv.
- TAMLA, Ü. & L. MALDRE, 2001. Artefacts of Bone, Antler and Canine Teeth among the Archaeological Finds from the Hill-Fort of Varbola. In: A.M. Choyke & L. Bartosiewicz (eds.). *Crafting Bone: Skeletal Technologies through Time and Space - Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group Budapest*, British Archaeological Reports International Series 937, Oxford, Archaeopress, 371-381.
- TIELENS, M., no date. *De Bikkel en het Spel*, unpublished gaming instruction, Geldermalsen.
- ULBRICHT, I., 1984. *Die Verarbeitung von Knochen, Geweih und Horn im mittelalterlichen Schleswig*, Ausgrabungen in Schleswig, Berichte und Studien 3, Neumünster, Wachholtz.
- VERWEIJ, A., 2018. *Gallery of Ancient Dice* online: <http://averweij.web.cern.ch/averweij>, accessed 27.1.2018.
- VILSTEREN, V.T. VAN, 1987. *Het Benen Tijdperk - Gebruiksvoorwerpen van been, gewei, hoorn en ivoor 10.000 jaar geleden tot heden*, Assen, Drents Museum.
- VOGT, U., 2012. *Der Würfel ist gefallen. 5000 Jahre rund um den Kubus*, Hildesheim: Georg Olms.
- VON ANDRIAN, F., 1901. Die Siebenzahl im Geistesleben der Völker. *Mitteilungen der Anthropologischen Gesellschaft in Wien* 31, 225-274.
- VON BUTTEL-REEPEN, H., 1927. Ein vorgeschichtlicher Würfel und weitere Forschungsergebnisse aus dem Gräberfeld von Helle, Gemeinde Zwischenahn. Übersicht über Würfel funde. *Oldenburger Jahrbuch* 31, 281-290, pl. 1-2.
- WEGNER, G., 1982. Zwei Spielwürfel der römischen Kaiserzeit aus dem Gebiet zwischen Weser und Ems. *Archäologische Mitteilungen aus Nordwestdeutschland* 5, 33-38.

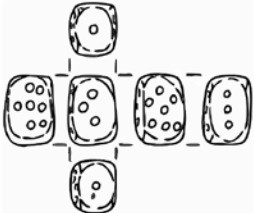
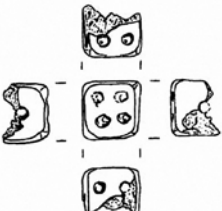
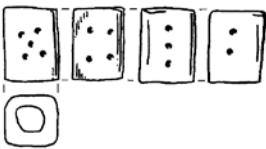
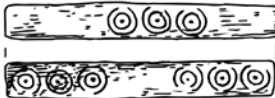
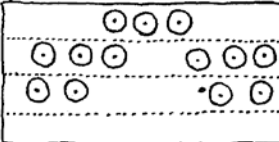
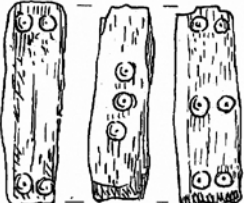
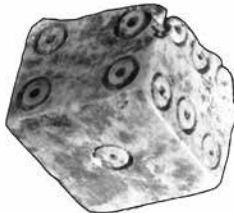
Appendix 1. Finds of dice not following the canonical numbering


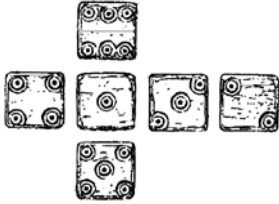

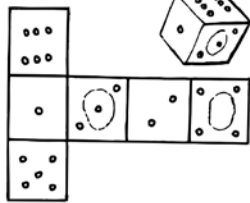

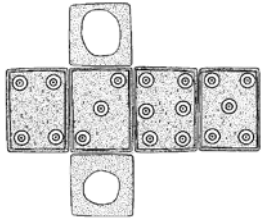
No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
1	Tepe Gawra Iraq	c. 2750 BC Sumerian	1 : 6 2 : 3 4 : 5		1 clay	Ineichen 1996: 41-42, fig. 5; 1999: 4; van der Heijdt 1990: 17
2	Mohenjo-Daro Pakistan	c. 2500 BC Harappa	1 : 2 3 : 4 5 : 6		3 stone (2), ceramic (1)	Ineichen 1996: 41, fig. 5; van der Heijdt 1990: 16
Iron Age						
3	Greece	7th c. BC	1 : 5 2 : 6 3 : 4		1 clay "Palamedes" die	Ineichen 1996: 43-44, fig. 6; van der Heijdt 1990: 18; National Archaeo- logical Museum Athens
4	Jetzelsdorf Austria	La-Tène Celtic	3 : 5 4 : 6 (1 : 1)		2 bone	Ruß 2005: 771-773, fig. 44, 47a, f
5	Jetzelsdorf Austria	La-Tène Celtic	3 : 4 5 : 6 (1 : 1)		6 bone	Ruß 2005: 771-773, fig. 44, 47b-e, g-h



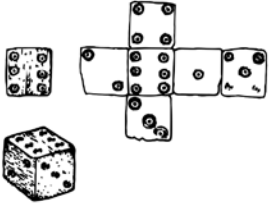
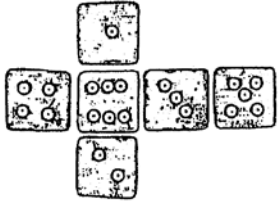


No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
6	Hostice Czech Republic	Roman Iron Age	1 : 10 2 : 5		1 bone	Hermesen 2000: 139; Krüger 1982: 142, 149, 229, 297, fig. 34.8, cat. no. 80
7	Hostice Czech Republic	Roman Iron Age	1 : 19 2 : 5		1 bone	Hermesen 2000: 139; Krüger 1982: 142, 149, 230, 297, fig. 35.1, cat. no. 80
8	Stradonice, Stare Hradisko Czech Republic	Roman Iron Age Celtic	3 : 5, 4 : 6 or 2 : 4, 3 : 5		some hundred bone, antler	Krüger 1982: 142-154, 227-229, 298-300, fig. 32, no .11-21, fig. 33, nos. 1-11, fig. 34, nos. 1-2, 4-6, cat. no. 97-98
9	Stradonice Czech Republic	Roman Iron Age Celtic	1 : 3 2 : 3		1 bone	Krüger 1982: 142-154, 229, 298-299, fig. 34.1, cat. no. 97
10	Stradonice Czech Republic	Roman Iron Age Celtic	2 : 4 3 : 3		1 bone	Hermesen 2000: 139; Krüger 1982: 142-154, 229, 298-299, fig. 34.3, cat. no. 97
11	Vimose Denmark	Roman Iron Age Germanic	3 : ? 6 : ? ? = 0 or 4		2 bone	Krüger 1982: 141, 222, 291-292, fig. 10.5- 6, cat. no. 42; von Buttel-Reepen 1927: 288-289
12	Aislingen Germany	Roman Iron Age Roman	1 : 3 2 : 4 5 : 6		1 bone	Krüger 1982: 141-154, 241, 306, fig. 46.6, cat. no. 132




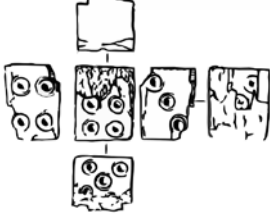
No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
13	Bad Wimpfen Germany	Roman Iron Age Roman	1 : 6 2 : 2 3 : 4		1 bone	Schallmayer 1994: 73, fig. 2
14	Bielefeld Germany	Roman Iron Age Germanic	1 : 1 2 : 5 3 : 4		1 clay	Bischof 2001: 78, 216
15	Dorsten-Holsterhausen Germany	1 st - 4th c. AD Germanic	1 : 6 2 : 4 3 : 5		3 ceramic	Vogt 2012: 56
16	Elxleben Germany	Roman Iron Age Germanic	1 : 0 4 : 6		1 bone	Krüger 1982: 142-154, 232 302, fig. 37.6, cat. no. 108
17	Groß Kelle Germany	Roman Iron Age Germanic	3 : 6 4 : 0		3 ivory (elephant or narwhal)	Krüger 1982: 140-141, 153, 231, 302, fig. 36.16-18, cat. no. 111; Museum Schwerin: 374-382, 407-409
18	Leeste Germany	Roman Iron Age Migration Period Germanic	1 : 6 2 : 3 4 : 5		1 clay	Bischof 2001: 75-77, fig. 49.3, 51; Focke-Museum Bremen
19	Märschendorf Germany	Roman Iron Age Germanic	2 : 4 3 : 5		1 bone drilled	Wegner 1982: 35-36, fig. 3; Museum für Naturkunde und Vorgeschichte Oldenburg: 2999

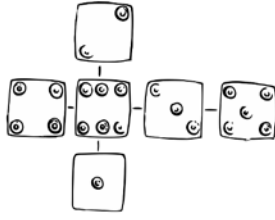
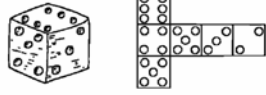
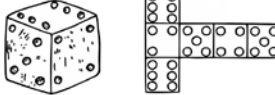



No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
20	Mahlstedt Germany	2 nd - 3 rd c. AD Roman Iron Age Germanic	3 : 3 4 : 4 5 : 5		1 clay	Bischof 2001: 77-78, 216; Wegner 1982: 33- 35, fig. 1
21	Quedlinburg Germany	Roman Iron Age Germanic	2 : 4 3 : 5		1 bone	Krüger 1982: 142-154, 232 305, fig. 37.7, cat. no. 128
22	Rheindorf Germany	Roman Iron Age	4 : 5 5 : 10 9 : 12		1 bone	Krüger 1982: 141-154, 241, 316, fig. 46.3, cat. no. 205
23	Teterow Germany	Roman Iron Age	1 : 3 2 : 5 4 : 6		1	von Buttell-Reepen 1927: 288
24	Trier Germany	Roman Iron Age Roman	3 : 4 5 : 5 6 : 6		1 bone	Wegner 1982: 34; Landesmuseum Trier
25	Trier Germany	Roman Iron Age Roman	4 : 4 5 : 5 6 : 7		1 bone	Wegner 1982: 34; Landesmuseum Trier
26	Welschingen Germany	Roman Iron Age Germanic	3 : 4 6 : 5		2 bone	Krüger 1982: 142-154, 239, 318, fig. 44.7-8, cat. no. 229; Museum Karlsruhe: c 11219
27	Baard Netherlands	Roman Iron Age - Early Middle Age Germanic	2 : 10? 3 : 4 5 : 6		1 clay	Hermsen 2000: 140, fig. 5; Fries Muesum, Leeuwarden
28	Broekpolder Netherlands	Roman Iron Age	1 : 2 3 : 6 4 : 5		1 bone	Hermsen 2000: 144
29	Castricum Netherlands	2 nd c. AD Roman Iron Age	1 : 6 2 : 4 3 : 5		1 clay	Hermsen 2000: 144

No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
30	Didam Netherlands	4th - 5th c. AD Roman Iron Age Germanic	1 : 1 3 : 3 7 : 7		1 clay	Hermsen: 2000: 139, fig. 2-3; Vogt: 2012, 57
31	Nieuw Wehl Netherlands	Roman Iron Age Germanic	1 : ? 4 : ? ? : ?		1 clay	Hermsen 2000: 142, fig. 6
32	Sneek Netherlands	Roman Iron Age Germanic	2 : 4 3 : 5		1 bone	Krüger 1982: 142-154, 244 321, fig. 49.4, cat. no. 253
33	Dorotowo Poland	Roman Iron Age	3 : 6 4 : 0		2 glass	Krüger 1982: 141-154, 224, 292, fig. 29.14-15, cat. no. 47
34	Krakówka Poland	Roman Iron Age	3 : 4 6 : 0		2 glass	Krüger 1982: 141-154, 224, 293, fig. 29.17, cat. no. 51
35	Leg Piekarski Poland	Roman Iron Age	3 : 0 4 : 6		4 bone	Krüger 1982: 141-154, 224, 293, fig. 29.9-12, cat. no. 52
Middle Ages						
36	Aschaffenburg, Germany	13th - 14th c. AD Late Middle Age	1 : 2 3 : 6 4 : 5		1 bone	Höpfner, pers. com. 19. 8. 2005; Stiftsmuseum Aschaffenburg: 70590

No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
37	Braunschweig, Germany	13th - 14th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		1 bone	Grefen-Peters 2005: 50-52, fig. 3
38	Bremen Germany	13th - 14th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		3 bone	Bischof 2005a: 42-43, fig. 6.2; 2005b: 12-13, Abb. 5.4; 2006: 222, 226, Abb. 11.1; Lehnert 1997: 57-58, pl. 7.6, 16.4, 25.5; Rech 2004: 275-276, 385-386, fig. 289, 392.1; Landesarchäologie Bremen
39	Duisburg Germany	13th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		2 bone	Seibt <i>et al.</i> 1990: 212, cat. no. 346; Niederrheinisches Museum Duisburg: 83:34; 82:34/77
40	Göttingen Germany	13th - 14th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		1 bone	Bernhauer 2007: 226; Rech 2004: 386; Schütte 1978; 1979: 56-57, 60, fig. 3.10
41	Hattingen Germany	13th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		5 bone	Seibt <i>et al.</i> 1990: 160, cat. no. 203-204; Kulturgeschichtliches Museum Hattingen: 75/10; 76/14; 76/18; 81/1; 87/2
42	Magdeburg Germany	12th - 15th c. AD	1 : 2 3 : 4 5 : 6		2 bone	Bernhauer 2007: 226; Prilloff 2009; Landesmuseum für Vorgeschichte Sachsen-Anhalt: AM 79.00-80.00/G.80-1,50-37; jkf 11,60/8,80/54,15-191
43	Oldenburg (Starigard) Germany	8th - 9th c. AD Slavic	3 : 5 4 : 6		1 bone	Gabriel 1991: 227-228, fig. 32.1; Labner 2002: 48

No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
44	Schleswig Germany	11th - 14th c. AD Middle Age	3 : 5 4 : 6 4 : 5		1 walrus ivory	Ulbricht 1984: 39-40, 58-59, pl. 87.10
45	Schleswig Germany	11th - 14th c. AD Middle Age	1 : 2 3 : 4 5 : 6		5 bone	Ulbricht 1984: 39-40, 58-59, fig. 6b, pl. 46.5, 9-10, 87.6
46	Soest Germany	Middle Age	1 : 2 3 : 4 5 : 6		1 bone	Doll 2007: 186, fig. 127.1; Stadt Soest: 94/582
47	Wirdum Germany	13th - 14th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		1 bone	Peters 2002: 46, 49, fig. 39.4
48	Dorestad Netherlands	15th c. AD Late Middle Age	3 : 5 4 : 6 (1 : 1)		1 bone	Nieuwenbourg-Bron 1996: 43; van der Heijdt 1990: 69-70
49	Nieuwenhoorn Netherlands	13th c. AD Late Middle Age	1 : 2 3 : 4 5 : 6		1 bone	van Vilsteren 1987: 47, fig. 69; Afdeling Archeologie, BMA Amsterdam
50	Saint-Denis France	11th - 14th c. AD Middle Age	1 : 2 3 : 4 5 : 6		2 bone	Unité d'Archéologie de la Ville de Saint-Denis
51	Saint-Denis France	11th - 14th c. AD Middle Age	1 : 2 3 : 6 4 : 5		1 bone	Unité d'Archéologie de la Ville de Saint-Denis

No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
52	Bordeaux France	14th - 15th c. AD Late Middle Age	2 : 2 4 : 4 6 : 6		14 bone	Neveux 2004
53	Bordeaux France	14th - 15th c. AD Late Middle Age	1 : 1 3 : 3 5 : 5		18 bone	Neveux 2004
54	Bordeaux France	14th - 15th c. AD Late Middle Age	1 : 1 2 : 2 3 : 3		8 bone	Neveux 2004
55	Bordeaux France	14th - 15th c. AD Late Middle Age	4 : 4 5 : 5 6 : 6		14 bone	Neveux 2004
56	Bordeaux France	14th - 15th c. AD Late Middle Age	4 : 4 4 : 4 4 : 4		1 bone	Neveux 2004
57	Genf Switzerland	14th c. AD	1 : 3 2 : 4 5 : 6		2 ivory	Verweij 2018: cat. no. 380; Vogt 2012: 58
58	Genf Switzerland	14th c. AD	1 : 2 3 : 4 5 : 6		1 ivory	Verweij 2018: cat. no. 380; Vogt 2012: 58
59	Bodrum (Serçe Limani wreck) Turkey	1025 AD	5 : 7 7 : 9 10 : 14		1 bronze suggested to be a weight	Cassavoy 2006; Bodrum Museum of Underwater Archae- ology
60	York United King- dom	10th - 11th c. AD Middle Age	3 : 4 5 : 6 5 : 0		1 walrus ivory	MacGregor <i>et al.</i> 1999: 1982-1985, 2047, fig. 941, cat. no. 7890

No.	Provenance	Dating / Culture	Numbering	Illustration	No. of Specimen / Material / Remarks	Reference; Collection: Inv. No.
61	York United Kingdom	11th - 15th c. AD Middle Age	1 : 2 3 : 4 5 : 6		12 bone (10), walrus ivory (2)	MacGregor <i>et al.</i> 1999: 1982-1985, 2022, 2047, 2051, 2059, fig. 941, cat. no. 7116-7117, 7891-7892, 8164
62	Konstanz Germany	13th - 16th c. AD Late Middle Age - Early Modern	2 : 5 3 : 4 5 : 6		1 bone	Erath 1999: 89, 96, fig. 8c Archäologisches Landesmuseum Baden-Württemberg Konstanz
63	Konstanz Germany	13th - 16th c. AD Late Middle Age - Early Modern	4 : 4 5 : 5 6 : 6		1 bone	Erath 1999: 96, fig. 8b Archäologisches Landesmuseum Baden-Württemberg Konstanz
64	Lübeck Germany	Late Middle Age	1 : 2 3 : 4 5 : 6		1 bone	Falk 1983: 106-107, 126, fig. 1.7
65	Bergen Norway	15th c. AD	3 : 6 4 : 5 5 : 4		1 wood	Rekkavik 2018
66	Gordion Turkey	9th - 6th c. BC	1 : 6 2 : 3 4 : 5		1 bone?	Exhibition Anatolian Civilizations Museum Ankara, 9.9.2018

