Historical Metrology: Lost in Translation?

Recent generations have increasingly disagreed about the history of the Troy weight system in particular, and thus historical metrology in general. I judge mistranslation of historical understandings is part of this problem, and I will here attempt to separate, explain, and illustrate three degrees of mistranslation: regarding standards, structure, and rounding off.

Standards

Kisch[1] instanced a set of three "exactly even" standard Cologne weights officially produced in 1703, which were re-weighed in 1870. The heaviest was found to be 468.125g, the lightest 467.548g. An apparent error of 0.577 g, which is perhaps better understood as 0.3%. This immediately leads to the first problem of translation. In 1703 these weights were understood as identical, by 1870 they were not.

The question confronting us then is: is this first problem of translation important to our understanding of historical metrology? My reply is: not really. Let us consider the deep history of Troy weight. Many, myself included, have favoured an origin of Troy in the Moslem Ratl Kabir, these days dated to the 8th century.[2] That standard very probably derives from the Persian standard fixed by Darius around 500 BC, which in turn derives from the Sumerian standard of Shulgu, fixed around 2,150 BC.

Today 16 oz Troy weighs approximately 497.65563g

A "palace" weight of Darius, (British Museum) yields a mina of 498.87g[3] (or sometimes 500.19g[4])

The "palace" weight of Shulgi, (Louvre) yields a mina of 496g[5] (or sometimes 502g[6])

What should we conclude from this evidence? It suggests, that over thousands of years, the standard has moved by around 0.3%. That is to say, in pre-modern terms, it seems to have stayed exactly even. Notice too the errors here seem smaller than those sometimes made in 20th century archaeology. I suggest it is misguided to let such small variations divert our attention from the astonishing consistency observed, over thousands of years.

Structure

Today 16 oz Troy weighs about 497.65563g and 16 oz Imperial weighs about 453.59237g. Exact decimal figures that hide the true relationship between the two standards. If we turn back the clock to around 1580,[7] we are led to a simpler and more exact rendition of the relationship. Troy 16oz was 7,680 grains, Imperial 16oz was 7000 grains. Translating our understanding into those medieval Troy grains opens the door to understanding. Consider the following historical transformation (expressed in medieval Islamic grains) of the Sumerian/Troy Standard:

7,680 x 7/8 = 6,720 the Attic Mina (c. 700 BC?)

6,720 x 12/16 = 5,040 the Roman Libra (c. 400 BC?)

5,040 = 12 x 8 x 52.5 the Roman Libra expressed in Imperial denarii (Nero)

100 x 52.5 = 5,250 the Florentine 12oz pound of 100 denarii (c. 1100?)

5,250 x 16/12 = 7,000 which is 16 Florentine ounces and the Imperial pound. (c. 1300)

Mathematically: 7,680 x 7/8 x 100/96 = 7,680 x 175/192 = 7,000

In the understanding of the anonymous gentleman who advised Elizabeth I around 1580, probably much of this history was forgotten, but it seems the mathematics lived on. The rise of decimal notation from 1620 onwards explains why this important historically based mathematical insight has been increasingly lost to the world in general for more than 300 years.

Rounding Off

Having pointed out how decimal representation hides mathematical historical reality, we come to the problem of rounding within decimal practice. A kind of physical violence is done to the raw facts when the tools of decimalisation are applied. Modern metrological "facts" are the stumps left by rounding.

In 1967 Skinner detrmined the reformed Umayyad dirhem at two sterling pennyweights,[8] thus 60 Troy wheat grains[9] which he announced at 2.92g. As the sterling pennyweight is by intention 30 Troy wheat grains and Maqrizi, back in the 15th century, had fixed the Umayyad dirhem within an Islamic tradition at 60 grains,[10] it was an obvious step to take. Independently, in 1960, Miles had preferred a fix close-by at around 2.93g[11]. It is disappointing therefore to find Heidemann in 1998[12] undermining this symmetry, against the opinions of prior generations, by rounding off to 2.90g.

In 1989 the numismatist Blunt and his associates considered the weight standard of Alfred the Great's "late Southern" penny and fixed it at c. 24 grains or 1.57g.[13] That of course suggests a Troy pennyweight by intention. However by 2013, we find Sawyer, rounding off to 1.60g,[14] perhaps advised by Naismith.[15] It is perhaps worth adding that in 2024 Naismith wrote at some length on the "standardisation" of the medieval penny without regard to any target weights.[16]

In 2020 Malek encouraged readers to accept that later "Sasanid coins were intended to weigh approximately 4.1 grams".[17] This is an advance on the c. 4.0g he published in 1993.[18] Careful studies of the plentiful late issues of Khusru II point to something very close to 4.13g. If, as seems very plausible, Khusru was adhering to the mina of Darius, then rather than the traditional 120 drachms to the mina, it would appear he was striking 121. Much as we later find it suggested that Henry III was striking 242 rather than 240 pennies to the pound.

Pre-moderns never used decimal representation, and so, of course, they never rounded off.

References:

1. Kisch, B. *Scales and weights; a historical outline* (Yale) 1965, page 9

2. Tye, R. *Sumair and the Unity and Influence of ‘Abd al-Malik’s Weight Reforms* Maß und Gewicht 2022 (online)

3. https://www.britishmuseum.org/collection/object/W_1888-0512-Bu-257

4. https://collection.sciencemuseumgroup.org.uk/objects/co57654/trilingual-standard-of-darius-the-great-bc521-485

5. https://collections.louvre.fr/ark:/53355/cl010146962

6. Chambon, G. & Otto, *A Weights and Measures as a Window on Ancient Near Eastern Societies*

Gladbeck 2023, page 55 (online)

7. The surviving Winchester "avoirdupois" weights which Connor dated to 1357 seem to represent 16oz Florentine, and are mostly about 1% lower than modern standards. The sets distributed by Elizabeth in 1588 enforcing her legal definition seem to be inherently fixed at 7,000 Troy grains. I have come across no official written definition of the 7,000 grain standard prior to legislation of 1824.

8. Skinner, F. G. *Weights & Measures,* HMSO, 1967 page 86

9. Notice that the Arab division of the Ratl Kabir yielded a carat of about 0.194g. That carat yields two separate grains: one third, the "Troy Barley" grain which seems to increasingly dominate English usage after 1351, but one quarter, the "Troy Wheat" grain was normally usage before that date. Early Arab sources make use of both grains. For English usage see for instance: Connor R. D. *The Weights and Measure of England*, HMSO 1987, p. 124

10. Allouche A. *Mamluq Economics,* Salt Lake City 1994, page 57

11. Miles, G. C. *Byzantine Miliaresion and Arab Dirhem* (ANS) Vol. 9 (1960), p 213 (online)

12. Heidemann, S. *The Merger of Two Currency Zones in Early Islam* Iran, Vol. 36 (1998), page 100

13. Blunt, C. with Stewart, B. and Lyon, C. *Coinage in Tenth-Century England*, Oxford 1989 Page 237

14. Sawyer, P, *The Wealth of Anglo-Saxon England* Oxford, 2013,

15. Naismith, R. *Early Medieval Monetary History* Farnham, 2014, page 55

16. Naismith, R. https://www.degruyterbrill.com/document/doi/10.1515/9783110987126-003/html

17. Malek, H. in *Ancient Iranian Numismatics* Irvine 2020, page 157

18. NC 1993, https://www.jstor.org/stable/42667896

* * *

Mathematical Postscript: concerning the decimal representation of numbers

Hilbert 1926: *no one will cast us out from the paradise that Cantor has created for us*

Cohen 2005: *The vast majority of statements about the integers are totally and permanently beyond proof in any reasonable system*