Introduction: Numeracy

Compared to some of the other topics in this collection, numeracy has a long history, and its interpretation and emphasis varies according to the field of investigation. The collection includes papers on numeracy as a method of representation, ordinality, as well as private and public numbering practices. The origins of numeracy, the conception and abstraction of numbering, remain unknown, lost to prehistory. Whitehead alludes to the cultural tsunami that was the recognition of numbering by imagining the thoughts of the first person who made the connection between seven fish and seven days[1].

As opposed to general numeracy, the onset of ordinality, the attachment of scale to numbers, seems historically secured, at least according to some researchers. Guyer[2] claims ordinality might have emerged in historical Atlantic Africa, in the era of the commercial trades in the extractive commodities of slaves, ivory and gold. Guyer also gives evidence for the claim that ordinality has formed deep cultural and religious narratives and ontologies. For example, Christianity developed a hierarchical order for the universe, with animals (below angels and human beings) ranked by relative intelligence and independence: the most noble is not possible to domesticate; the next level is domesticated but spirited (horses, dogs); and at the bottom are docile domesticated animals (sheep). Guyer further points out that while rank order may be only one form of numerical expression in mathematics, it is a powerful dynamic in social life almost everywhere. Social stature is ranked by age, by achievement, by station, etc. in hierarchical forms everyone is subject to.

Thrift's text interprets the significance of calculation in current cultural contexts. His text includes conundra from the history of numeracy culture, such as the question as to whether the discovery of mathematics resulted from the transition from a visually based preliterate society to a verbally based literate culture. The author observes that mathematics allowed the world to be seen as concise, transferable and thus manageable. In particular, mathematics and numeracy was able to establish repeatability, the concept of population as a thinkable entity, and mass lists and registers. This last component paved the path to the invention of technologies which not only recorded, copied, duplicated and stored information but also, in effect, created the modern idea of what information consists of. These technologies include the typewriter, prepared forms, filing systems, card files and new means of duplication and indexing. Notably, these practices and apprehensions of number do not just describe a reality but construct reality. Thrift claims that a new phase in numeracy culture has emerged in recent years as calculation has become automated and ubiquitous, and he calls this *qualculation*[3]. He defines this term as an activity arising out of the construction of microworlds which allow many millions of calculations continually to be made in the background of any encounter. Qualculation has generated a tendency to frame number as quality, in the sense that calculations are so numerous and so pervasive that they show up as forces rather than discrete operations, so Thrift.

[1] Whitehead, A., Science and the Modern World, 1925 (paperback edition, Free Press, Simon&Schuster, 1997, p 20)
[2] Guyer, J., The eruption of tradition? On ordinality and calculation, Anthropological Theory March 2010 vol. 10 no. 1-2 123-131, 2010.
[3] Thrift, N., Movement-space: The changing domain of thinking resulting from the development of new kinds of spatial awareness, Economy and Society, Vol. 33, Iss. 4, 2004.

Another group of texts describes connections between numeracy and literacy, ranging from basic literacy to illiteracy in numeracy amongst expert groups.

One paper describes methods devised for illiterates to monitor growth and health in infants. Several examples of non-numeric measurement systems are described, including an intuitive weight (correlated to growth) monitoring scheme that removes the abstraction of a graphic display and maps the abstraction of number to a physical experience by recording infants weight with a spring loaded scale. A uterus monitoring system based on a tape measure with holes is also proposed, as well as a visual thermometer that indicates temperature with a binary color code (green if temp is ok)[4]. This collection of field-tested examples shows that it is possible to perform simple health monitoring techniques without recourse to the abstraction of number. Similarly, the "Reporting Wheel" developed by the organization *InStedd* is designed to let people with limited literacy encode environmental conditions. The Reporting Wheel consists of small cardboard wheels that can "encode" a series of values or pictograms into a number that can be transmitted via simplified text messaging, and a backend service that collects the reports and assists an administrator in configuring responses.

A different aspect of numerical literacy is addressed by a paper on the historical conventions of numeric notation (place value notation), and how these conventions have come to influence everyday digital tools such as ATMs and calculators[5]. How one represents numbers influences how readers of numbers think about them. The author targets the mundane field of calculators and shows how improvements to calculator design and numeric process presentation would help in improving general numeracy. He suggests a list of features the new calculator should exhibit: clarity (operations should be seen when carried out), simplicity (consistent and uniform with clear and mathematically concise operator keys), and affordance for non-decimal fractional numbers, amongst others.

An overview of the recent history of various interpretations of numeracy in health care is offered in a research report conducted on the terms in the *Web of Science* database. Health numeracy has many aspects, including the primary numeric skills common to other domains (numeration, counting, hierarchy, then also fractions, proportions, probabilities), but also other, contextual aspects, such as: applied numeracy (risk communication, decision making) and interpretative numeracy (the ability to interpret strengths and limitations of numbers)[6]. The authors report on research on communicating risk through visual and verbal means.

Even experts grapple with numeracy – but who would know? One of the papers in the SiReBi collection offers a damning and entertaining report on the misuse of statistics principles in the social sciences[7]. In particular, the author criticizes the institutionalization of the null hypothesis significance test ("the null ritual") and shows how it became an unquestioned standard in the social sciences. In particular, the formulaic application of presets (such as the 5% significance

[4] D. Morley, "Why are Innovations in the Health Field Needed?", Appropriate Medical Technology for Developing Countries, 3rd IEE Seminar on, 4-4 Feb. 2004, p. 32/1-32/4

[5] N. Holmes, "Truth and Clarity in Arithmetic," Computer, Vol. 36, Iss. 2, Feb. 2003, p. 106-108

[6] H L. Vacher, Todd Chavez, "Quantitative Literacy on the Web of Science, 2 – Mining the Health Numeracy Literature for Assessment Items," Numeracy, Vol. 2, Iss. 1, Article 5, 2009, p. 1-47

[7] Gerd Gigerenzer, "Mindless statistics," The Journal of Socio-Economics, Vol. 33, Iss. 5, Nov 2004, p. 587-606

level) lacks, in the author's view, statistical sophistication (it is applicable only where one has really absolutely no idea of the problem at hand). The author shows how widespread the misinterpretation of the p-value (the probability of the data) is amongst academics and in textbooks. The true test of a model, the author reminds the reader, is to fix its parameters on one sample and to test it in a new sample.

A very different aspect of numeracy is represented in a series of papers that address numeracy for subjective-private assessment of well-being ("private numeracy"), as represented by the current trend of self-quantifiers (people who measure and track as many aspects of their life as possible in order to better understand factors that influence their own personal well-being)[8]. While the methods of modern self-trackers have changed, the concept is very similar to the well-established concept of self-experimentation common amongst behaviorists. One text from the collection describes a behaviorist's understanding of self-experimentation, which offers, so the author, a venue into self-control, systematic variation, experimental ethics and controlled record keeping. It also permits the functional analysis of private phenomena and has the paradoxical consequence, so the author, of causing us to be less self-important[9] - a strong contrast to the more common interpretation that self-trackers are narcissists.

Subjective numeracy can be a sought-after commodity. In consumer testing, for example, the subjective experience of potential customers is of intense interest. One of the papers in the collection offers an examination of consumer testing in perfume marketing[10]. The authors observe that, rather than being measured as consumers through the testing device, the participating persons engage with the work of becoming measuring instruments themselves. The authors focus on how participants are affected by such a task, but also, more generally, by the way in which the testing device provokes a number of realities that may stand as sources of useful knowledge for the purpose of marketing. The testing sessions observed followed a specific quantitative olfactory testing protocol. The overall purpose of the test is to assess the performance of a series of fragrances through blind taste testing within large samples of participants to provide a sound basis for the decision of which fragrance to use for the development of a new perfume. The authors describe several interesting sub-aspects of the research, including the perfume engineers' attempt to create a new vocabulary to measure the way in which a perfume is experienced and to trade consumer experience between perfumers and marketers; or: the testing participants self-concern with their 'reliability' and ability to generate reproducible results, properties which are usually voluntarily delegated to machines.

In addition to the focus on subjective/private numeracy, the collection contains materials on numeracy in the public domain. One contribution describes a distributed recreational beach water monitoring system[11] that combines data from EPA-approved water quality assessment systems and human intuition, gathered by personal interviews with swimmers at the beach, to a new experimental metric of recreational water experience: the swimming pleasure measure (SPM).

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[8] http://quantifiedself.com/conference/Mountain-View-2011/

[9] Neuringer, A., "Self Experimentation: A Call for Change," Behaviorism, Vol. 9, 1981, p. 79 – 94

[10] Muniesa, F., Trebuchet-Breitwiller, A., "Becoming a Measuring Instrument," Journal of Cultural Economy, Vol. 3, Iss. 3, Nov. 2010, p. 321 - 337

[11] Böhlen, M., Atkinson, J., "Ambient Intelligence at the Beach," WI-IAT 2010, 31 Aug. - 3 Sept. 2010, p. 361 - 364

This metric is weighted heavily towards the human experience expressed by the beach goers input, but modified to reflect information they cannot perceive, for example bacterial contamination levels. This third way of knowing proposes a distributed crowd-machine interaction scenario in a complex environment. This vein of work is related to citizen science activities that have become popular over the last several years. With the advent of social media, the collection of data can be shared across a wide swath of the population instead of being performed only by experts. This *crowdsourcing* approach has also been in action for radiation monitoring in the vicinity of Fukushima's damaged nuclear reactors[12], for example.

Related to numeracy in public domains, but focusing on the social practices of numeracy, is a text on false and provisional numbers[13]. These classes of numbers are to be distinguished from numbers as referents to stable entities that carry the same meaning no matter what their context. Provisional and false numbers do not share this stability, nor are they meaningful outside specific contexts. Provisional numbers are used in planning and strategizing activities such as quarterly reports to assist groups in setting the parameters for tasks at hand and debating their relative merit. In other instances, so the author, provisional numbers parade as stable and fixed indicators, though their provisional status is well known by those responsible for making them. False numbers appear when the primary task is to learn how to deploy numbers, making the relative accuracy of the numerical sign less important than the attempt to master the logic of formal procedures.

Further Reading

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[12] http://www.aljazeera.com/news/asia/2011/04/201142317359479927.html

[13] Lampland, M., "False numbers as formalizing practices," Social Studies of Science, Vol. 40, Iss. 337, Apr. 2010, p. 377 - 404