Arianna Borrelli

Heat and cold in observation and explanation

Fever, climatic changes, melting metals, cooking food: all these phenomena have been often subjected to a close, careful and systematic examination, sharing at least some features with scientific observation. Moreover, terms like "hot", "cold" and "temperature" can have descriptive roles in music, psychology, gastronomy and the theory of colours. Hot and cold can be observed in nature and also, as Count Rumford remarked, "by means of machinery contrived for the mere mechanical purposes of the arts and manufactures", in his case the workshops of the Munich arsenal [1].

Observations of heat and cold provide a solid starting point for studying, first, the interplay of sense perception and instruments and, second, the relationship between observation and its description - especially in qualitative vs. quantitative terms. Both subjects are particularly relevant to the history of scientific observation, since quantitatively described observations performed with the aid of gauged instruments have come to represent one of the pivotal ideals of modern science: measurement.

The line from qualitative to pre-quantitative and then to quantitative observation has often been drawn, with the history of thermometry serving as an example [2]. Yet historical studies have also brought to light the complexity of this process [3]. By investigating observations of heat and cold, this subject can be approached not just as the prehistory of scientific measurement, but as part of the history of scientific observation.

The project could initially focus on those aspects of past observations that today commonly appear as "less scientific", then explore the cultural context they shared with seemingly "more scientific" ones. A possible line of research and argument is sketched below.

Senses

How could heat and cold be perceived and qualitatively described? Medical observations of fever offer well-documented examples of attentive, skilled usage of all senses to examine body heat, from antiquity up to the 19th century [4]. In early modern natural philosophy, various perceptions of heat and cold were carefully described in qualitative terms, for example by Francis Bacon, Robert Boyle and Joseph Black [5]. Meanwhile, thermometers were variously being used since the 17th century [6].

Qualities and their quantities

Terms like "temperature" and "degree" actually testify to a past in which the opposition between quantity and quality was less sharp than today [7]. The language of complementary qualities (e.g. hot/cold) and their mixtures ("temperatures") has a tradition dating back to antiquity. Intensities of qualities ("degrees") were being quantified already in the middle ages, yet, up to the late 18th century, the intensive quantity of a quality was thought of as intrinsically different from any extensive quantity such as length [8]. This difference reflected observations, such as that two masses of hot water, when joined, do not become twice as hot.

Instruments and pre-quantities

What did early modern scholars actually observe in connection with thermometers? In Italian summer days, members of the Accademia del Cimento gauged their thermometers by putting a bit of butter on the bulb and waiting for it to melt [9]. The Englishman Stephen Hales marked on his instruments the degree "of water, when heated to the greatest degree that I could bear my hand in it, without stirring it about" [10]. Significantly, he distinguished this degree of heat from the one he could tolerate, if he did allow himself to stir the hand: he was observing himself very carefully.

Flexible descriptions

When a phenomenon is considered as a "temperature" of complementary qualitative principles, description and explanation are not always distinctly kept apart. While Lavoisier found the term "phlogiston" in this sense too ambiguous, such language could also be perceived as flexible and close to observation [11]. Many German experimentalists of the early 19th century chose to speak of their work on heat transformation in terms of polarities and relative degrees [12]. Had this choice more to do with observational practices or with *Naturphilosophie*? Here is an opportunity to examine the interdependence between styles of description, observational practice and the sheer desire to observe.

Senses and qualities - again

Today, very little place seems to be left for senses and qualities in scientific observation, and even the "felt temperature" has been quantified. What went out of focus, when instruments and quantities gained centre stage? This question can be asked also of less academic crafts like baking, cooking or brewery [13]. Finally, we may ask: who feels the "felt temperature"? The immediate answer is: Klima-Michel (35, 1,75m, 75 Kilo), a computer-simulated male observer, whose perceptions scientists observe [14].

For further reference see:

A. Borrelli, “Giovan Battista Della Porta’s Neapolitan magic and his humanistic meteorology”, in: Siegfried Zielinski and Eckhard Fürlüs (eds.), *Variantology 5. On Deep Time Relations of Arts, Sciences and Technologies* (Köln: Walther König, 2011) [in press]

A. Borrelli, “Die Reproduktion des Temperaturbegriffs”, in: Ute Frietsch and Bettina Bock von Wulfingen (eds.), *Epistemologie und Differenz. Zur Reproduktion in den Wissenschaften* (Bielefeld: Transcript, 2010) 59–82

A. Borrelli, “Die bewegende Kraft des Feuers: Naturgeheimnisse und „nutzlose“ Technik in der Frühen Neuzeit”, *Praxis der Naturwissenschaften* 4/59 (Juni 2010) 5–10

A.Borrelli, “The weatherglass and its observers in the early seventeenth century”, in: Claus Zittel, Gisela Engel, Nicole C. Karafyllis and Romano Nanni (eds.), *Philosophies of technology: Francis Bacon and its contemporaries*, vol. 1 (Leiden: Brill, 2008) 67-130 (Intersections 11/1)

A. Borrelli, “Pneumatics and the alchemy of weather: What is wind and why does it blow?”, in: Siegfried Zielinski and Eckhard Fürlus (eds.), *Variantology 3. On Deep Time Relations of Arts, Sciences and Technologies in China and elsewhere* (Köln: Walther

König, 2008) 27-72

References quoted :

[1] B. Thompson, Count Rumford, *An experimental inquiry concerning the source of the heat which is excited by friction*, Philosophical Transactions 88 (1798) p. 80-108, quoted from: R. B. Lindsay (ed.), *Energy: historical development of the concept* (Stroudsburg 1975) p. 207.

[2] G. Bachelard, *La formation de l'esprit scientifique. Contribution à une psychanalyse de la connaissance* (seizième tirage, Paris 1999) p. 215-218; R. Carnap, *Philosophical foundations of Physics. An introduction to the philosophy of science*, ed. by M. Gardner (New York et al. 1966) p. 51-53 and 59; A. C. Crombie, *Quantification in Medieval Physics*, Isis 52 (1961) p. 143-160.

[3] T. S. Kuhn, *The function of measurement in modern physical science*, Isis 52 (1961) p. 161-190; T. Frängsmyr et al. (eds.), *The quantifying spirit in the 18th century* (Berkeley et al. 1990); M. Norton Wise (ed.), *The values of precision* (Princeton 1995); G. Boehme, *Temperatur und Wärmemenge. Ein Fall alternativer Quantifizierungen eines lebensweltlich-technischen Begriffs*, in: P. Eisenhardt et al. (eds.), *Der Weg der Wahrheit.* (Hildesheim et al. 1999) p. 217-226.

[4] V. Hess, *Der wohltemperierte Mensch. Wissenschaft und Alltag des Fiebermessens (1850-1900)* (Frankfurt et al. 2000) p. 19-39; M. Nicolson, *The art of diagnosis: medicine and the five senses*, in: W. F. Bynum and R. Porter (eds.), *Companion encyclopedia of the history of medicine*, vol. 2 (London et al. 1993) p. 801-825, esp. p. 806-807.

[5] Some examples in: F. Bacon, *Neues Organon: lateinsich-deutsch,* ed. by W. Krohn, vol. 2 (Hamburg 1990) p. 300-348 (F. Bacon, Instauration magna, Novum Organum, liber secundus, Aph. X-XIII); *Works of Robert Boyle*, ed. by M. Hunter and E. B. Davies, vol. 4 (London 1999) p. 335-340 and vol. 8 (London 2000) p. 342-352; J. Black, *The nature of heat*, in: J. Black, *Lectures on the elements of chemistry, given at the University of Edinburgh, 1766-1797* (Philadelphia 1807) p. 21-34, reprinted in: R. B. Lindsay (ed.), *Energy: historical development of the concept* (Stroudsburg 1975) p. 195-203.

[6] Hess, *Der wohltemperierte Mensch* (as in note 4) p. 39-55; W. E. Knowles Middleton, *A history of the thermometer and its use in meteorology* (Baltimore 1966); C. Licoppe, *La formation de la pratique scientifique: le discours de l'expérience en France et en Angleterre (1630-1820)* (Paris 1996) p. 108-112 and p. 282-285.

[7] *Temperature*, in: *The Oxford english dictionary,* vol 17 (second edition, Oxford 1989) p. 749-750; *Degree*, in: *The Oxford english dictionary,* vol 4 (second edition, Oxford 1989) p. 399-400; V. Nutton, *Humoralism*, in: W. F. Bynum and R. Porter (eds.), *Companion encyclopedia of the history of medicine,* vol. 1 (London et al. 1993) p. 281-291.

[8] Crombie, *Quantification* (as in note (2)) p. 151; E. Sylla, *Medieval quantification of qualities: the "Merton school"*, Archive for the history of exact sciences 8 (1971) p. 9-39; G. Keil, *Qualitäten- und Gradenlehre*, in: *Lexikon des Mittelalters*, vol. 7 (1999) col. 353-354; I. Kant, *Kritik der reinen Vernunft* (2nd ed. 1787) p. 199-218 (KrV B 199-218).

[9] M. Miniati, *L'Accademia del Cimento*, in: M. Miniati (ed.), *Museo di storia della scienza - Firenze - Catalogo* (Prato 1998) p. 132-137, esp. p.135.

[10] S. Hales, *Vegetable statics* (1727), forew. by M. A. Hoskin (London et al. 1961) p. 33.
[11] T. L. Hankins, *Science and the Enlightenment* (Cambridge et al. 1985) p. 106-110; J. Riskin, *Science in the age of sensibility. The sentimental empiricists of the French Enlightenmnt* (Chicago et al. 2002) p. 247-249.
[12] K. L. Caneva, *Physics and Naturphilosophie: a reconnaissance*, History of science 35 (1997) p. 35-106.
[13] H. O. Sibum, *Les gestes de la mesure. Joule, les pratiques de la brasserie er la science*, Annales: histoire, sciences sociales 53 (1998) p. 745-774.
[14] G. Jendriztky et al., *Ein objektives Bewertungsverfahren zur Beschreibung des thermischen Milieus in der Stadt- und Landschaftsplanung ("Klima-Michel-Modell")* (Hannover 1979); *Dämmkraft der Unterhose*, in: Der Spiegel 3 (1997) p. 150.