Food for Thought from Carnot

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The Food

"In fact, it is no bad summing up of Carnot's work to say that, as the Greeks gave us the abstract ideas (point, line, etc.) with which to think of space, and the 17th century those (mass, acceleration, etc.) with which to think of mechanics, so Carnot gave us those needed in thinking of heat engines. In each case the ideas are so pervasive that we use them even to state that they never apply exactly to visible objects.

"Carnot's 'unit of thought' was the well-known perfectly frictionless, perfectly insulated engine, which gains and loses all its heat at two standard temperatures T and *t*, and imparts motion to nothing except the crankshaft; in particular, not to the particles of the steam. It is therefore 'reversible,' that is, capable, on reversal, of transferring all the heat back from sink or condenser to source. The expansions and contractions in it are all either isothermal or adiabatic [involving no loss or gain of heat], and we can reason only about a complete cycle of operations, that is, one which returns the working substance to its original state in *every* respect.

"With such an engine it can be shown to follow that the work done per unit of heat transferred ('efficiency') is independent of all details, such as the nature of the working substance, and is in fact simply equal to (T - *t*) / T; otherwise we can get an unlimited amount of work from it without recourse to the source."

"The 'Second Law' [of thermodynamics] was now precisely stated as the impossibility of getting an unlimited amount of heat or work out of a Carnot engine (and, *a fortiori*, out of any other less efficient engine). Clausius (1850) and Thomson (1851) gave equivalent statements of the law ....

"Thomson had been much concerned at the dependence of 'temperature' on the properties of a particular gas or liquid; and it was because he saw in Carnot's work a method of defining an 'absolute' (that is, a work) scale (1848) that he welcomed it. To give efficiency not unity (T - *t*) / T, T must be finite. Thus the suggestion, implicit in Charles' law, of an absolute zero at about -273° C. was confirmed." [all quotations from Pledge 1939, p. 144]

The Thought

So, in the same way that Plato's redefinition of the elements of geometry (seeing lines as indivisible planes and points as indivisible lines) dramatically increased the productivity of geometry, and in the same way that Galileo's thought experiment concerning a perfectly frictionless plane for balls to roll on became the basis for Newtonian mechanics, Carnot's perfectly frictionless, perfectly insulated engine became the basis for advances in thermodynamics and in temperature measurement.

We thus see in the development of each of these sciences the same criteria and motivations that lead to Rasch's models, especially the focus on an idealization of the variable as something that can stand on its own independent from the particular details of the specific lines, points, planes, gases, or liquids involved.

What will it take to bring researchers in the human sciences to recognize and accept the validity, utility, and opportunity opened up by these criteria? Is it a fear of reductionism? Is it a math phobia? Is it simply the inertia of existing rewards and motivations that support the status quo?

Or is it the lack of a context that rewards the mathematical coordination of different experiments into a common framework, that assumes total incommensurability as the norm, as seems to be traditional in the human sciences?

I'm betting on the latter and aim to educate, agitate, and lobby for a new measurement culture that values metrological networks and a realization of quantity that follows through on Thurstone's sense of it as the language in which the community of science thinks together. This is what every additional Rasch instrument calibration points to.

When we get to the point at which several instruments intended to measure each of the variables of interest have been calibrated, the commonalties and differences in the calibrations will cry out for explanation, and these explanations will lead to better theories, which will lead to better instruments, which will lead to better data, etc. (Ackermann 1985; Galison 1999). This process will then, in all likelihood, given the historical development of the other sciences, lead to the derivation of conventions for data quality and reference standard metrics.

The French revolutionaries thought they could institute the metric system inside of six months, but it took 50 years, and even now, 150 additional years later, global implementation is still incomplete. Though the efficient thing to do would be to take the bull by the horns and deliberately set out to create rational quantitative measurement in the human sciences, the process will inevitably be fraught with politics, emotions, and the protection of vested interests. We probably won't live to see the day when a metrology system for even a single psychosocial variable is implemented on a broad scale. Probably still less likely will we be around to appreciate the new breeds of research results that will be produced by communities of investigators able to think together in common mathematical languages for the first time. We can, however, help prepare the ground, sow the seeds, and cultivate the plants from which this fruit will grow. And each new calibrated scale brings that day closer.

References

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Notes

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