Heat in Inter-theory Relations

In scientific realist eyes we are only warranted to assert that a theory is true or approximately true if that theory enjoys considerable explanatory and predictive success. The most well known challenge to this claim, the pessimistic meta-induction, holds that the history of science is replete with successful theories that are now considered false. In effect, this challenge raises doubts about the reliability of inferences from explanatory and predictive success to (approximate) truth. The main realist reaction has been to argue that upon closer scrutiny the historical record can be reconciled with scientific realism. When a successful theory is abandoned, not all of its components are discarded but only those that are *inessential* or *idle* for the theory's success. Their abandonment is thus inconsequential for the realist. In this talk I consider what the modern kinetic theory of heat managed to salvage from the outdated caloric theory and whether the inter-theoretic relations between the two theories support a realist view of science.

Antoine Lavoisier developed the first sophisticated theory of heat based on an idea whose roots go back to Antiquity, namely that heat is a special kind of substance. Lavoisier called this substance 'caloric'. According to his theory, caloric is an elastic fluid that is virtually imperceptible, flowing from warmer to colder bodies. It is also a conserved quantity and its particles are subject to two forces. One is repulsive and holds between caloric particles. The other is attractive and holds between caloric particles and particles of ordinary matter. As is well known, the caloric theory was dumped at around the middle of the nineteenth century. This was not merely a consequence of the numerous anomalies for which the theory had no convincing explanation. Rather, a more important factor seems to have been the rise in sophistication and success of the caloric theory's rival, namely the kinetic theory heat. Heat, according to this theory, is a consequence of the *motion* of particles. In more modern terms, heat is a form of kinetic energy possessed by a physical system.

If the realists are right, not only did certain theoretical parts of the caloric theory survive into our modern conception of heat but these parts are in fact solely responsible for the success the caloric theory enjoyed. I test this claim against two of the caloric theory's successes, namely the explanations (i) that matter expands by heating and contracts by cooling and (ii) that a special kind of heat (i.e. latent heat) is involved in changes of state. Take (i) as an illustration. The caloric explanation of this phenomenon has the same structure as the kinetic one. As the quantity of heat – caloric in the one case, kinetic energy in the other – is increased/decreased the force generated – repulsive in the caloric case, pressure in the kinetic case – increases/decreases and that in turn leads to an increase/decrease in the volume needed. Thus the caloric explanation was successful because it had managed to get the structure of such processes right, even though the specifics of the ontology were wrong, i.e. the existence of caloric and its repulsive force. This result tallies well with a special kind of realism, namely structural realism.

Some Relevant References:

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