Liberating energy: Investigating physicists' use of anthropomorphic cognitive metaphors when modeling matter-energy interactions in English and German.

Peter Hull
Friedrich-Alexander-Universität Erlangen-Nürnberg

In physics, terms relating to the restriction or granting of freedom are frequently employed in the context of matter-energy interactions, as evident in phrases such as "a photon is captured" and "energy was liberated". However, the philosophical concepts of freedom and liberty relate to sentient beings with rights and abilities to make decisions, meaning physical interactions between matter and energy do not literally involve freedom or liberty at all.

This work examines for the first time the hypothesis that physicists' language choices which attribute freedom to certain physical phenomena indicate the existence of related anthropomorphic cognitive metaphors (CMs). It builds on previous investigations into ontological cognitive metaphors (OCMs) for the concepts of energy and heat in physics. However, whereas earlier research focuses on the connections between inanimate phenomena through substance-based OCMs, such as energy as a liquid material, this work opens up a novel and potentially rich area of enquiry into cognitive models relating fundamental physical phenomena to the field of human interactions.

A specific group of frequently occurring metaphors, termed matter-energy confinement metaphors (MECMs), is defined and the results of an extensive series of empirical experiments to investigate their use by physicists are presented. The impacts of the use of MECMs on physicists' reasoning about specific physical processes, such as nuclear fission or particle annihilation, are examined using a methodology adapted from Thibodeau & Boroditsky and the surface-level features of MECMs are investigated via a large-scale online survey.

These experiments are conducted in parallel with separate groups of both English and German speakers. By exploring details of the use and effects of MECMs across two languages this work is also the first to allow a direct comparative analysis of both how these metaphors are encoded in language use and the underlying cognitive models they relate to.

The ultimate intention of this research is to establish concrete suggestions for language use among those teaching and learning about energy in physics, particularly in mixed language teaching environments such as those found at many German universities and research institutes.

References

Amin, Tamer G. 2020. Energy metaphors in science, learning and instruction. In Anke Beger & Thomas Smith (ed.), How metaphors guide, teach and popularize science, 73-110. Amsterdam: John Benjamins Publishing Company.

Brookes, David & Etkina, Eugenia. 2015. The Importance of Language in Students' Reasoning About Heat in Thermodynamic Processes. International Journal of Science Education 37. 759-779.

Lancor, Rachael. 2015. An analysis of metaphors used by students to describe energy in an interdisciplinary general science course. International Journal of Science Education 37. 876-902.

Scherr, Rachel E. 2012. Representing energy. I: Representing a substance ontology for energy. Physical Review Special Topics - Physics Education Research 8. 020114.

Thibodeau, Paul H. & Boroditsky, Lera. 2011. Metaphors We Think With: The Role of Metaphor in Reasoning. PLoS ONE 6(2): e16782.