

# Identifying blended ontologies for energy

Benjamin W. Dreyfus, Ayush Gupta, and Edward F. Redish  
Department of Physics, University of Maryland, College Park



## Previously on...

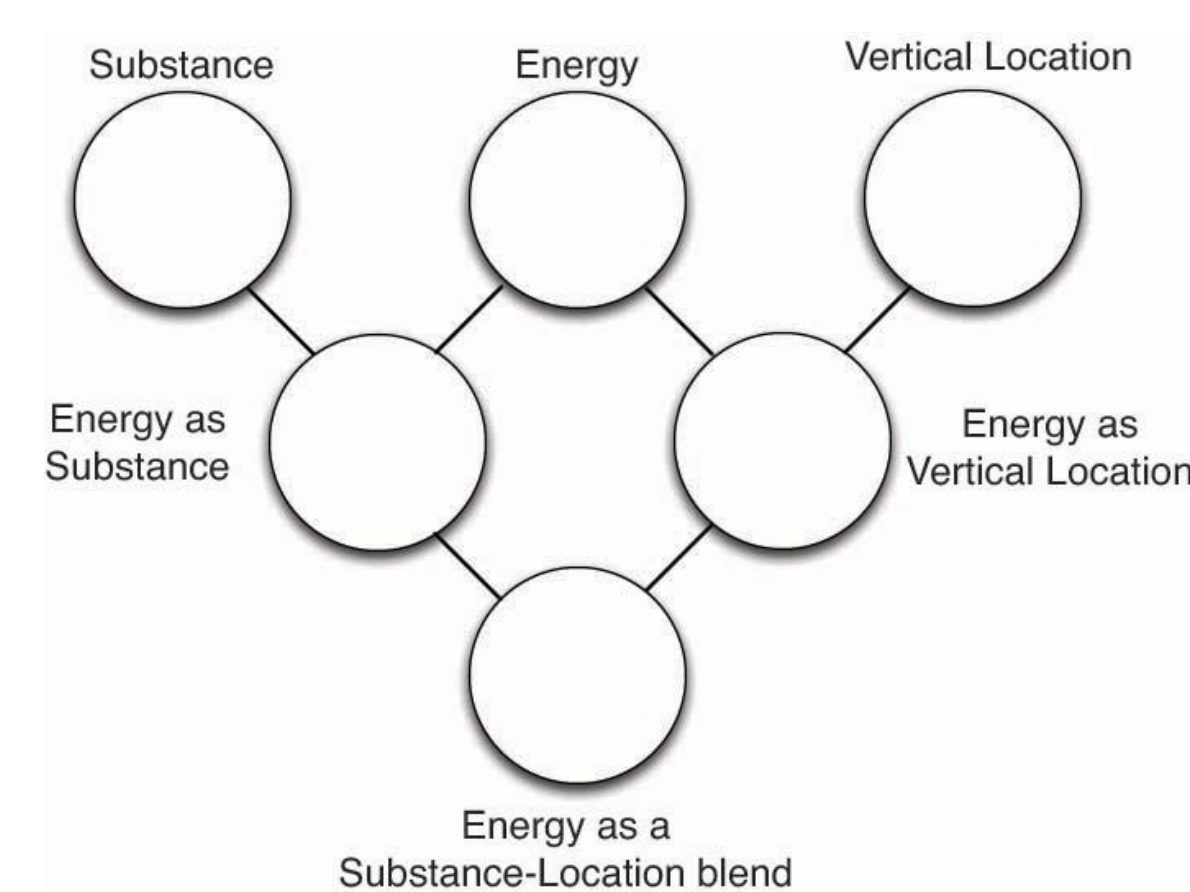
- **Ontological metaphors** for energy: metaphors for what kind of thing energy is
- Some are encouraging the use of the substance ontology for energy in instruction
- In our contexts, both the substance and location ontologies have affordances and constraints
- Students and experts can productively combine the substance and location metaphors for energy [1]

## But what does it mean to combine the substance and location ontologies?

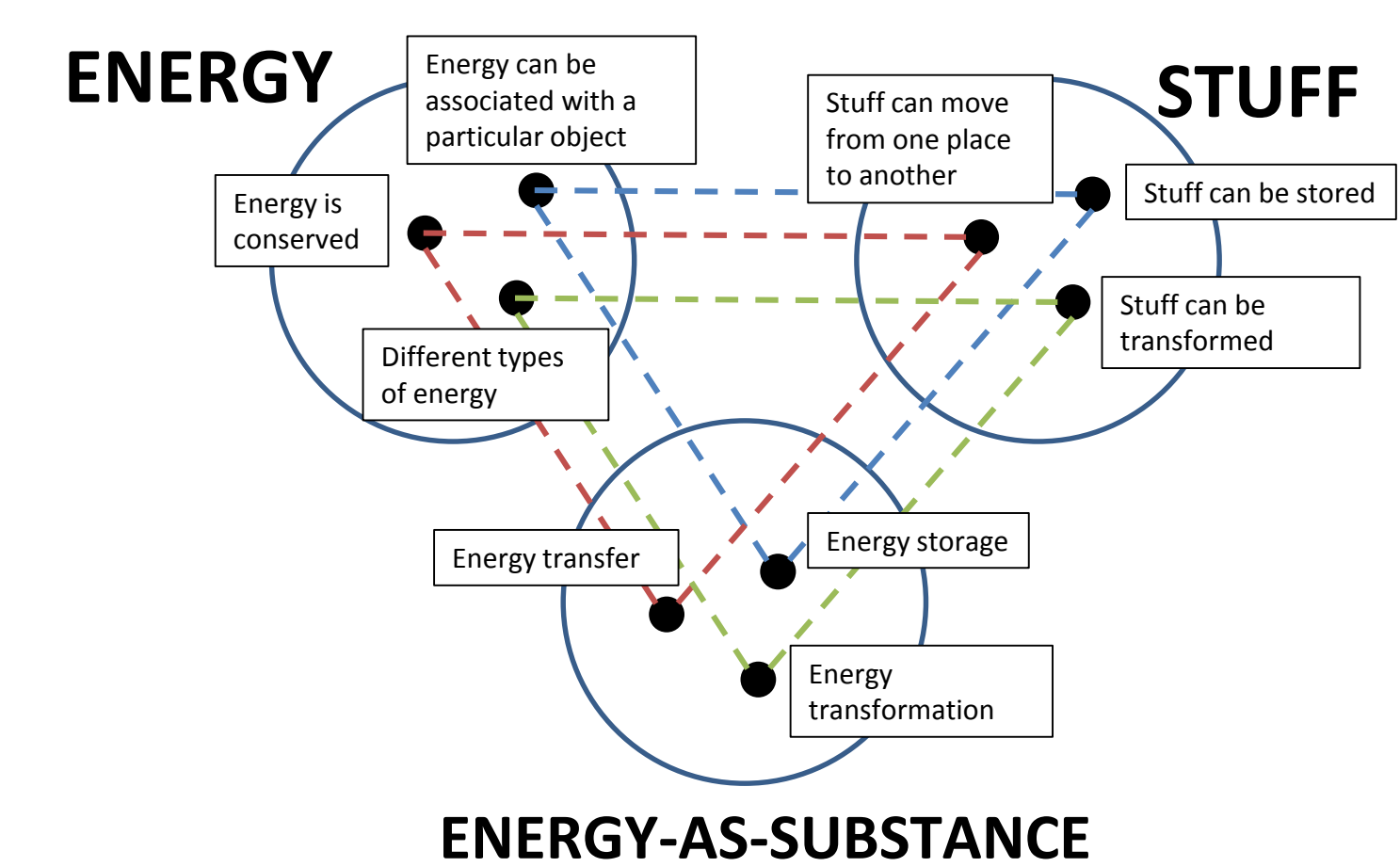
## Conceptual blending

To understand what it means to combine ontologies, we use Fauconnier & Turner's [2] conceptual blending framework, in which elements from input mental spaces are mapped to form a blended space.

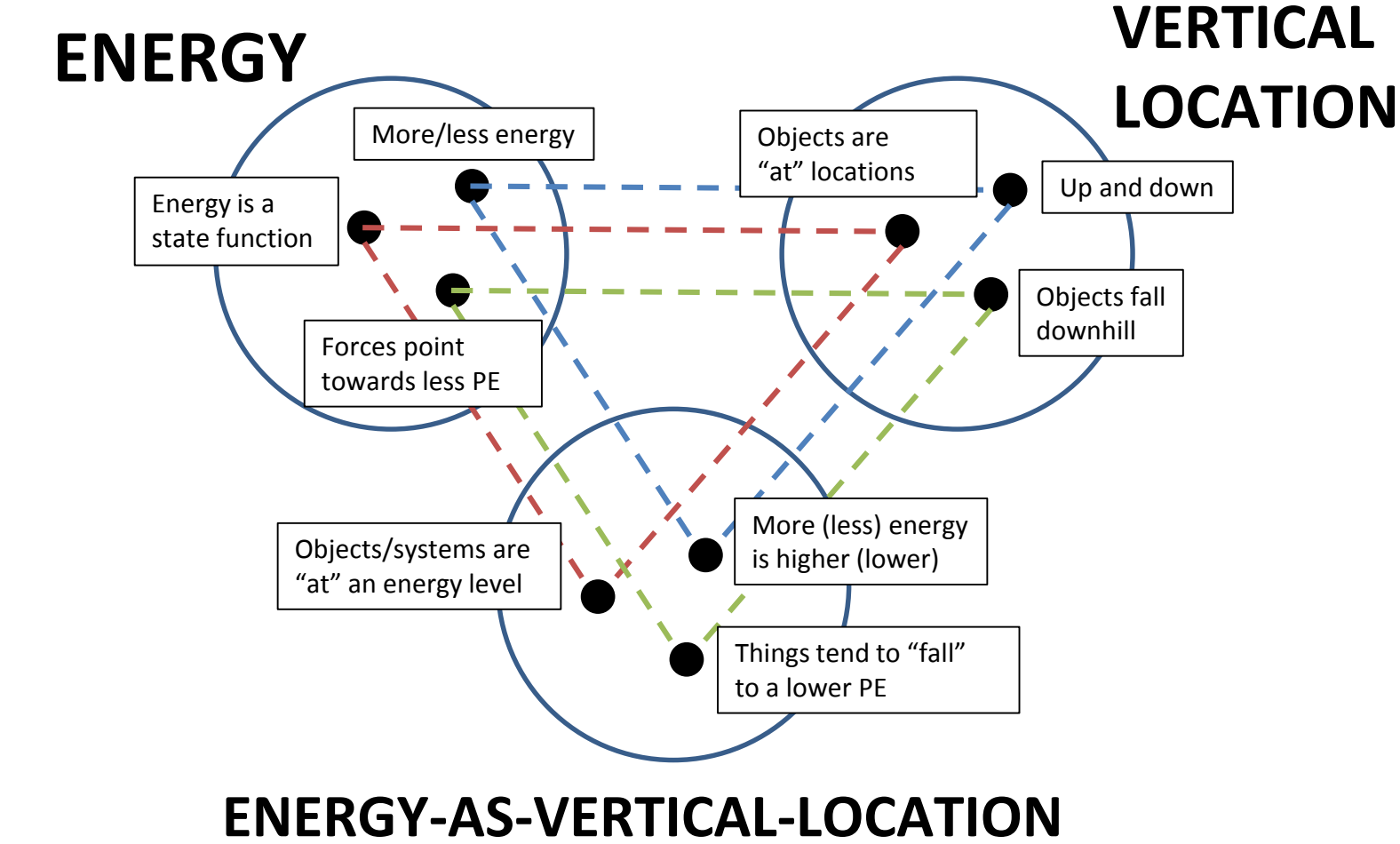
We understand the energy-as-substance and energy-as-location ontologies as conceptual blends, and they in turn can be blended in multiple ways to form blended ontologies.



### Energy-as-substance mental space



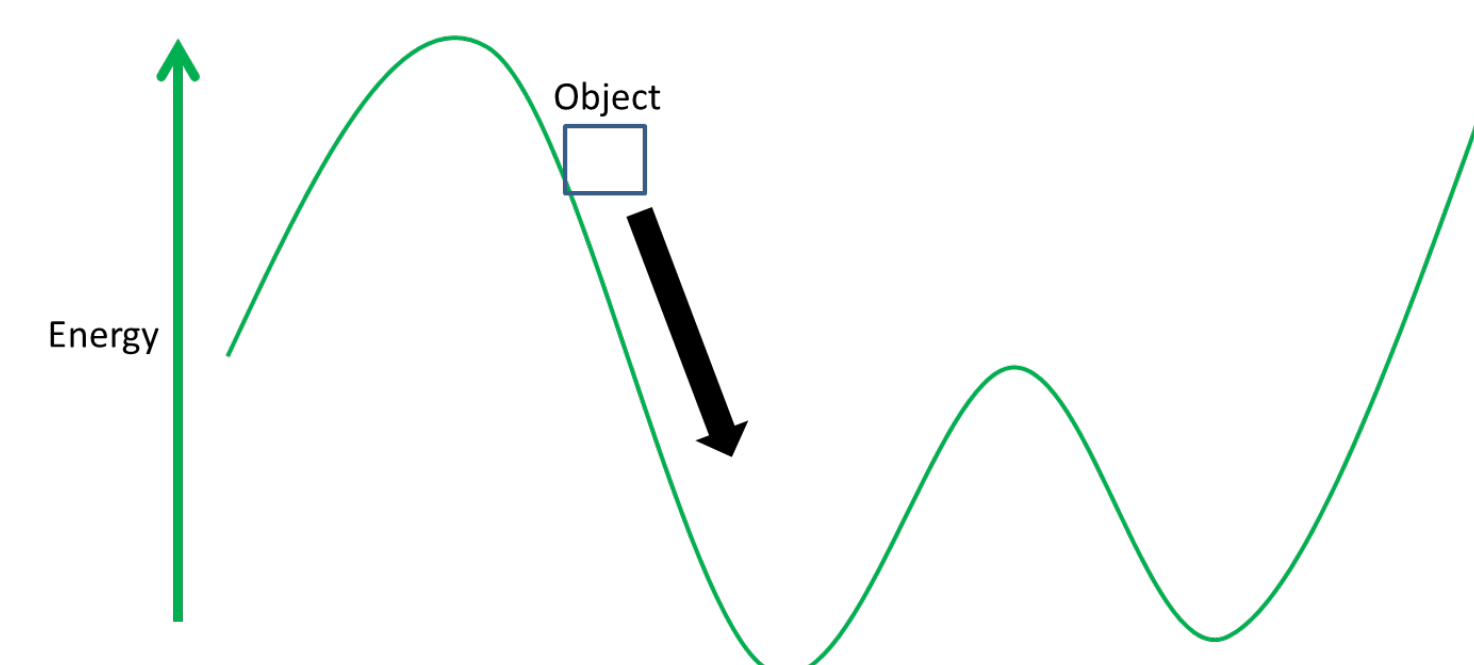
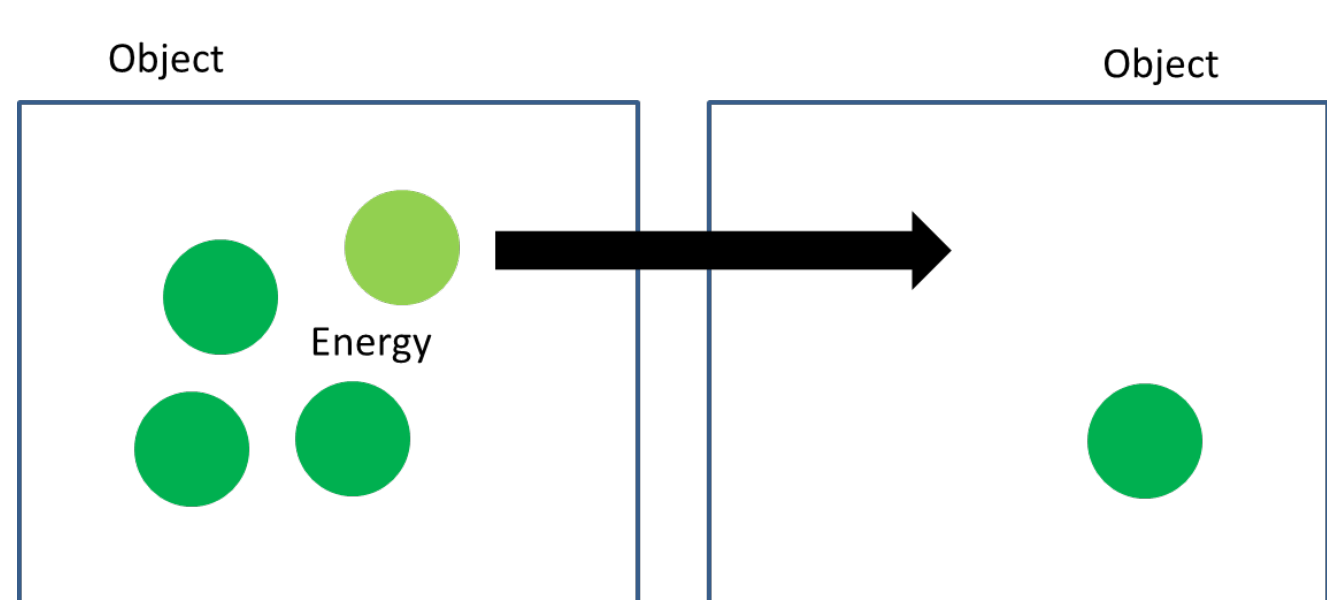
### Energy-as-location mental space



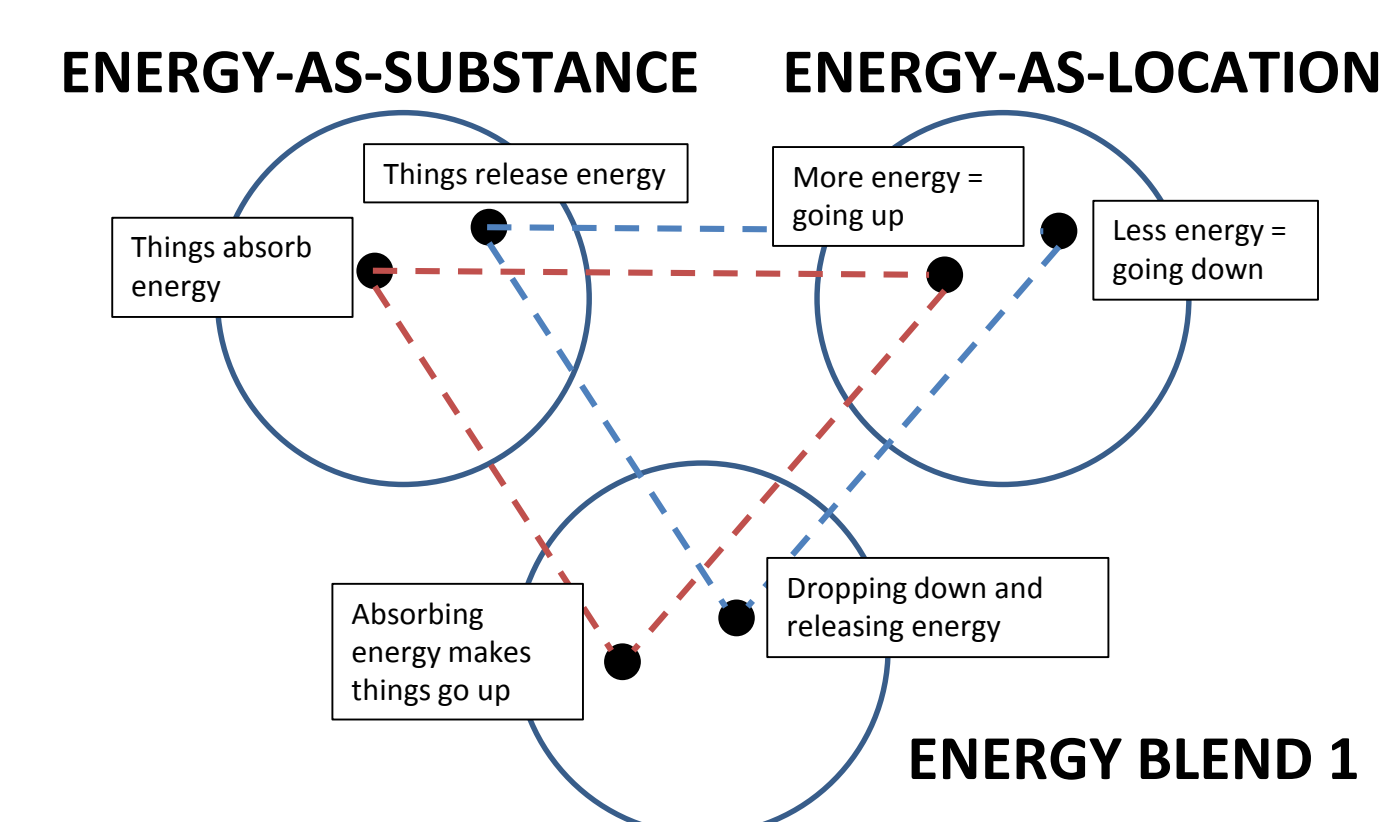
+

=

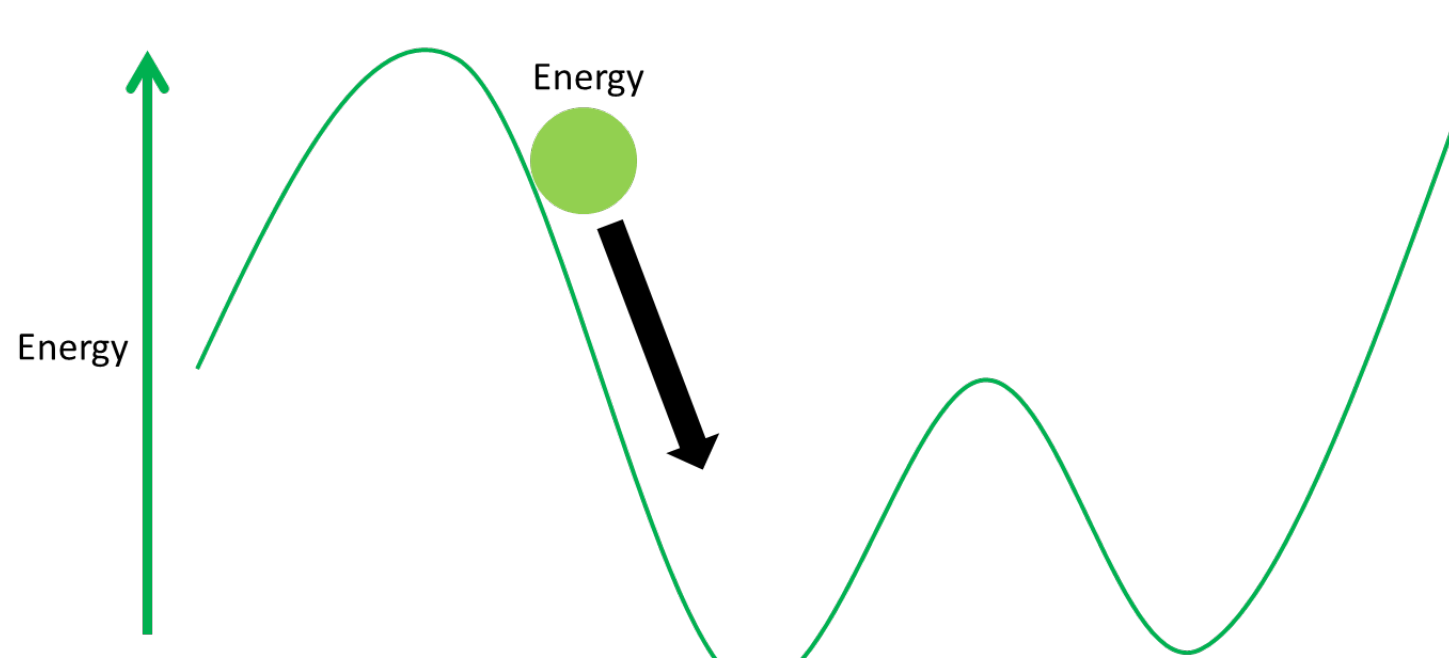
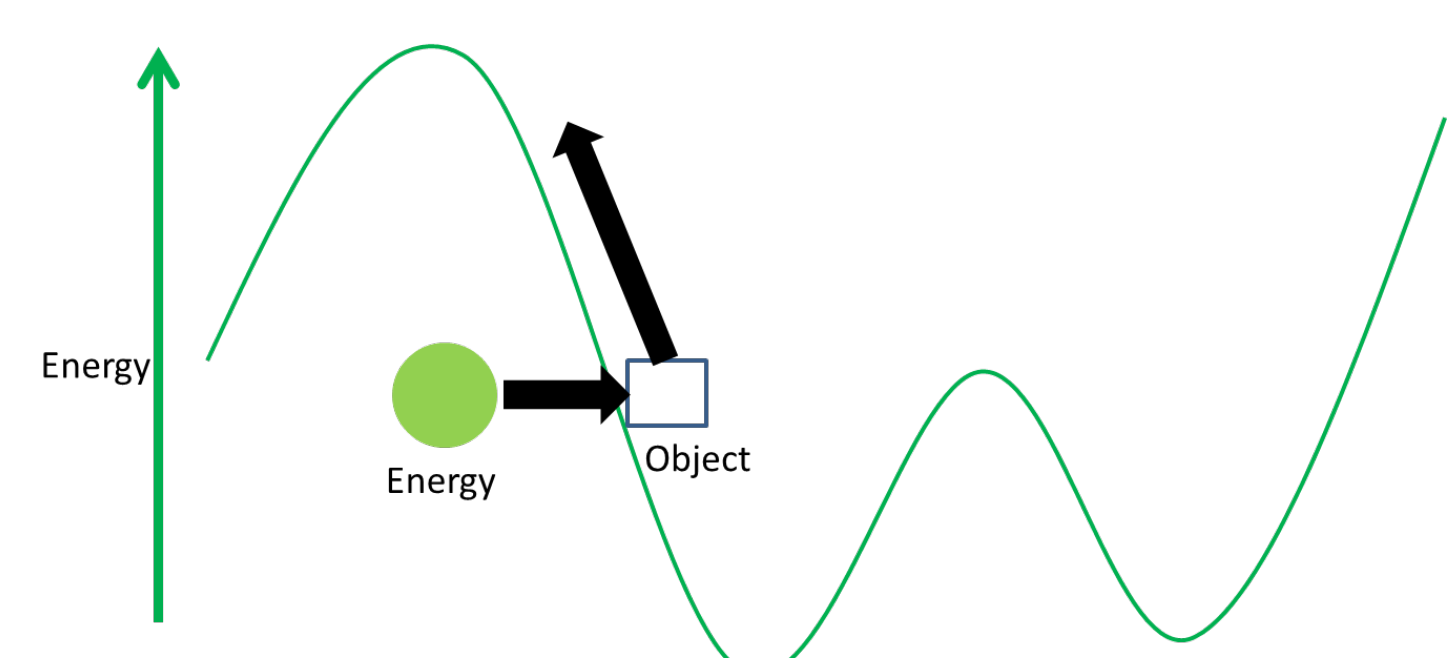
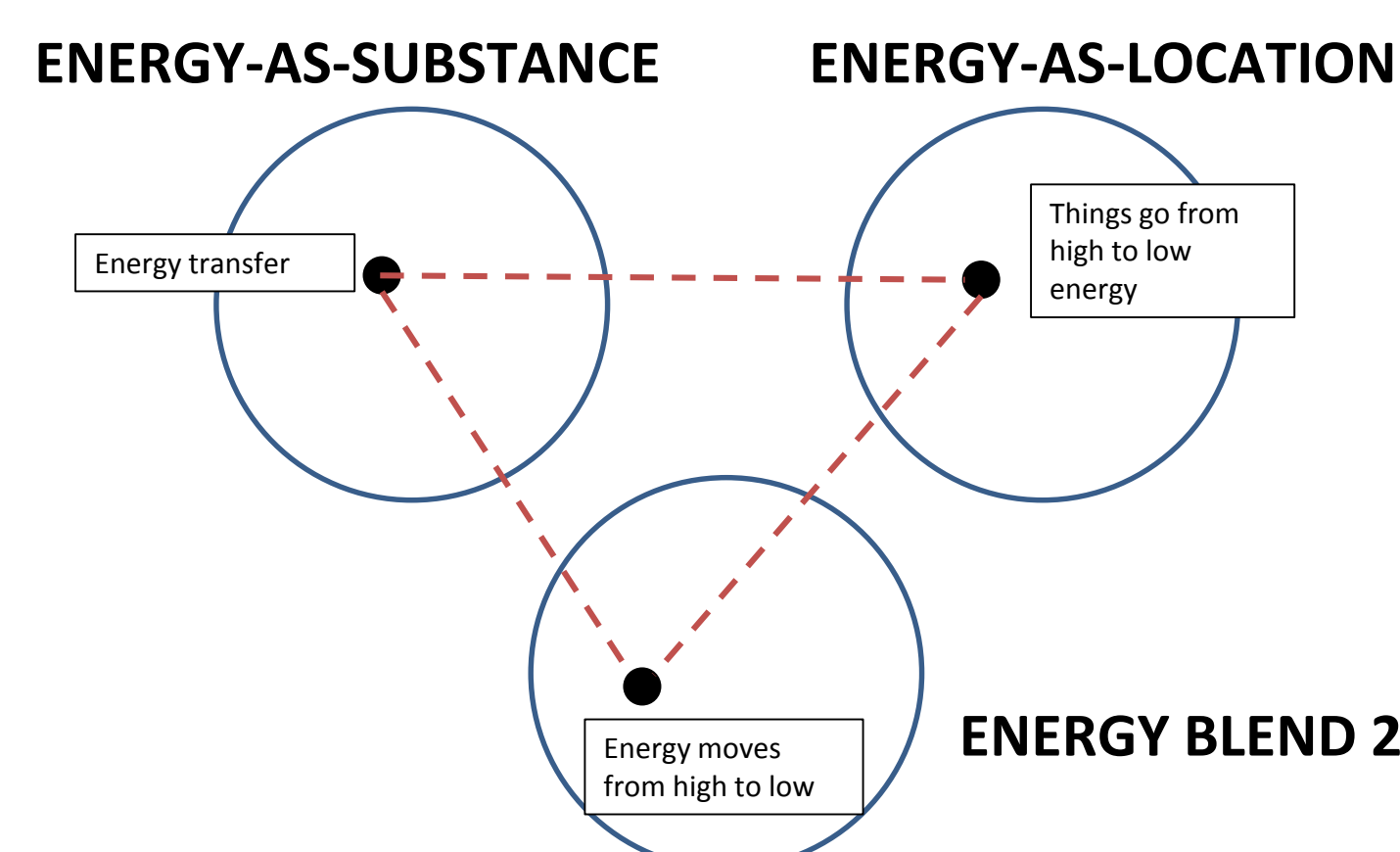
or



### Substance-location blend 1



### Substance-location blend 2



## Methodology

- **Predicate analysis:** Words or phrases in speech reflect individual ontologies [3], and the relationship between predicates reflects blending
- **Gesture analysis:** Gestures serve as representations of ontological metaphors.

## Evidence for ontological blending

- **Predicates** for two different ontologies that are **closely integrated**
- **Gestures** for two different ontologies that are **closely integrated**
- **Gesture-speech mismatch:** A gesture for one ontology simultaneous with a predicate for another ontology

## Data source

**Prof. Hilbert:** professor in a Physics for Biologists course, talking about chemical bond energy in class

The substance and location predicates are coordinated, suggesting Energy Blend 1.

**Betsy:** undergrad student in the Physics for Biologists course, talking about chemical bond energy in an interview

**Sam:** physics graduate student, talking about heat transfer in an interview

The substance and location predicates are inextricably connected in the same phrase, suggesting Energy Blend 2.

Conceptual blending helps us understand how students and experts coordinate multiple metaphors when reasoning about energy.

Contact: dreyfus@umd.edu

### References

- [1] B.W. Dreyfus, B.D. Geller, J. Gouvea, V. Sawtelle, C. Turpen, & E.F. Redish, "Ontological metaphors for energy in an interdisciplinary context," *Phys. Rev. ST-PER*, **10**, 020108 (2014).
- [2] G. Fauconnier & M. Turner, *The Way We Think: Conceptual Blending and the Mind's Hidden Complexities* (2002).
- [3] J.D. Slotta, M.T.H. Chi, & E. Joram, "Assessing students' misclassifications of physics concepts: An ontological basis for conceptual change," *Cogn. Instr.* **13**, 373 (1995).

### Acknowledgments

This work was supported by the NSF Graduate Research Fellowship (DGE 07-50616), NSF grants DUE 11-22818 and DRL 05-29482, and the HHMI NEXUS grant. Thanks to the interview participants, the rest of the NEXUS/Physics research team (Ben Geller, Julia Gouvea, Vashti Sawtelle, and Chandra Turpen), Renee-Michelle Goertzen, and the UMD Physics Education Research Group.

## Data

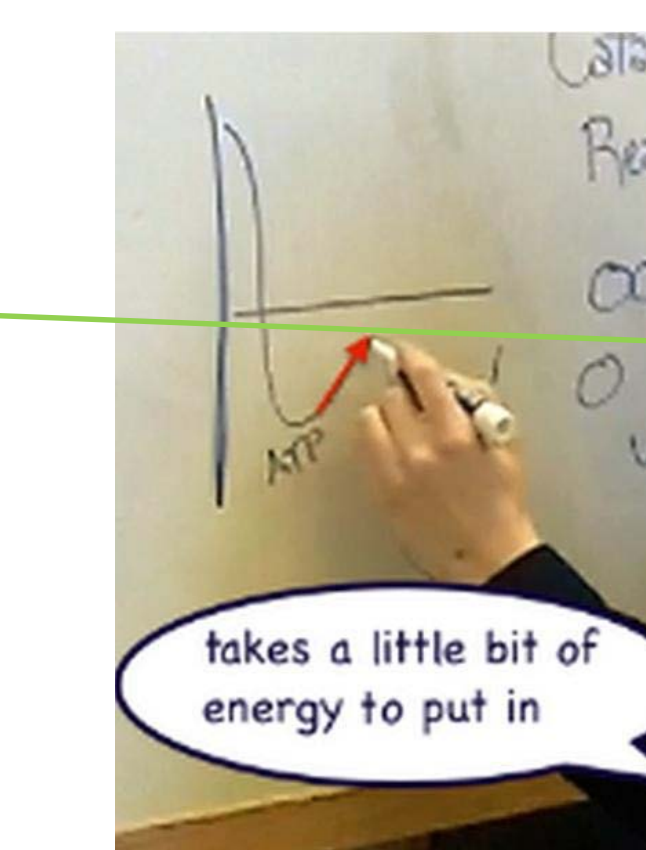
In each of the data sources, we see both *substance* and *location* predicates for energy.

But are the speakers **going back and forth** between two different ontologies, or using a **blended ontology**?

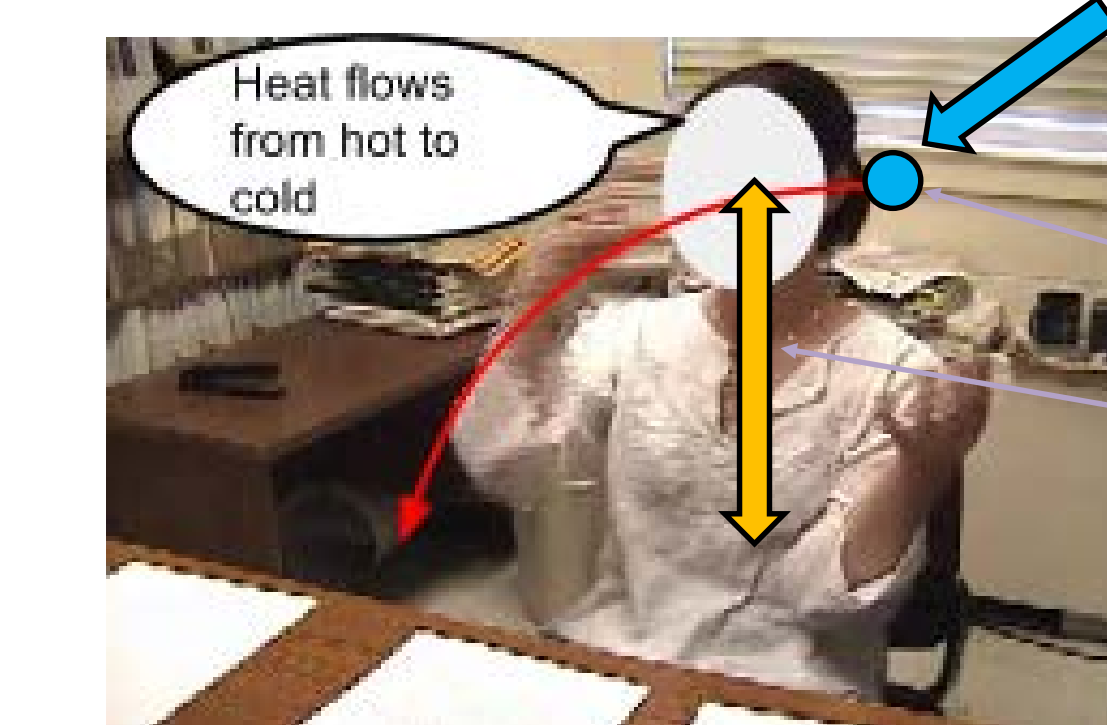
## Gestures



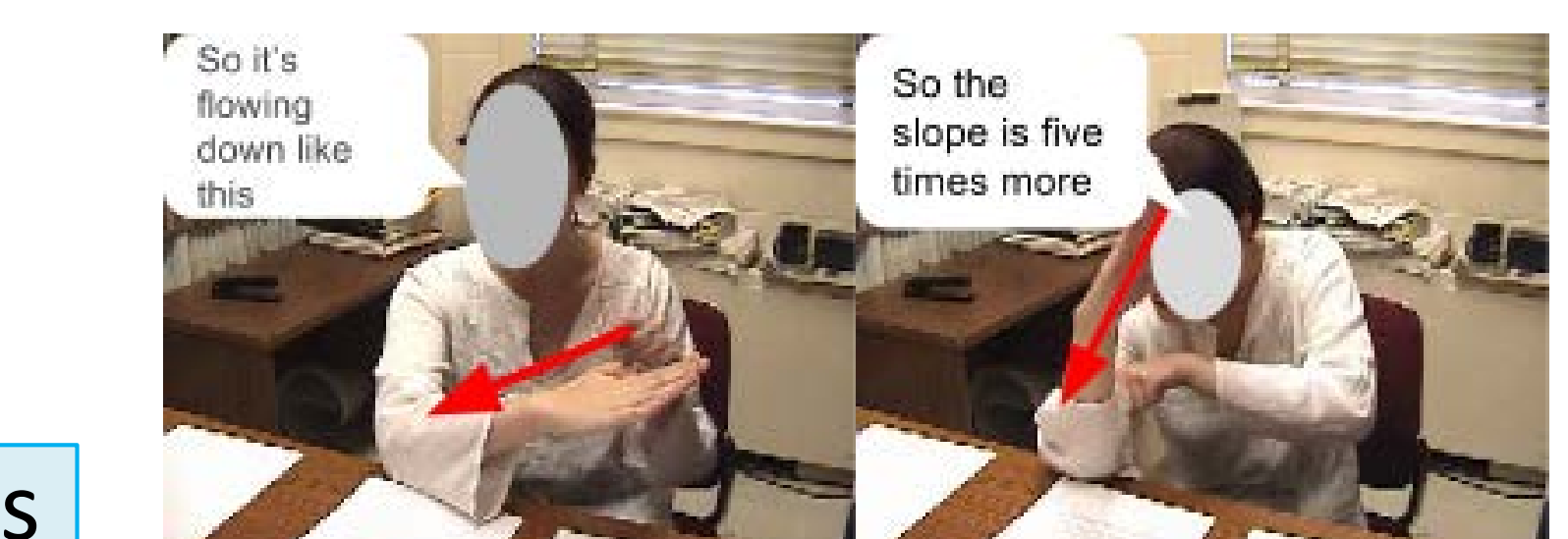
Prof. Hilbert gestures moving upward (**location**) while saying "you gotta put in this much" (*substance*), suggesting a blended ontology.



Betsy gestures moving upward (**location**) while saying "a little bit of energy to put in" (*substance*), suggesting a blended ontology.



Sam's gestures represent heat flowing (a *substance* metaphor), while the vertical dimension in this motion is energy as a **location**, so the two ontologies are integrated into a single gesture.



So **heat flows from hot to cold**, which is like thinking of hot as **higher up on a ramp** and cold as **lower down**. But if they both have the same ... starting point, then they both end at the **same place** but the one that's at 1-minute heating is **here**, so it's **flowing down** like this, and the **speed down this ramp would be your heat transfer**. And one's **all the way up here**, 5 times **higher**, so the slope is 5 times more, which I think means that it would cool 5 times faster 'cause **the heat would be transferred into the air and radiate away faster**.