

**Ontology:** categorization of the kinds of entities in the world, grouped by fundamental properties or characteristics

### Prior Work [1]

- Focus group study to investigate dynamics of students' ontologies
- Resulted in framework to describe different types of dynamic ontologies
- Argue it can be productive for students to reason in a messy / tentative manner

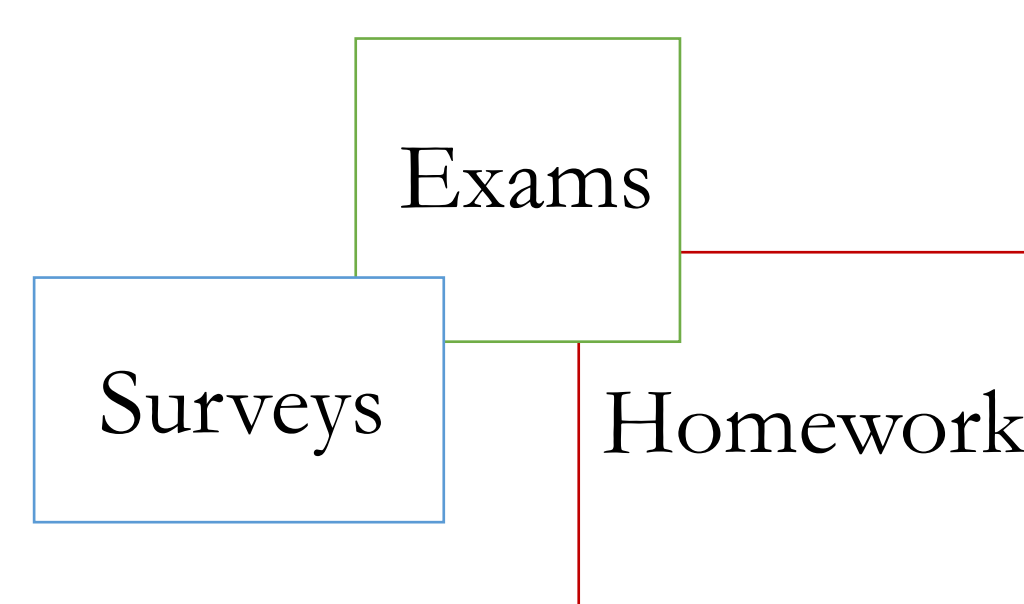
### Research Questions

- 1) *How can we modify the initial framework to apply it to student reasoning in individual written work?*
- 2) *Do we see the same dynamic ontologies in individual written work as in collective oral reasoning?*
- 3) *If so, what are the patterns of use of ontologies in these additional contexts?*

### Methods

7 Modern Physics students

3 data sources



3 topic areas

- Double slit experiment
- Mach-Zehnder interferometer
- Tunneling

### Coding scheme based on framework

Entity	Ontology	Structure
Photon	Particle	Unitary
Electron	Wave	Parallel
Light	Both particle/wave	Blended
	Something else	
	Not particle	
	Not wave	

### Framework for describing dynamic ontologies

		Application	
		Single (Not dynamic)	Multiple (Dynamic)
Construction	Stable (Not dynamic)	Unitary	Parallel
	Novel (Dynamic)	Blended	[ Parallel Blends ]

Structure	Definition	Example
Unitary	Single (often canonical) ontology applied throughout reasoning episode. Only referring to an entity as one type of thing (e.g., photon as a classical wave).	“The photon is acting like a classical wave in the sense that when it hits the beam splitters it will split. When it hits the second beam splitter is constructively and destructively interferes with itself and only will go into detector A.” – Bryan, <i>survey question on Mach-Zehnder interferometer with a single photon</i>
Parallel	Moving back and forth between two or more stable/robust ontologies; Usually parallel ontologies are temporally separated (key word: “then”).	“[Photons] behave like waves until they are detected like particles.” – Zach, <i>survey question on double slit experiment with single photons</i>
Blended	Drawing on prior notions to create new ontology; Combines elements from inputs, but new meaning emerges; Often indicated by hybrid particle/wave characteristics.	“The easiest way for me to think about photons is that they are particles of energy whose location is determined by probability that relates to interference patterns of waves.” – Bryan, <i>homework question on double slit experiment with single photon</i>

### Flexible use of ontologies in individual written work

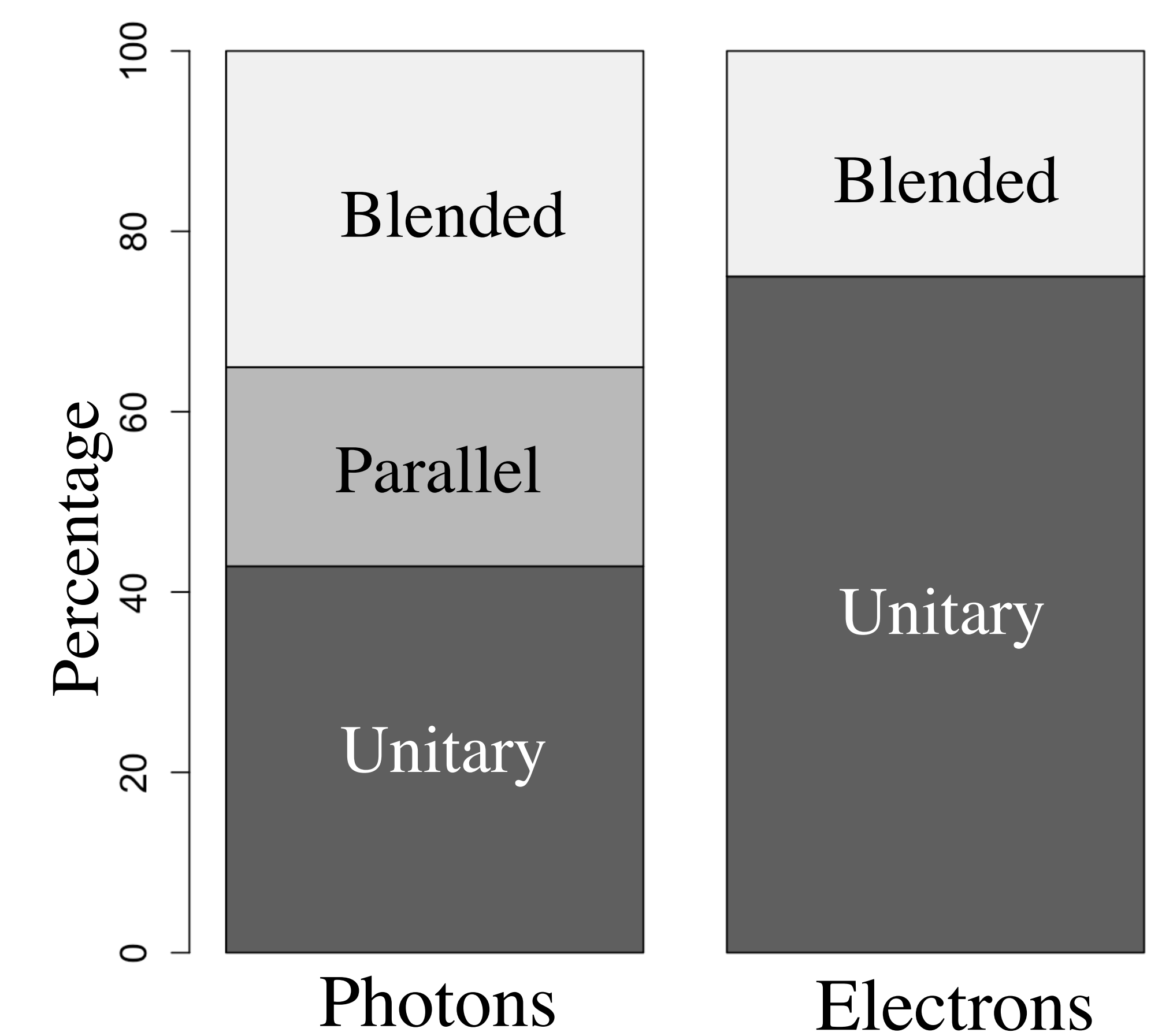
Variety of ontologies for each entity

	Photon	Electron
Wave	26%	60%
Particle	9%	15%
Both particle/wave	43%	5%
Something else	13%	20%
Not wave	9%	0%
Not particle	0%	0%

Variety of ontological structures

	Unitary	Parallel	Blended
Written	36%	22%	42%
MC	100%	0%	0%
<b>All</b>	<b>56%</b>	<b>16%</b>	<b>29%</b>

### Questions impact ontologies



Statistically significantly different at  $\alpha=0.05$  level  
**When excluding multiple-choice questions, the distributions are no longer significantly different**

### Future Work

- Investigate impact of wording and framing of prompts
- Extend coding / analysis to entire class (N=130)

[1] J. R. Hoehn and N. D. Finkelstein, Phys. Rev. Phys. Educ. Res. **14**, 010122 (2018).

