Planning to Save Energy: How Information Format Affects Accuracy

Thomas E. Gorman[1,2,*], Torsten Reimer[1,2], Juan Pablo Loaiza Ramirez[1,2], Hayden Barber[3]

[1]Communication and Cognition Lab, Purdue University, West Lafayette, IN, USA

[2]College of Liberal Arts Research Academy, Purdue University, West Lafayette, IN, USA

[3]School of Communication & Journalism, South Dakota State University, Brookings, SD, USA

PURDUE UNIVERSITY

RESEARCH ACADEMY | College of Liberal Arts

Introduction

- **Problem:** Energy insecurity is a critical public health concern (Bednar & Reames, 2020; Memmott et al., 2021).
- **Prior Work:** While interventions exist, success often hinges on communication format (Canfield et al., 2017; Fischer, 2008), such as the use of tables vs. figures, the framing of information (e.g., savings vs. costs), and energy literacy. Many reasoning tasks involving quantities are also influenced by reference class (e.g., absolute units like kWh may simplify calculations compared to relative units like % or derived units like USD) (Gigerenzer & Edwards, 2003; Reimer et al., 2015).

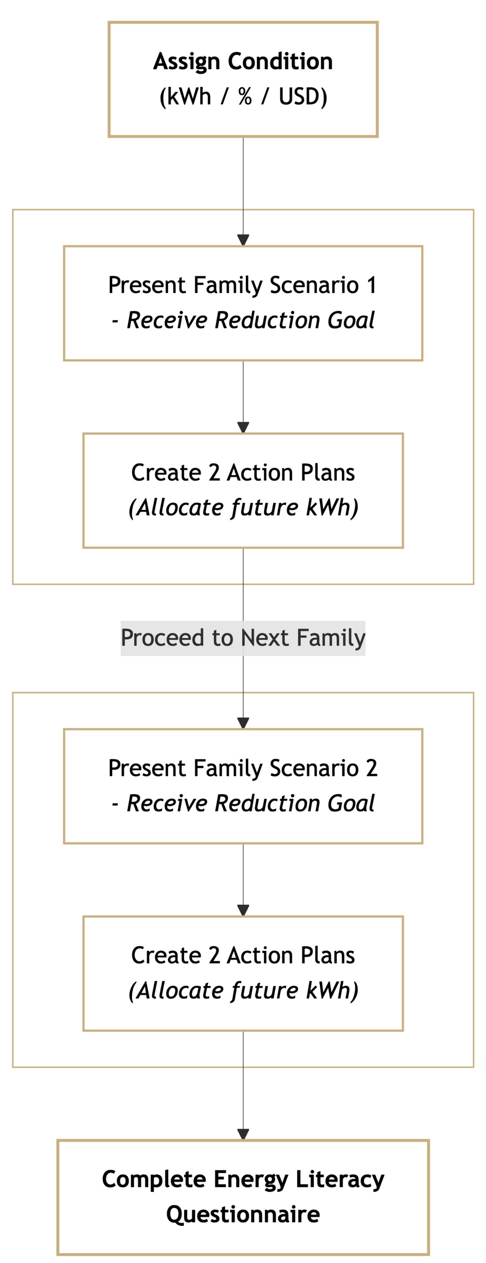
Research Questions & Hypotheses

- **Primary Question:** How does the Reference class (kWh, %, USD) used to present a reduction goal influence the accuracy of energy planning?
- **H1 (Reference Class):** Goals presented in **absolute units (kWh)** will benefit planning accuracy compared to percentage (%) or monetary (USD) formats.
- **H2 (Energy Literacy):** Individuals with **higher energy literacy** will demonstrate more accurate planning, regardless of format.

Methods

- **Design:** Two online experiments (N=229 & N=190 via MTurk) using a simulated household energy planning task.
- **Planning Task:** Propose appliance energy use (kWh) for hypothetical families to meet a target reduction goal.
- **Manipulation:** Reference Class of reduction goal (Between-Subjects): **kWh** vs. **%** vs. **USD**.
- **Exp 2 Factors:** Goal Difficulty (10% vs. 15% reduction) and Numerical Rounding (exact vs. rounded).

Figure 1: Procedure and Task Example



(a) Procedure overview

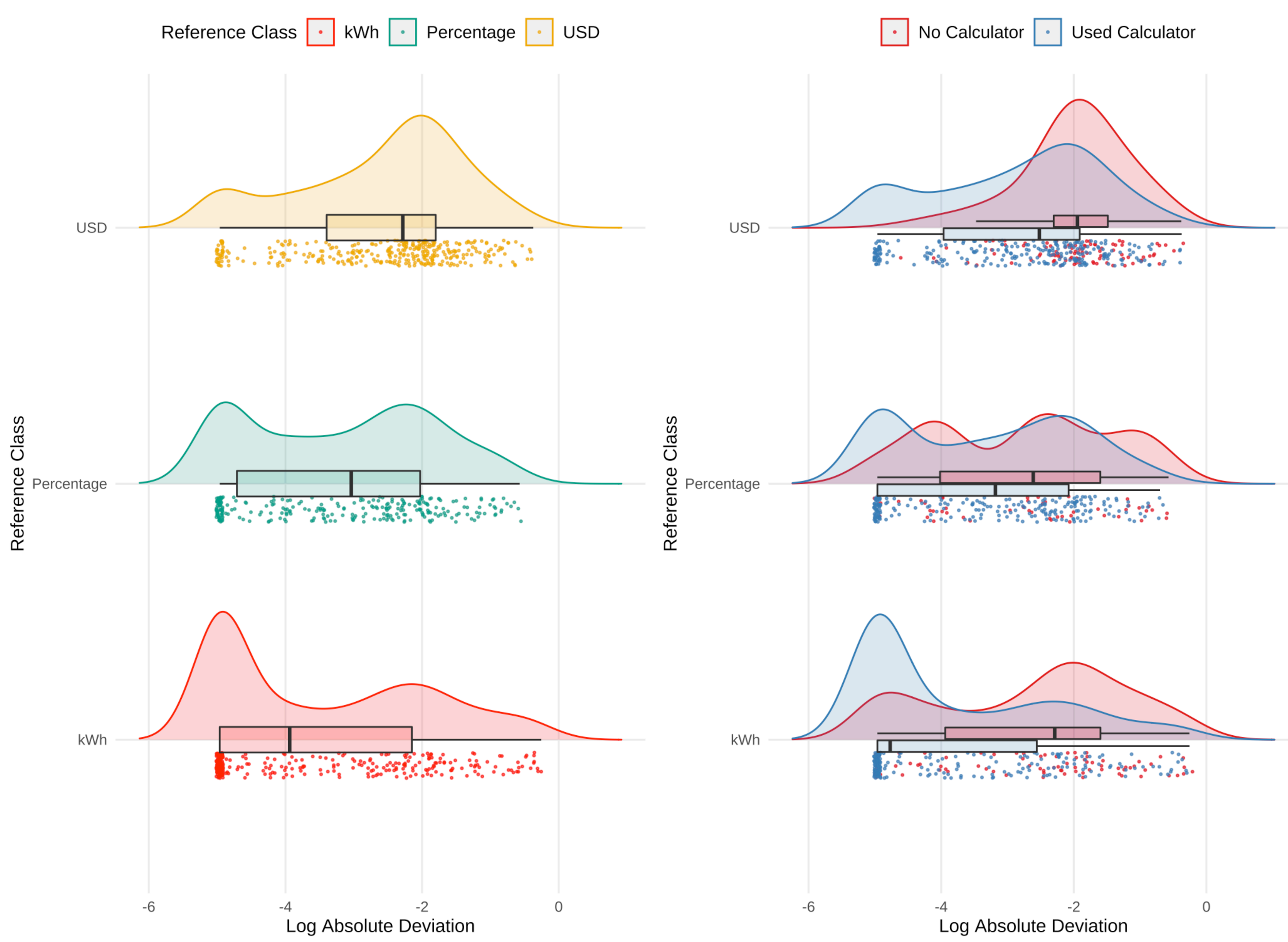
	Electricity Used Last Year by the Wells Family (kWh)	Average Electricity Used Last Year by Households in Colorado (kWh)	Action Plan 1
Cooling (Central A/C)	697	498	
Heating the Home	18,052	16,411	
Water Heating	11,667	5,832	
Refrigerator	1,370	1,142	
Other (Television, Lighting, Electronics, etc.)	7,982	6,652	
Total kWh	**39,768**	**30,535**	

(b) Example of planning task interface

Results

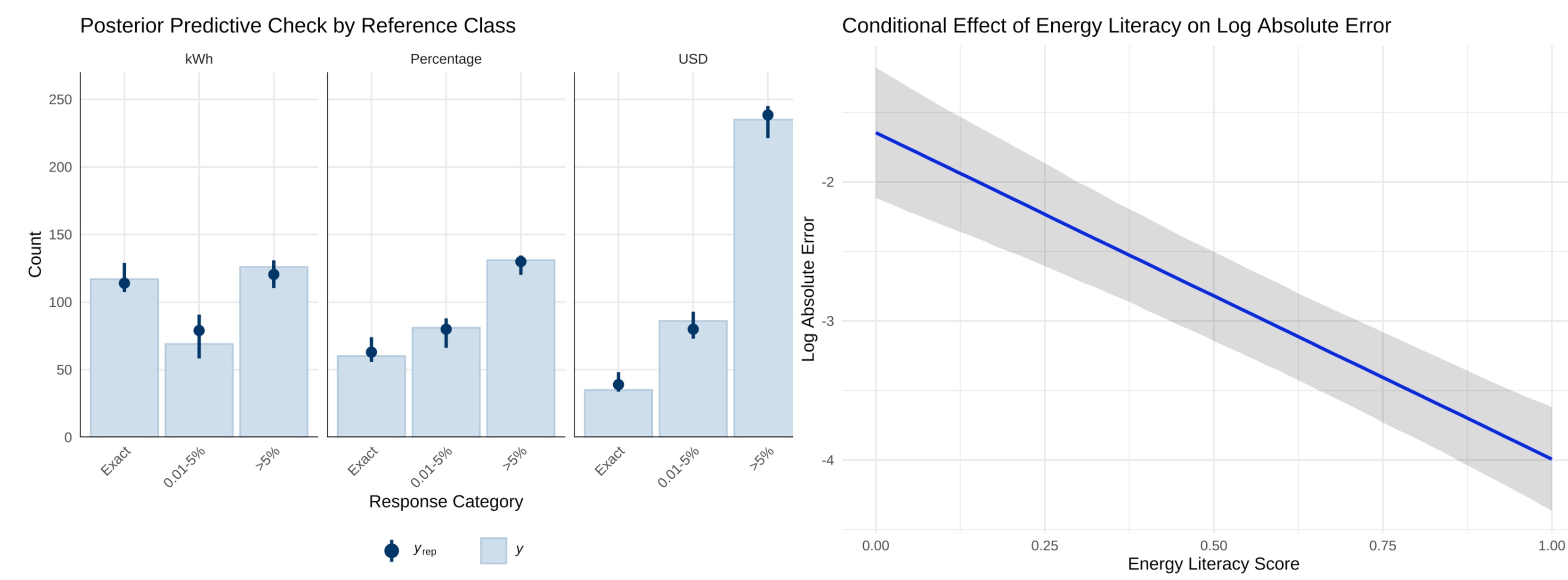
- **Key Measures:**
  - **Planning Accuracy:** Deviation between intended reduction goal and proposed plan (ordinal bins: exact, minor, large error).
  - **Energy Literacy:** 8-item knowledge scale score (DeWaters & Powers, 2011).
- **Analysis:** Bayesian mixed-effects regression:
  Accuracy Level ~ Reference Class $+$ Calculator $+ (1|$id$) + (1|$Family Scenario$)$
- **Effect of reference class (H1 Supported):** Smallest planning errors when reduction goal was presented in absolute units (kWh) compared to percentages (%) or dollars (USD) across both experiments.
- **Energy Literacy (H2 Supported):** Higher energy literacy scores associated with more accurate planning (lower error) in both experiments.

Figure 2: Reference Class Effect on Planning Error (Exp 1)



Distribution of log absolute error by goal format condition (Exp 1). Lower values indicate higher accuracy.

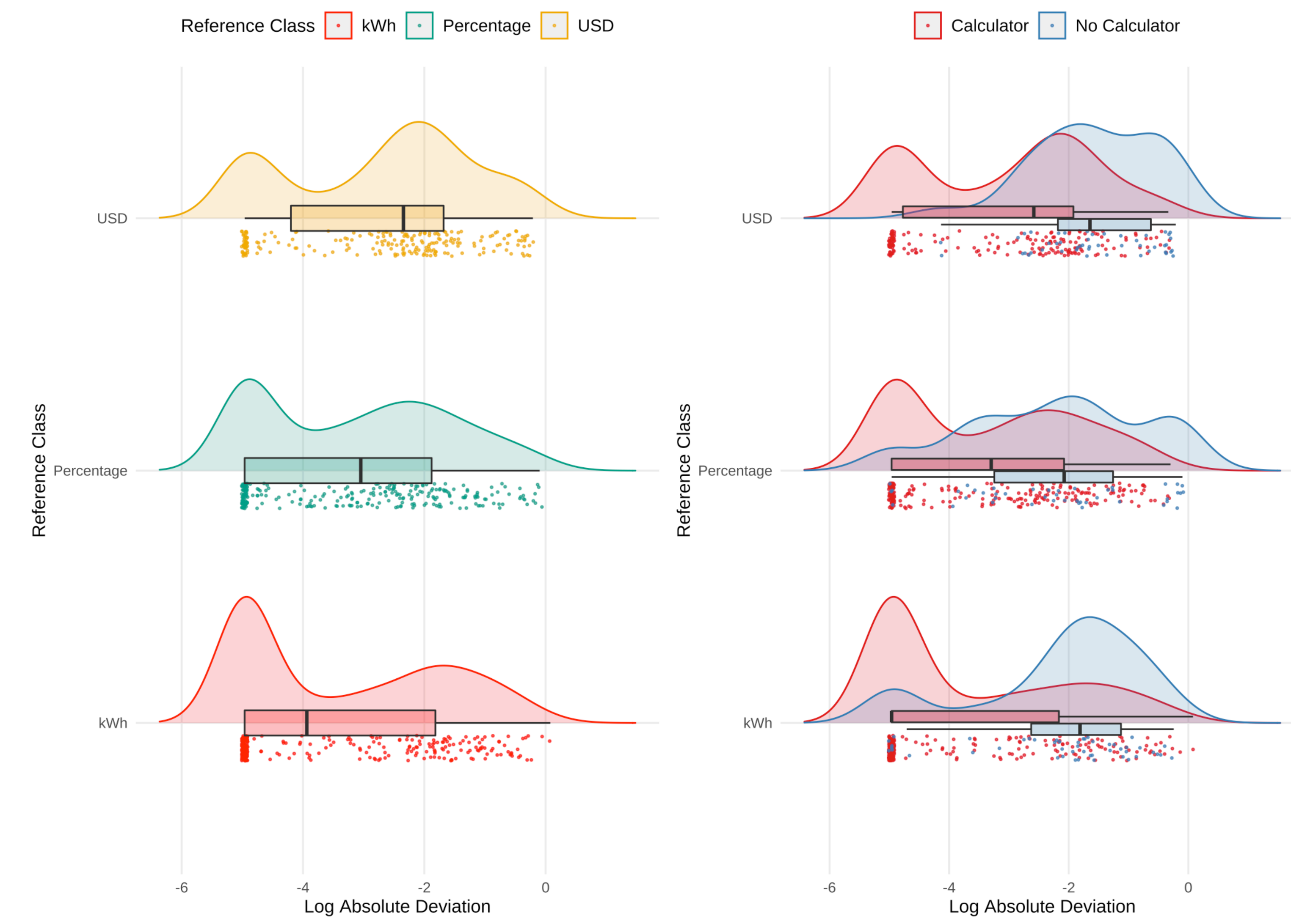
Figure 3 - Bayesian Regression Results (Exp 1)



(a) PPC for ordinal model. Blue bars are observed frequencies per accuracy level, dots show model predictions.

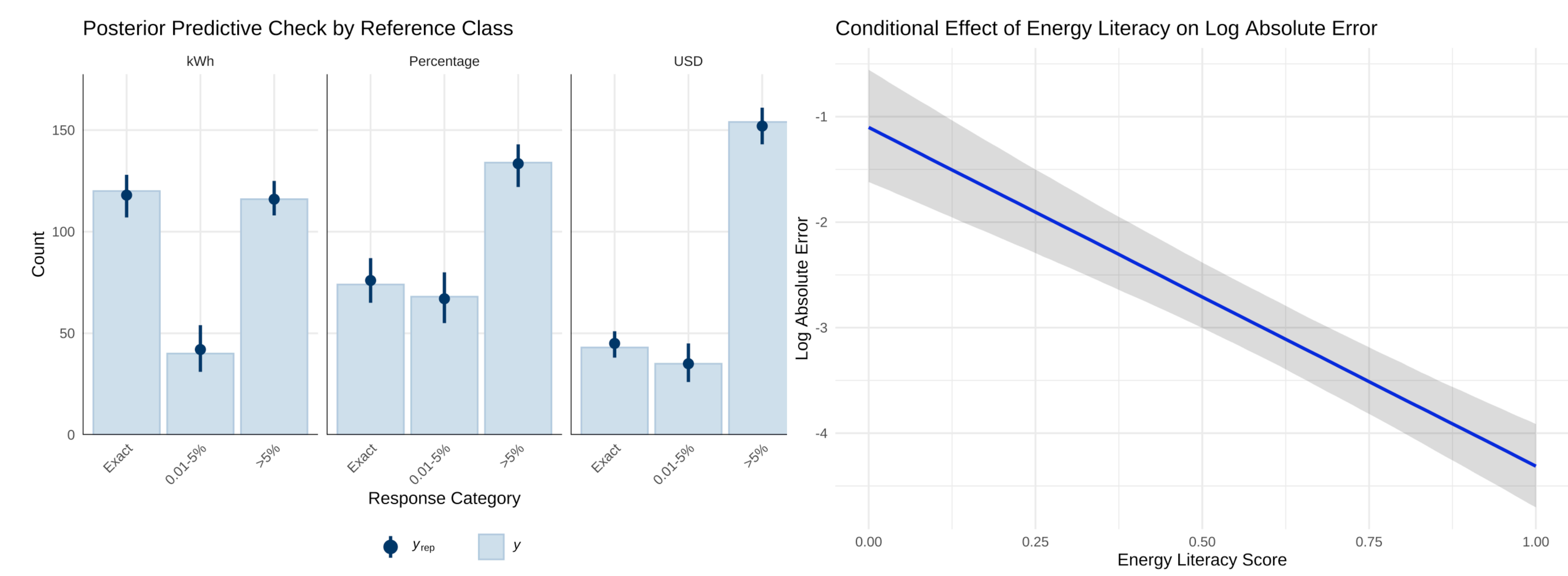
(b) Relationship between energy literacy score and log absolute error of reduction plans

Figure 4: Reference Class Effect on Planning Error (Exp 2)



Distribution of log absolute error by goal format condition (Exp 2). Lower values indicate higher accuracy.

Figure 5 - Bayesian Regression Results (Exp 2)



(a) PPC for ordinal model. Blue bars are observed frequencies per accuracy level, dots show model predictions.

(b) Relationship between energy literacy score and log absolute error of reduction plans.

Discussion

- **Key Finding:** Reference class significantly impacts planning accuracy. **Presenting goals in absolute kWh is superior** to relative (%) or monetary (USD) formats, likely by simplifying calculations and reducing cognitive load.
- **Energy Literacy Matters:** Higher domain knowledge consistently predicted better planning accuracy, emphasizing the role of energy education.
- **Limitations:** Lab simulation, short duration, self-reported calculator use.

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*Corresponding author: tegorman@purdue.edu