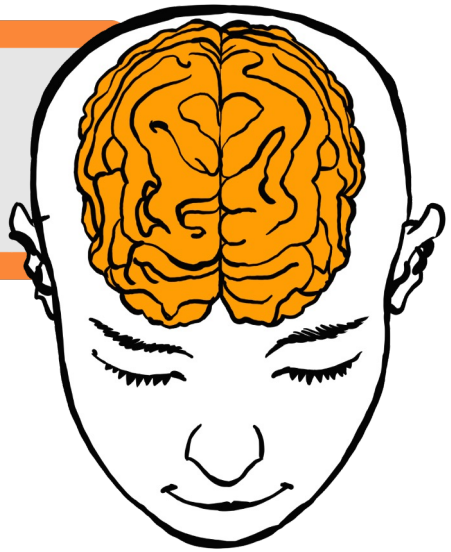
Computational Models



ReproducibilityTea

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Why Computational Models?

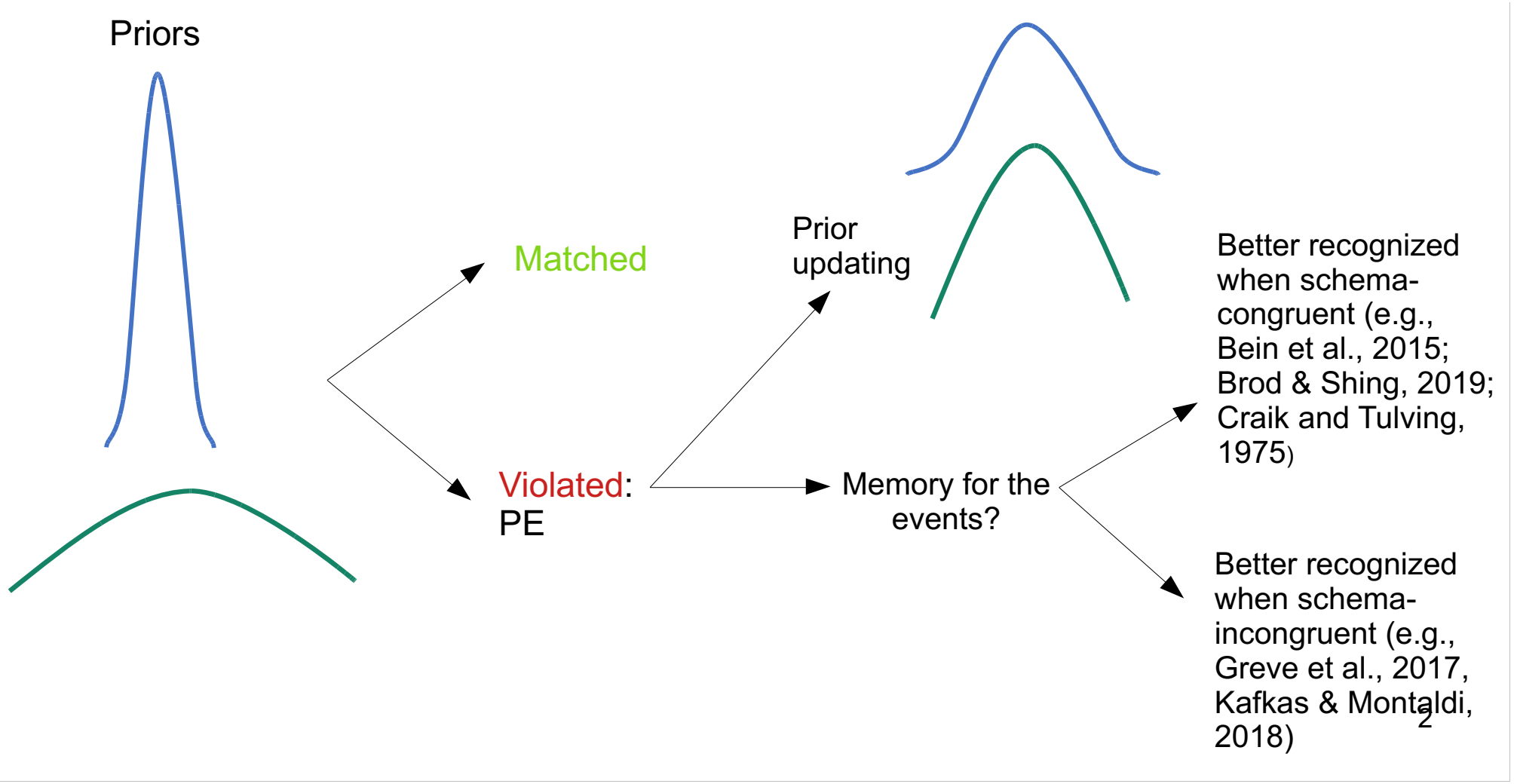
- Allow precise mathematical formulation and specification of assumptions and their implications

- Make us think deeply about the variables involved and their relationship

- Allow to compare different models based on different assumptions or theories

- Estimation of trial – level quantities that are not immediately observable (prediciton – prediction error)

e Research Question- PE and Memory

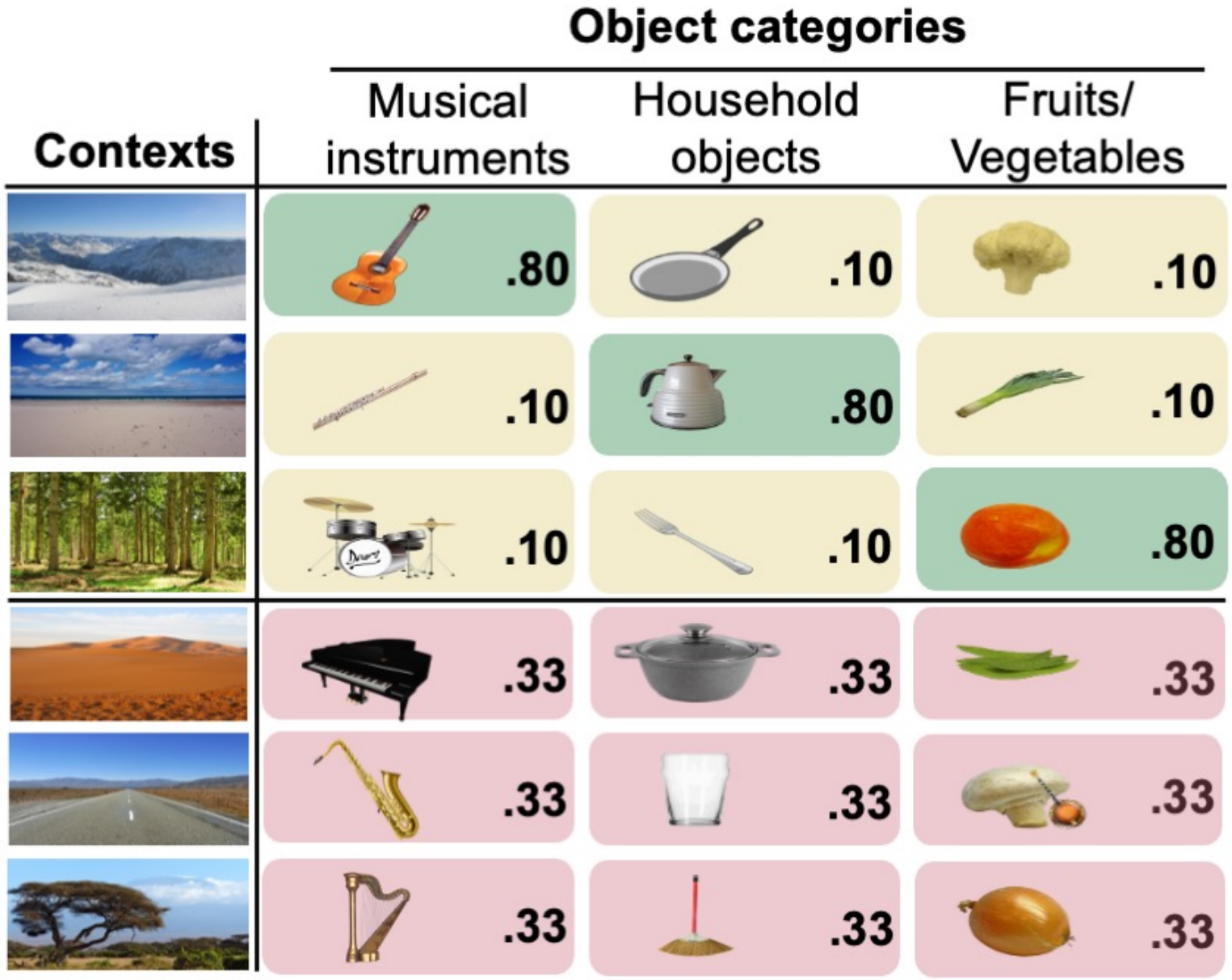


The Research Question

Strong priors

Weak priors

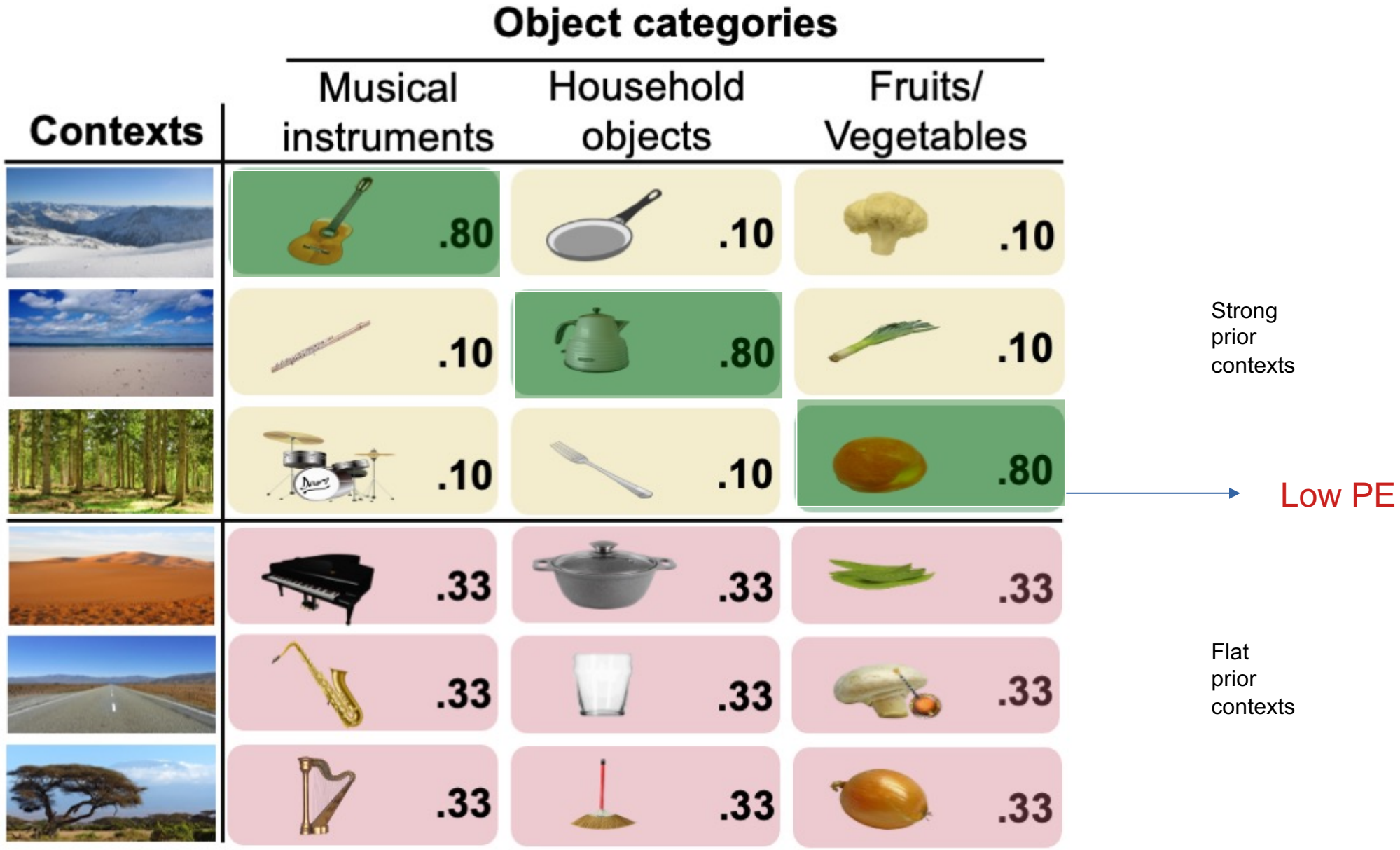
Three object **types** are presented embedded in each context following certain probability distributions.



Strong prior contexts

Flat prior contexts

Three object **types** are presented embedded in each context following certain probability distributions.



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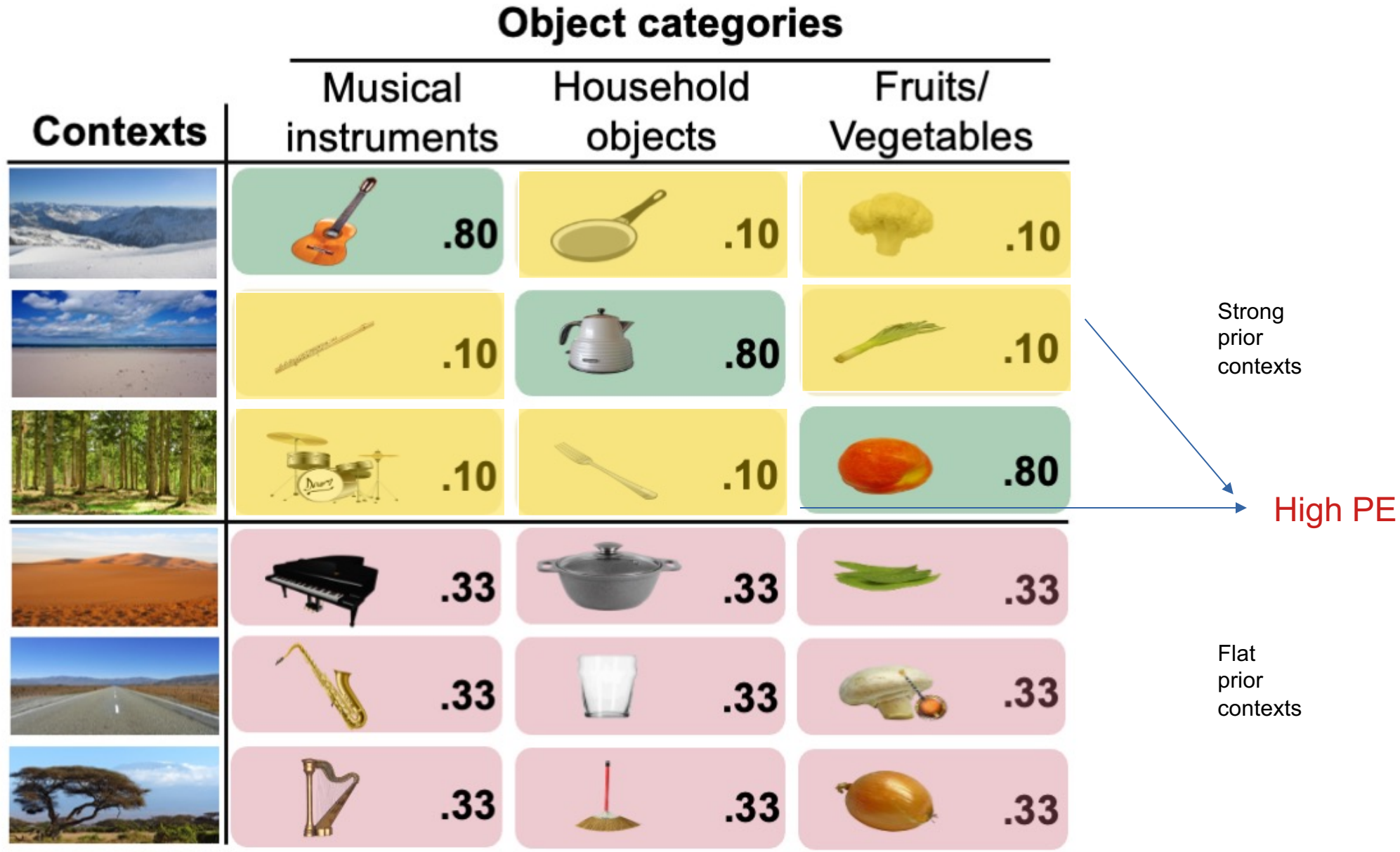

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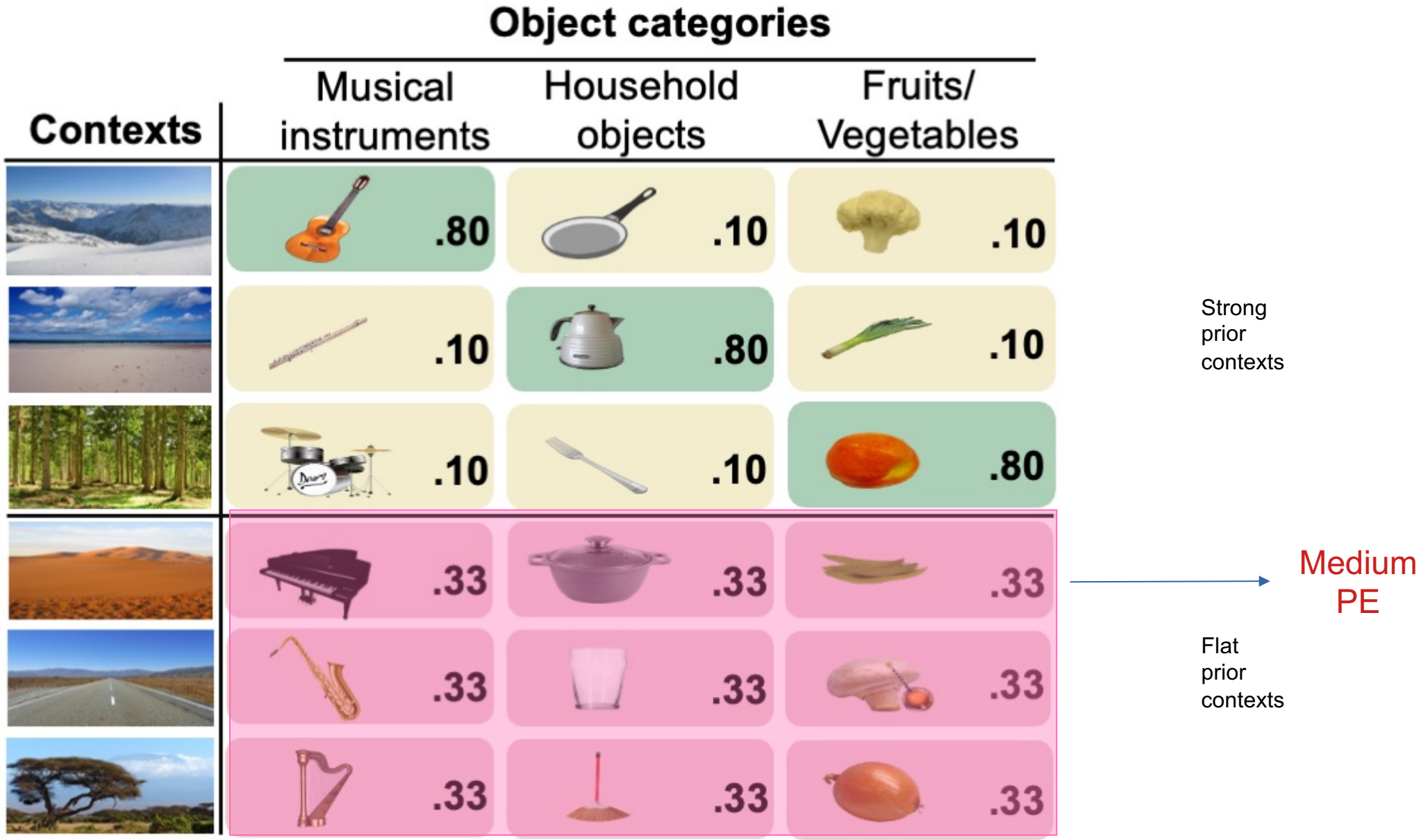
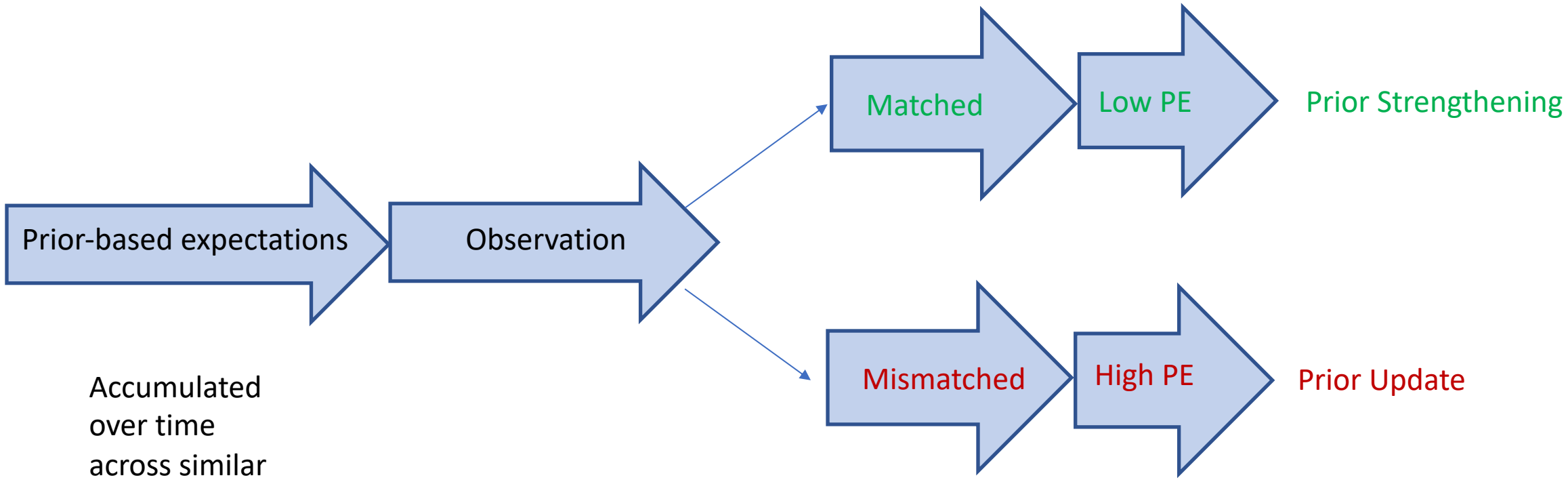
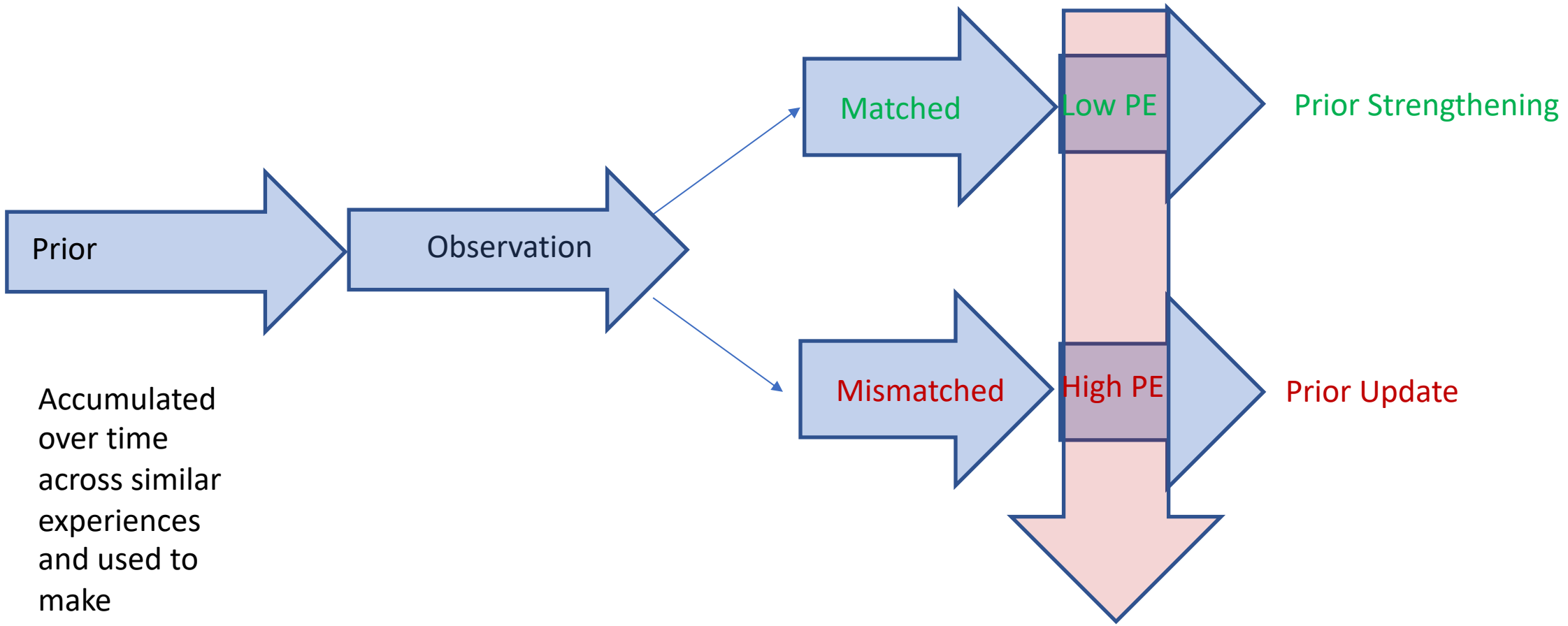


PE and Memory: what model?



Accumulated over time across similar experiences and used to make prediction

PE and Memory: what model?

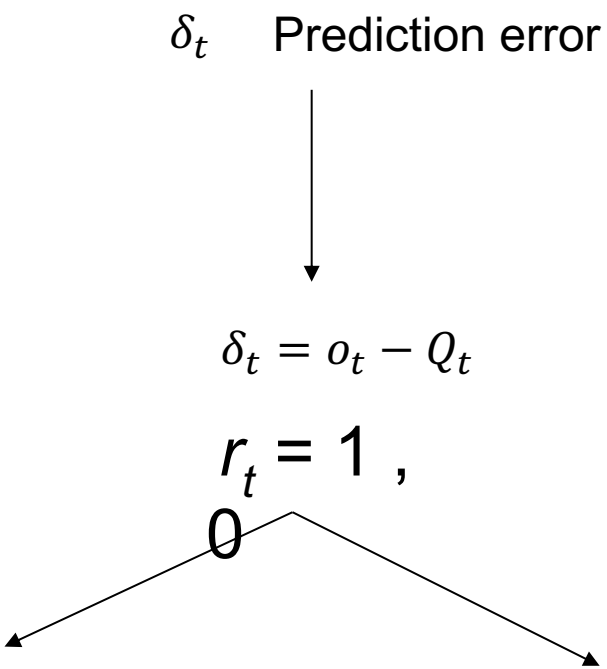


Accumulated over time across similar experiences and used to make prediction

Reinforcement Learning

$$Q_{t+1}^{(c,j)} = Q_t^{(c,j)} + \alpha \cdot \delta_t$$

$Q^{c,j}$	Value of object category *j* for context *c*
α	Learning rate - How much update depends on current PE. High: recent outcomes. Low: Past history.
δ_t	Prediction error



Observation -based - depending on the object category shown

Choice-based – depending on whether the choice was correct or not

$$r_t^j = \begin{cases} 1 \; if \; j = j_t \\ 0 \; otherwise \end{cases}$$

Observation-based PE:
It depends on the object category displayed, regardless of participants' choice. It is >=0, inversely proportional to the expected value.

	Instruments	Household Objects	Fruits or Vegetables
Q_t =	0.66	0.00	0.00
R_t =	0	0	1
$\delta_t = r_t - Q_t$	0-0.66 = -0.66	0-0.00 = 0.00	1-0.00 = 1.00
$Q_{t+1} + \alpha \cdot \delta$	0.66+(0.3·(-0.66))=0.46	0.0+(0.3· 0.00)=0.0	0.00+(0.3·1)=0.30

Choice-Based PE:
If participant predicted Instrument, but another object category, the PE for the category chosen is < = 0. The stronger the belief, the more negative it will be.

$$Q_{t+1}^{j,c} = \begin{cases} \alpha\delta_t \; if \; c_t = j_t \\ Q_t \; otherwise \end{cases}$$

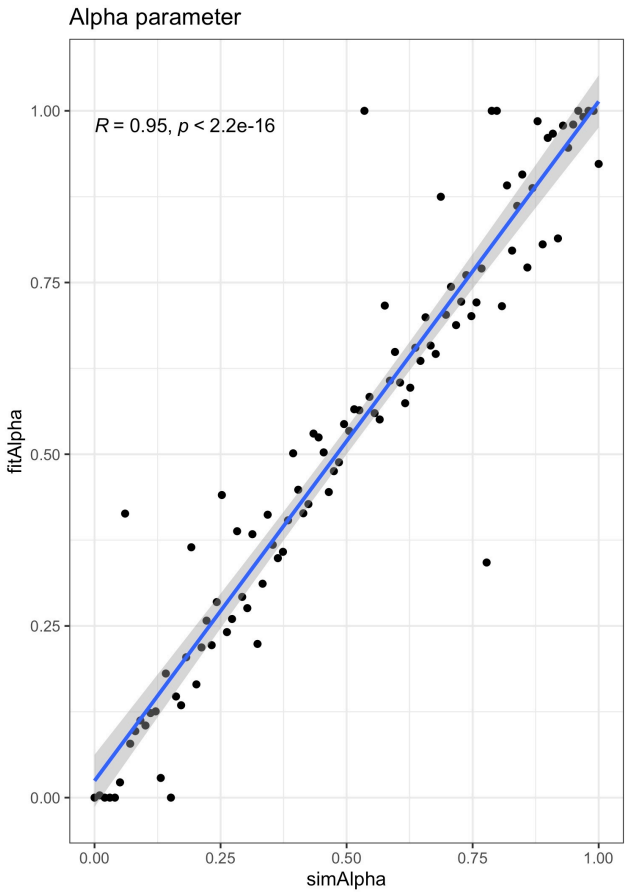
$$r_t^j = \begin{cases} 1 \; if \; c_t = j_t \\ 0 \; otherwise \end{cases}$$

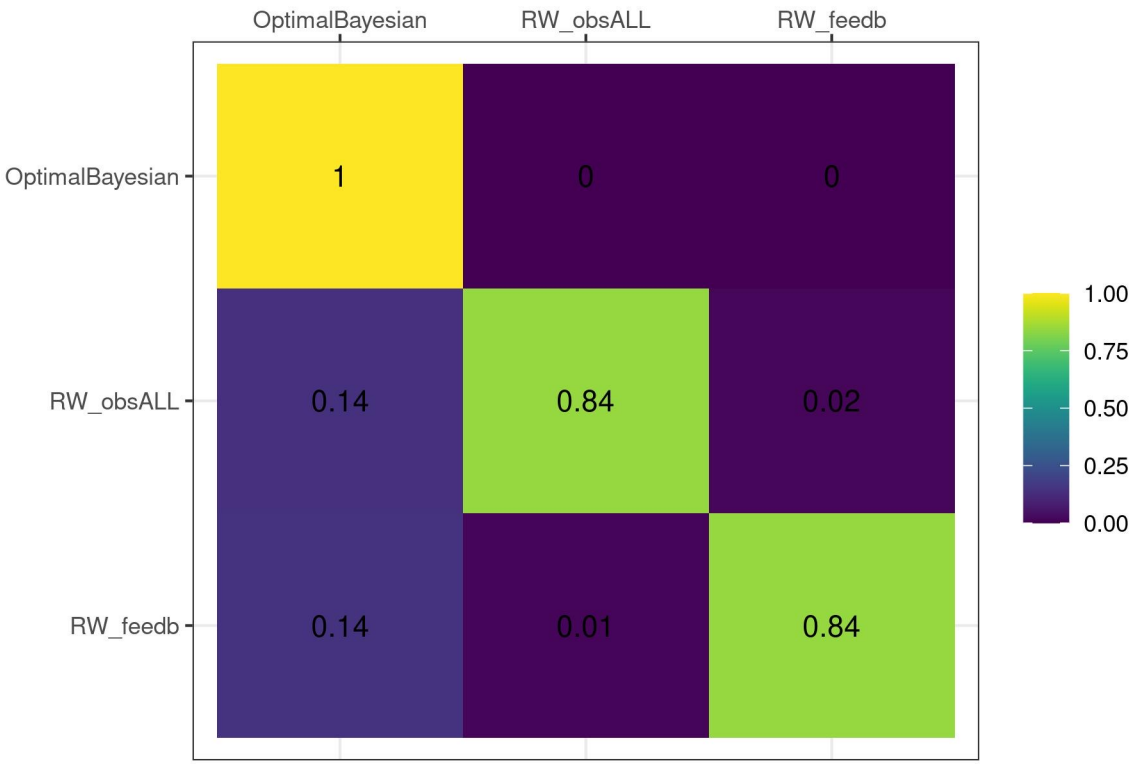
	Instruments	Household Objects	Fruits or Vegetables
R_t = 0		0	0
$\delta_t = r_t - Q_t$	0-0.66 = -0.66	0	0
$Q_{t+1} + \alpha \cdot \delta$	0.66+(0.3·(-0.66))=0.46	0	0

Choice-Based PE:
If participant successfully predicted a category, the PE for the category chosen is > = 0. The weaker the belief, the more positive it will be.

	Instruments	Household Objects	Fruits or Vegetables
Q_t =	0.66	0.00	0.00
R_t =	1	0	
	0		
$\delta_t = r_t - Q_t$	1-0.66 = 0.33	0	
	0		
$Q_{t+1} + \alpha \cdot \delta$	0.66+(0.3·(0.33))=0.53	0	
	0		

Parameter Recovery and Model Recovery





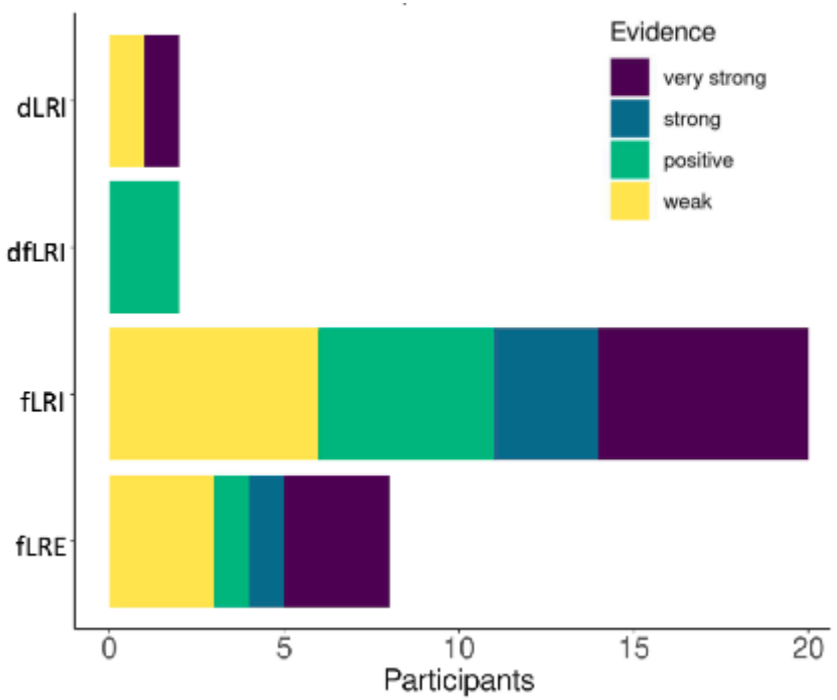
Parameter estimation and Model Comparison

Parameter estimation:
Alpha and beta values were estimated at the participant level through ML estimation

$$LL = \sum_{t=1}^{n} \log p(c_t | d_{1:t-1}, \theta, m)$$

Model Comparison:
Calculate BIC for each participant and each model, then counted the number of participants for which each model was the best.

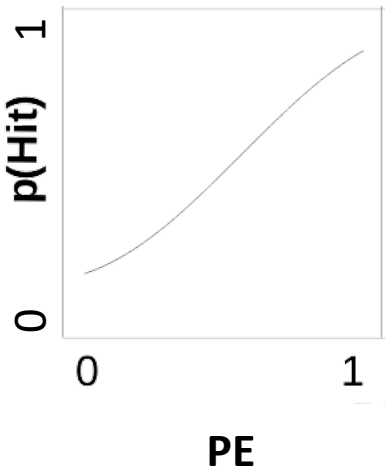
$$BIC = -2log\hat{L}L + k_m log(T),$$



Parameter estimation

α = 0.2 (participant 1), 0.4 (participant 2), ….

$$V_{t+1} = V_t + 0.2*PE$$



Conclusions

- Clearly state assumptions
- Formally compare models based on different assumption
- Compute latent variables -> Episodic memory

Thank you!