Prospective and Retrospective Cues for Sensorimotor Confidence

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New York University

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Why do we care? Sensorimotor confidence allows us to quickly assess if an action needs to be repeated or recalibrated prior to experiencing the consequences of its success or failure.

Temporally Distinct Cues

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Prospective Cues
available prior to the action

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available prior to the action

- Sensory information

Temporally Distinct Cues

Prospective Cues
available prior to the action

- Sensory information
- Prior experience with task

Temporally Distinct Cues

Prospective Cues
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- Sensory information
- Prior experience with task
- Knowledge of motor noise

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Retrospective Cues

depend on information available after the action and specific to a each action itself

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Retrospective Cues

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- Proprioception

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- Proprioception
- Knowledge of proprioceptive noise

Temporally Distinct Cues

Prospective Cues

available prior to the action

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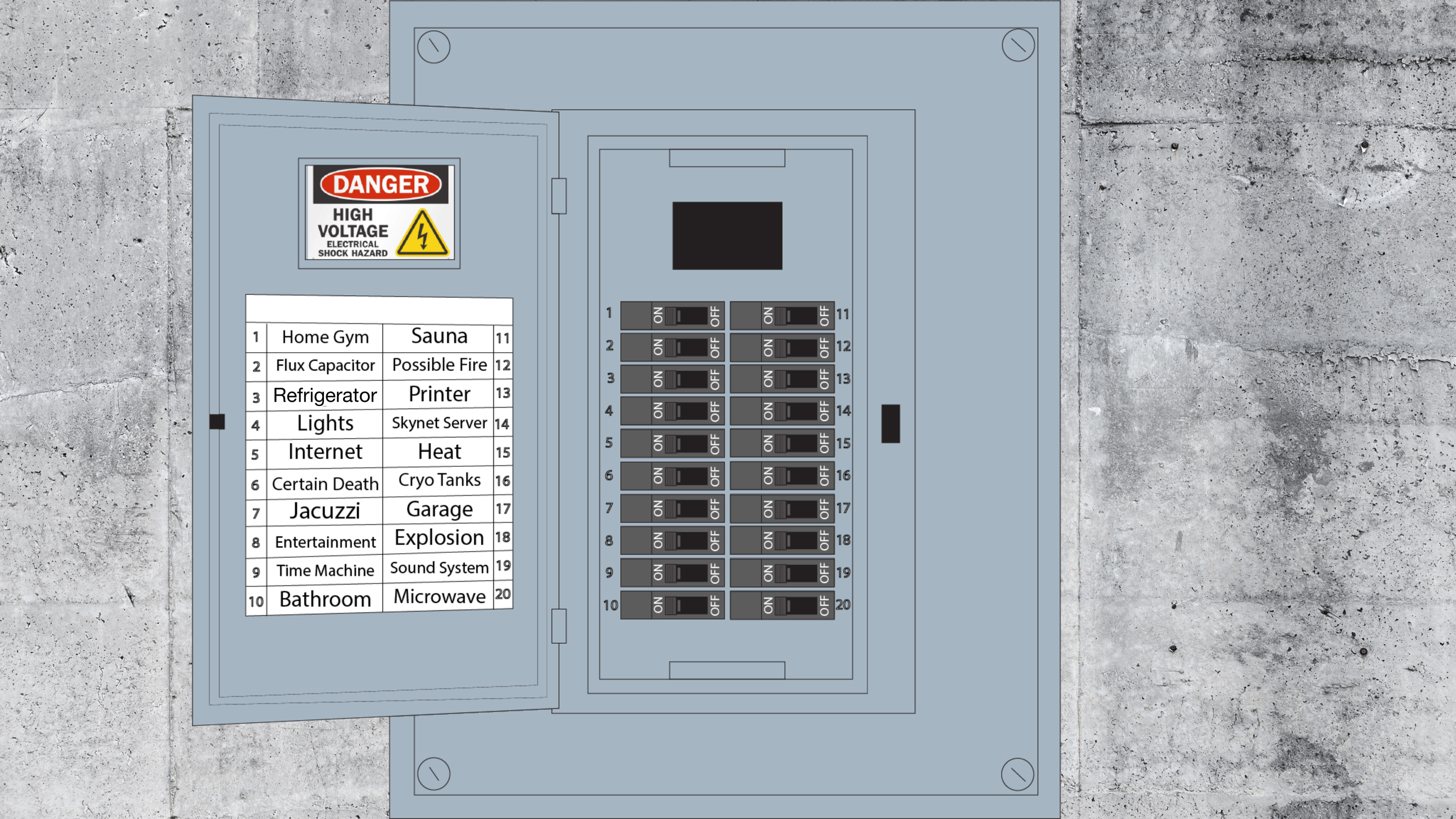
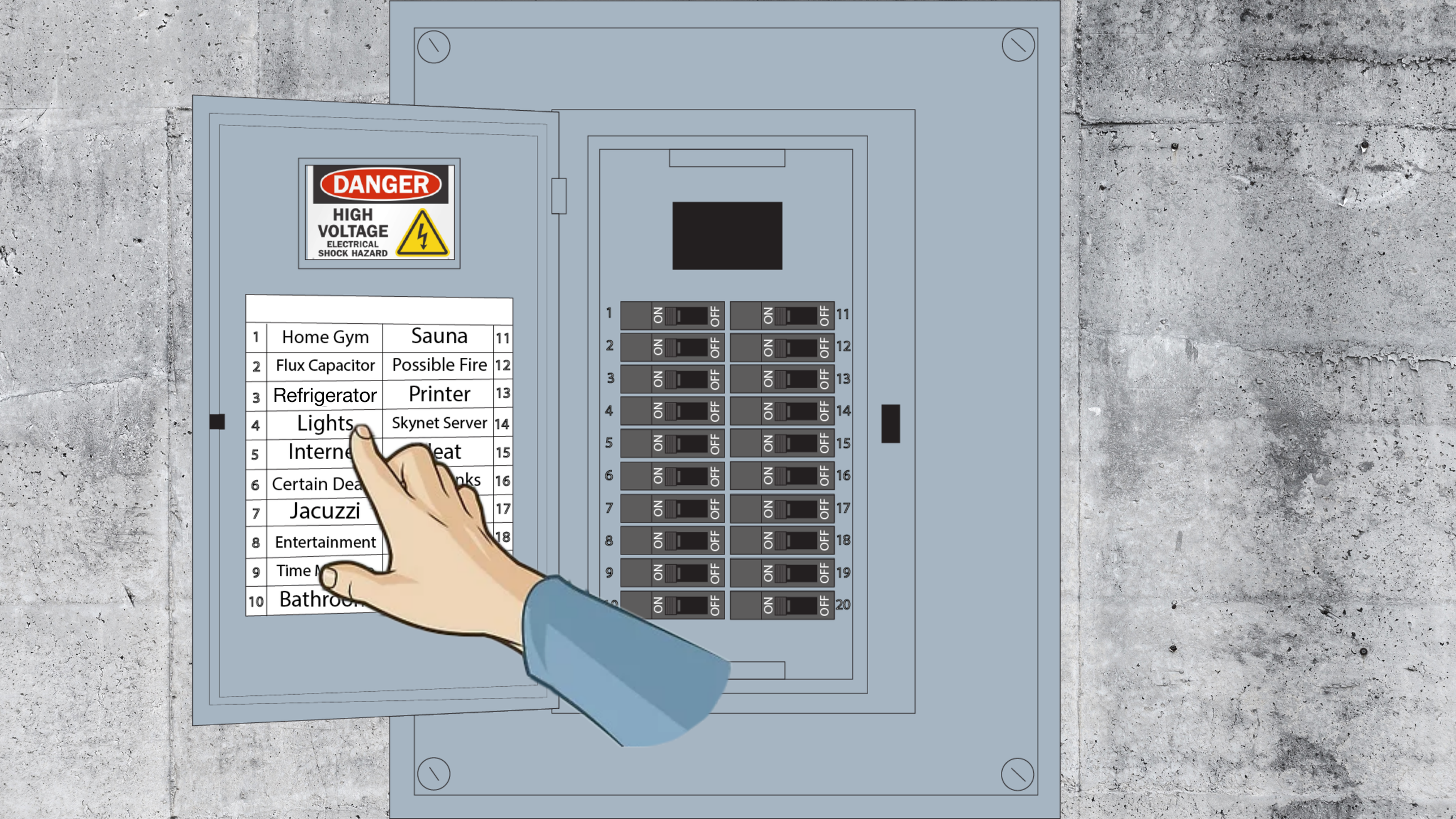
Retrospective Cues

depend on information available after the action and specific to a each action itself

- Proprioception
- Knowledge of proprioceptive noise
- Visual or tactile feedback (where available)


DANGER
HIGH VOLTAGE
ELECTRICAL SHOCK HAZARD
1 Home Gym Sauna 11
2 Flux Capacitor Possible Fire 12
3 Refrigerator Printer 13
4 Lights Skynet Server 14
5 Internet Heat 15
6 Certain Death Cryo Tanks 16
7 Jacuzzi Garage 17
8 Entertainment Explosion 18
9 Time Machine Sound System 19
10 Bathroom Microwave 20
ON OFF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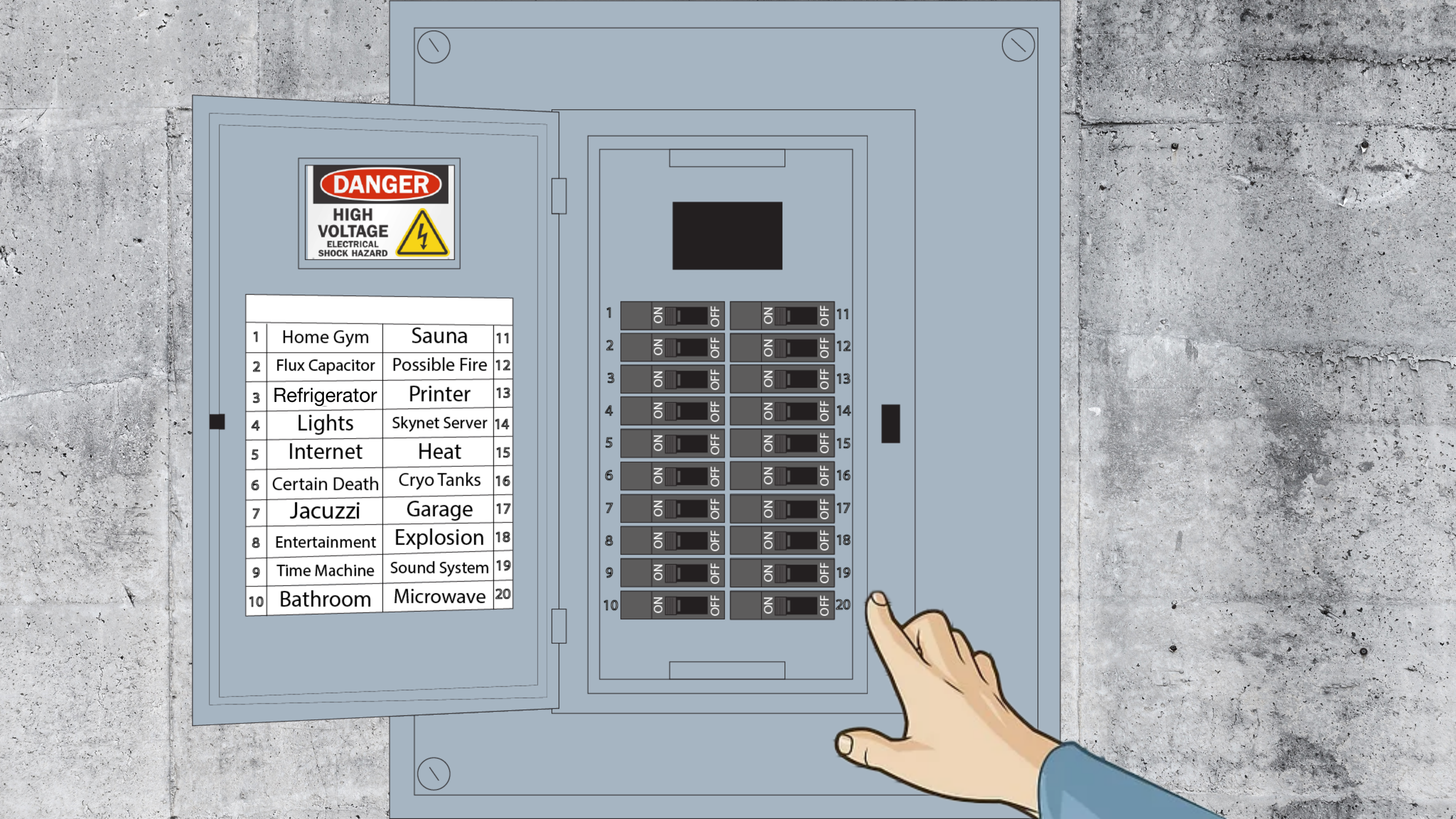
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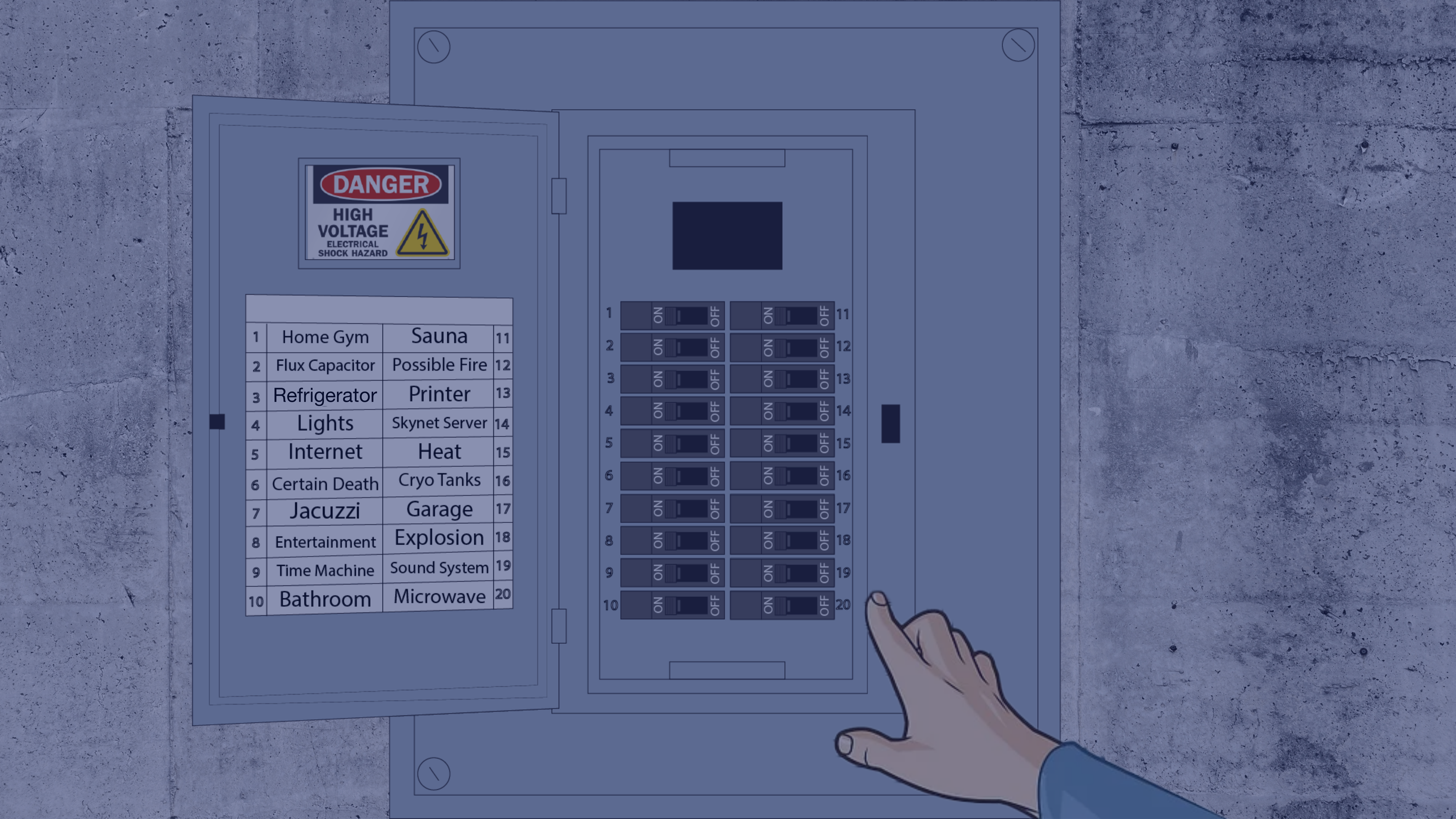
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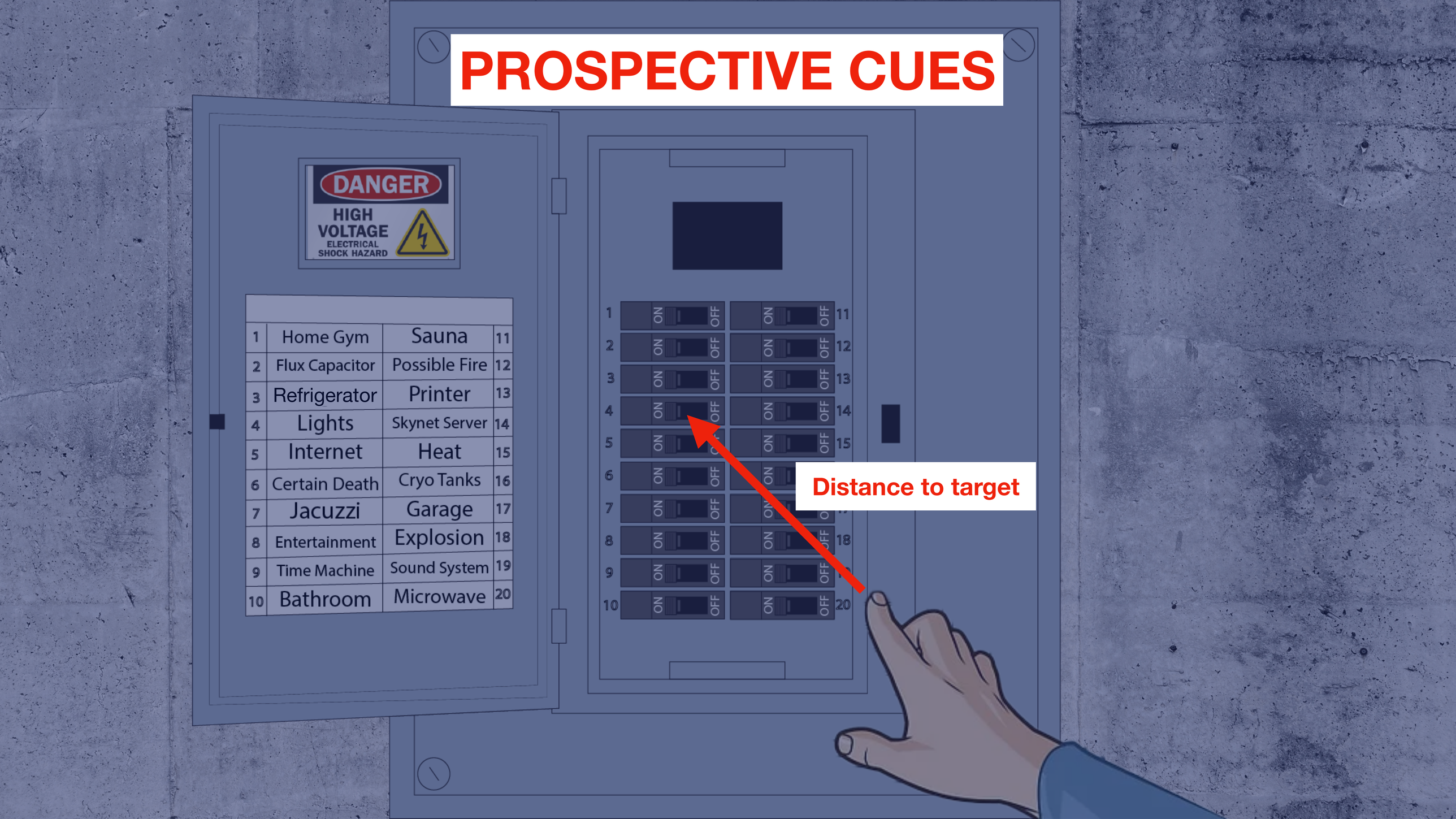
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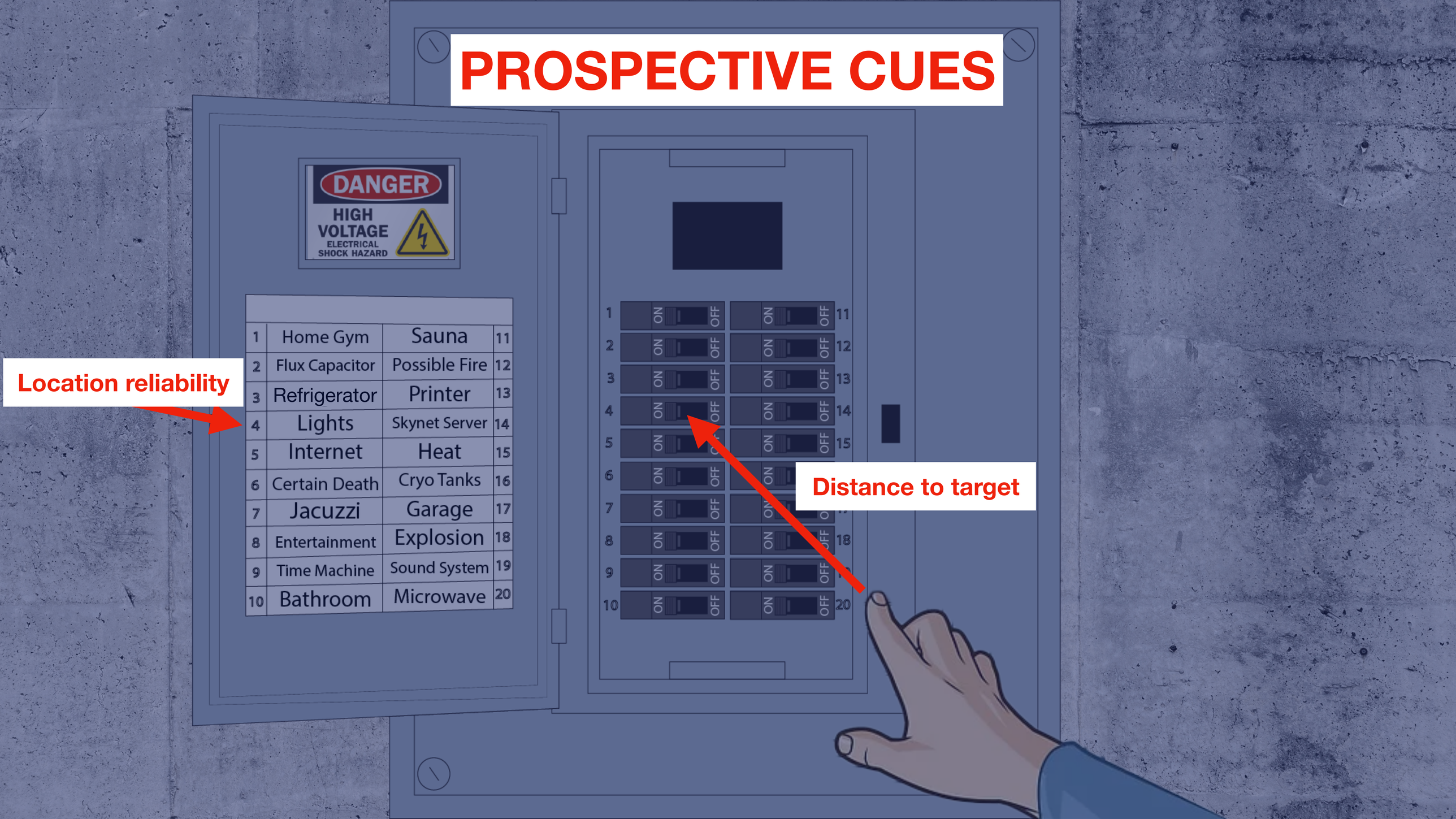
Distance to target

PROSPECTIVE CUES



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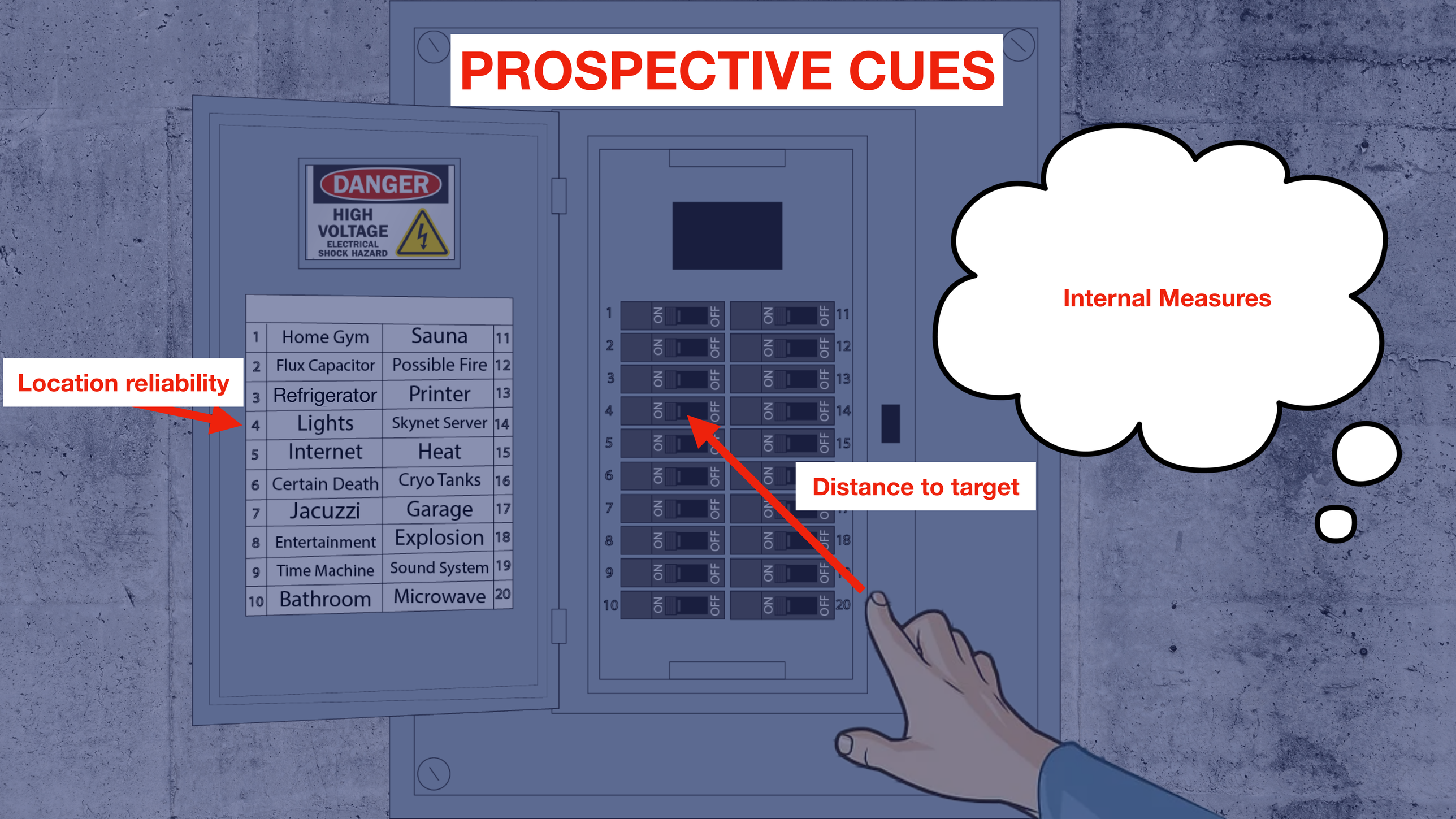

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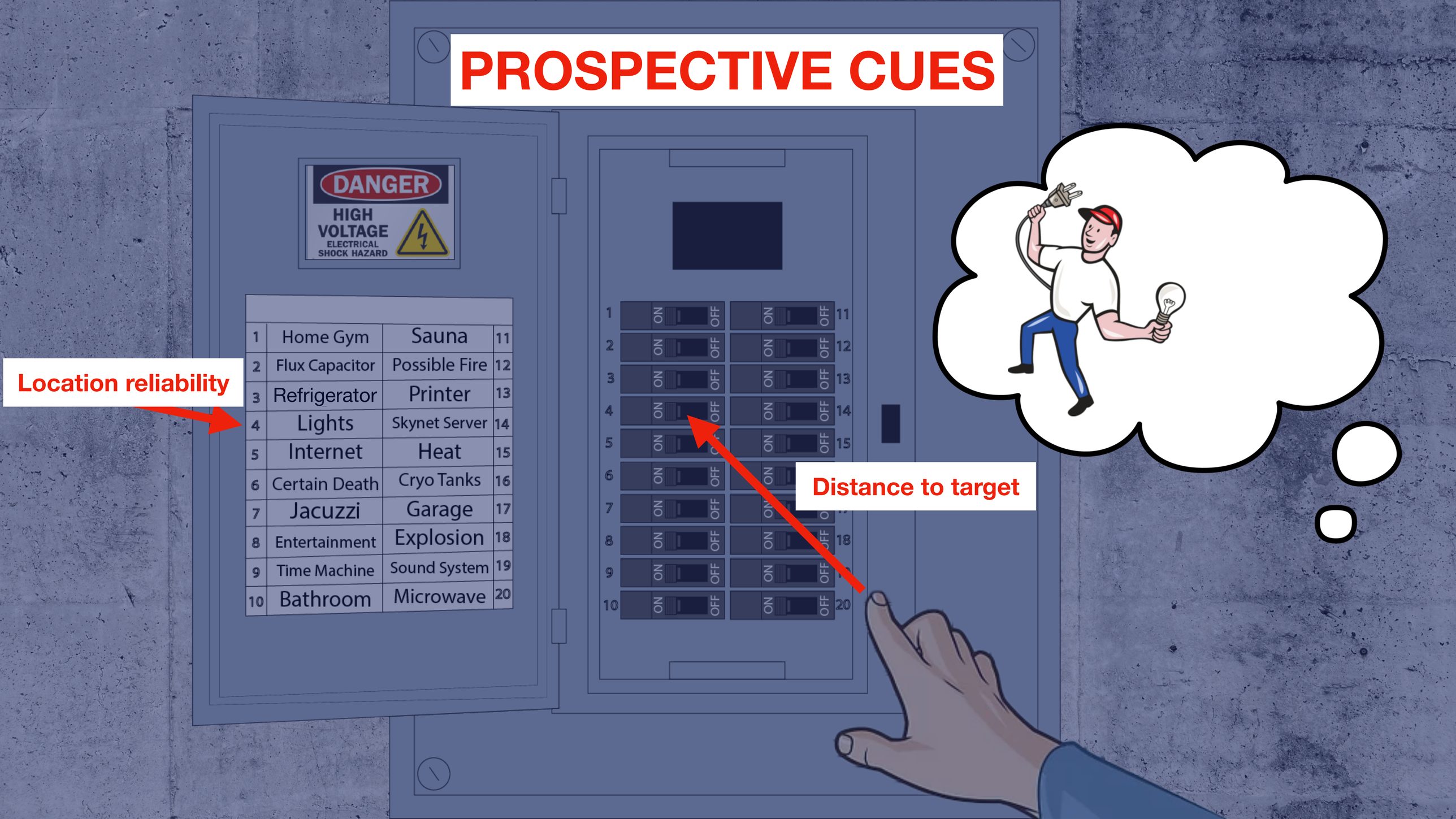

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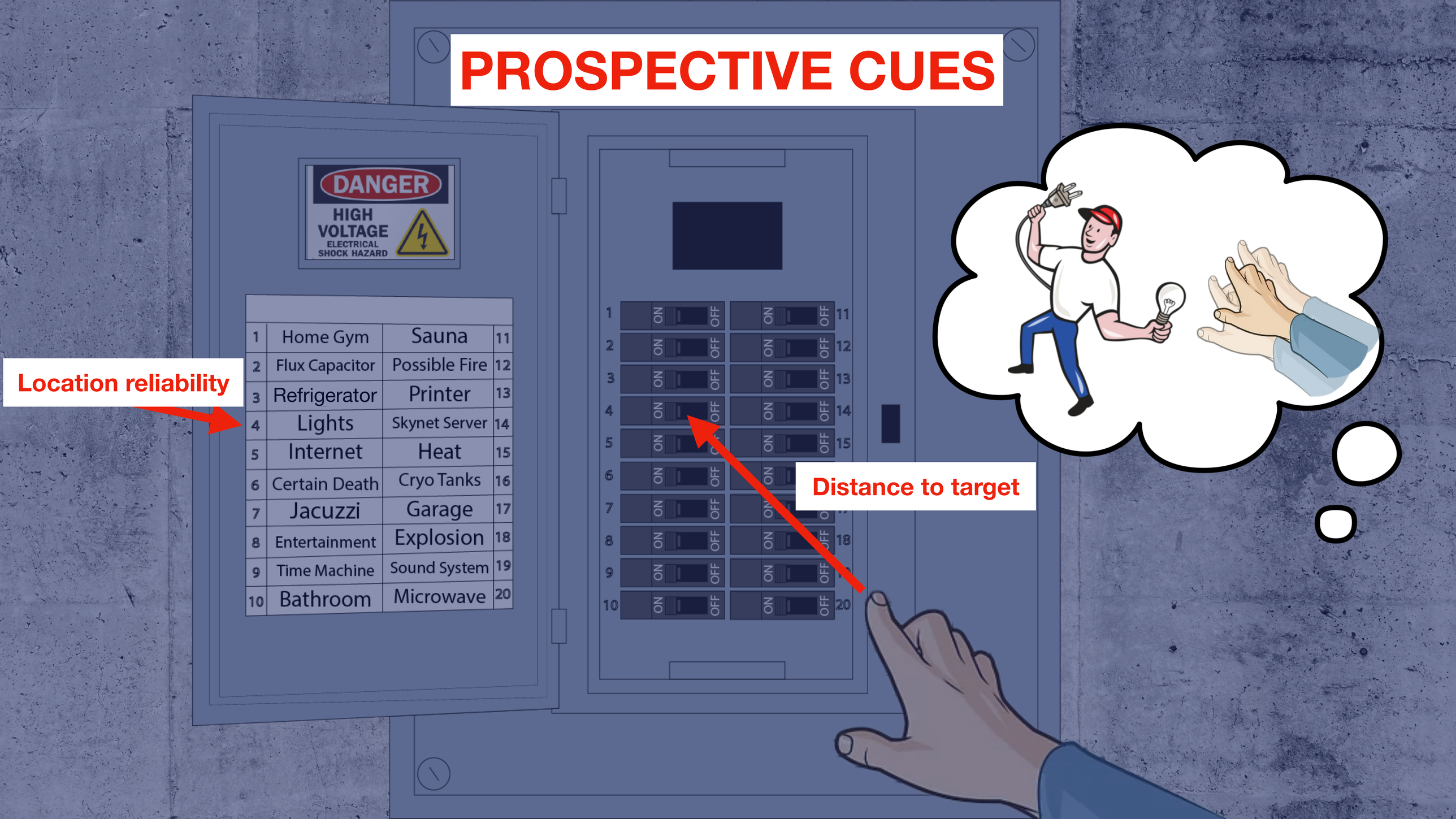

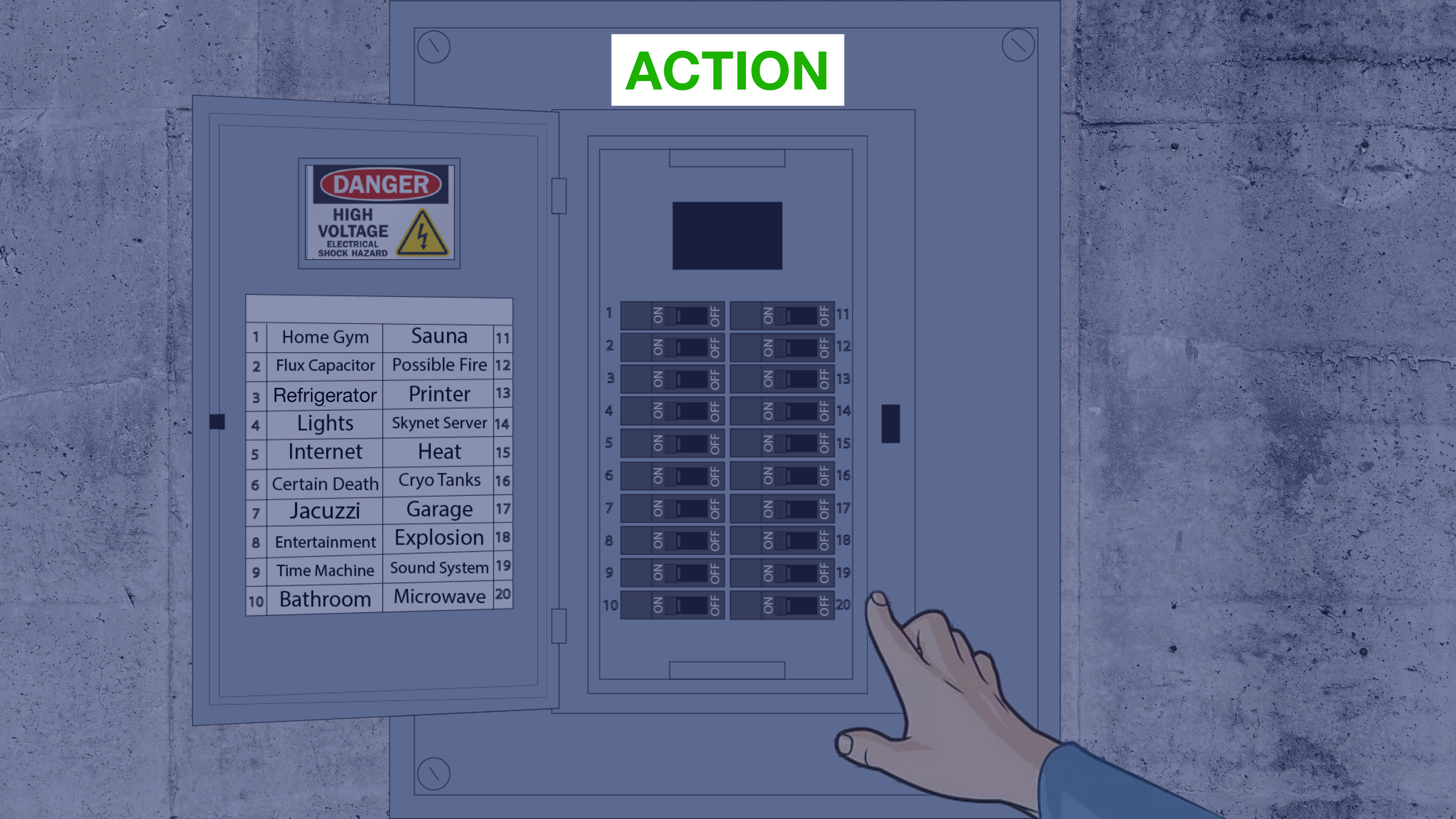
ACTION
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ELECTRICAL SHOCK HAZARD
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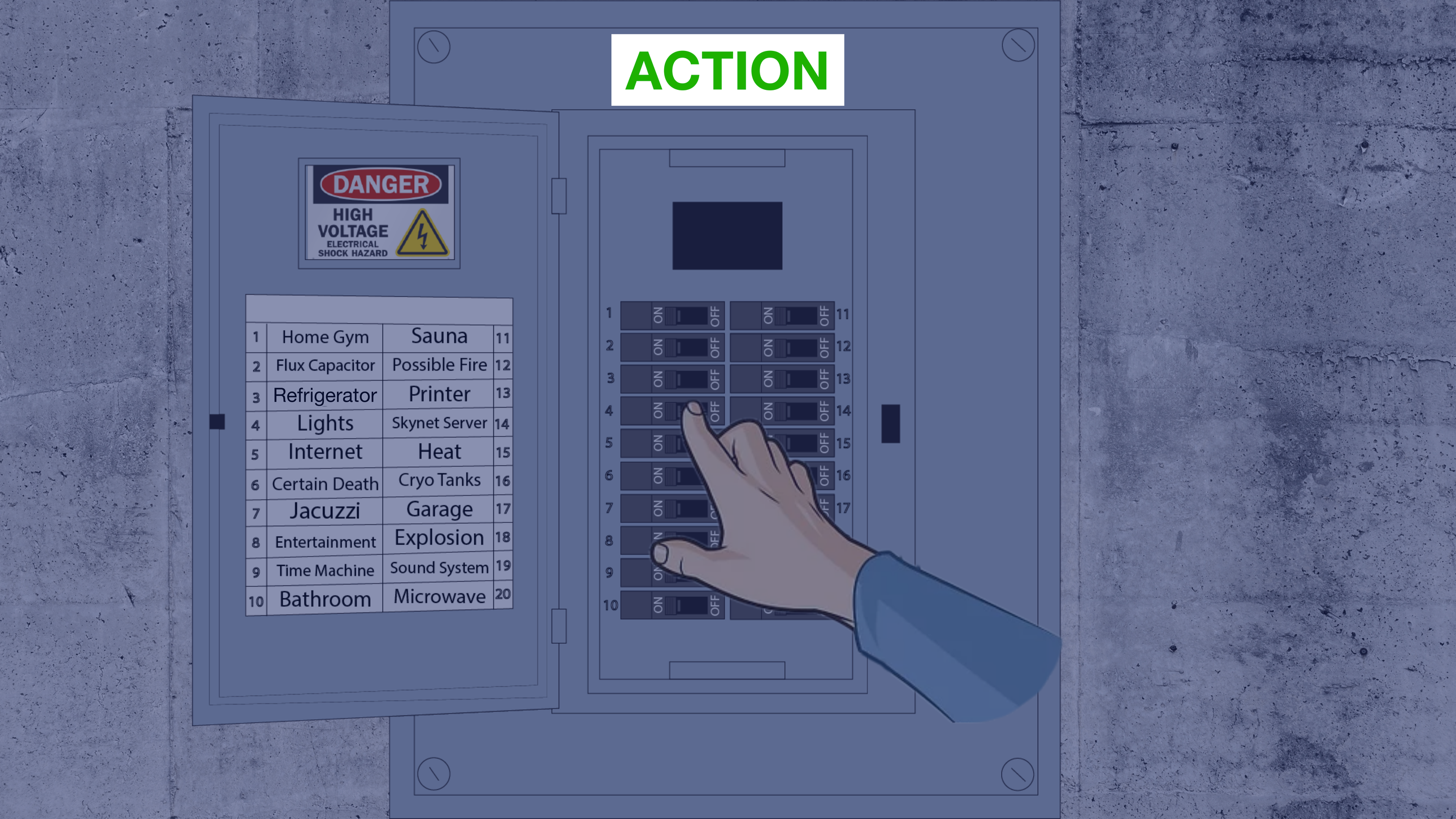
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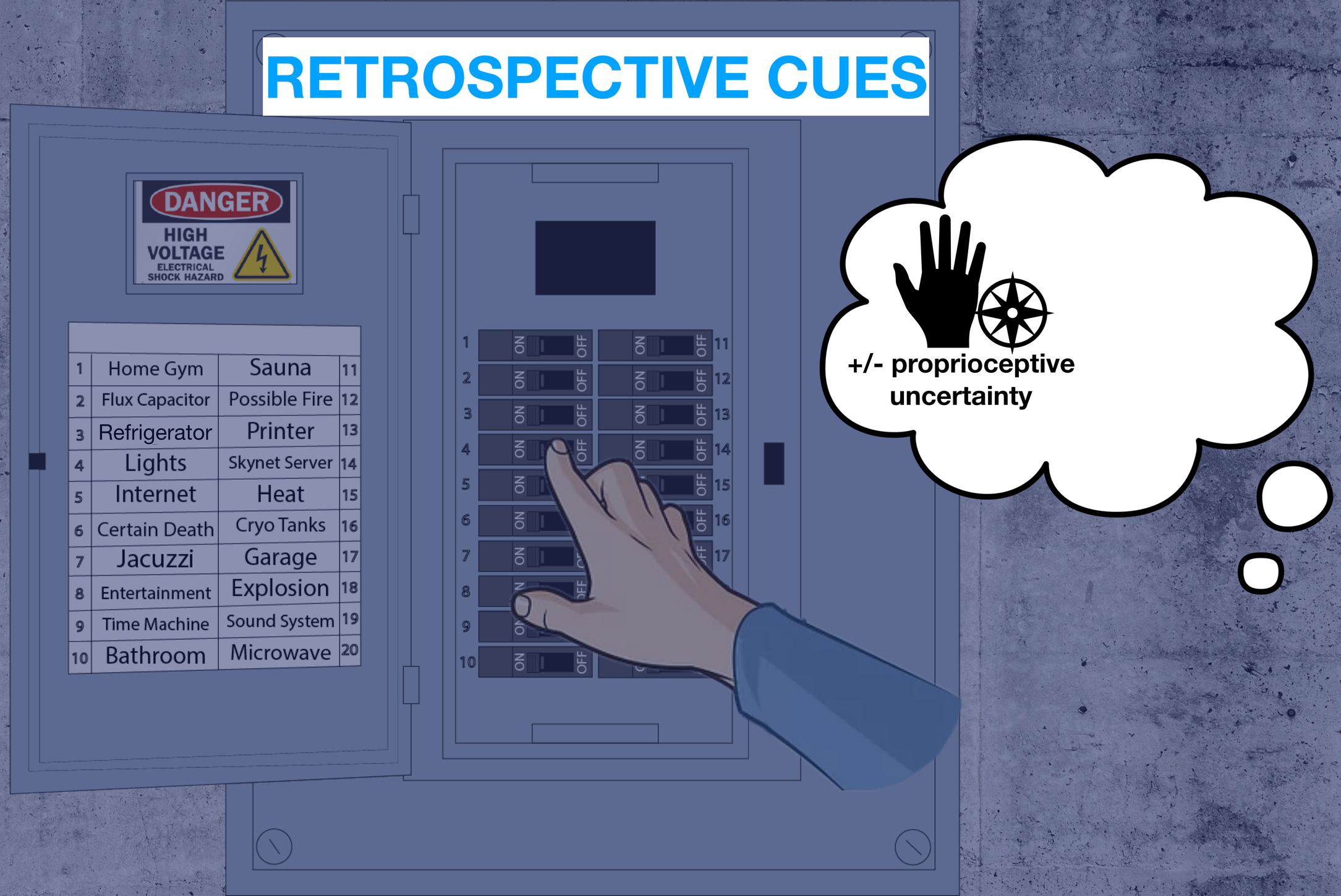
RETROSPECTIVE CUES



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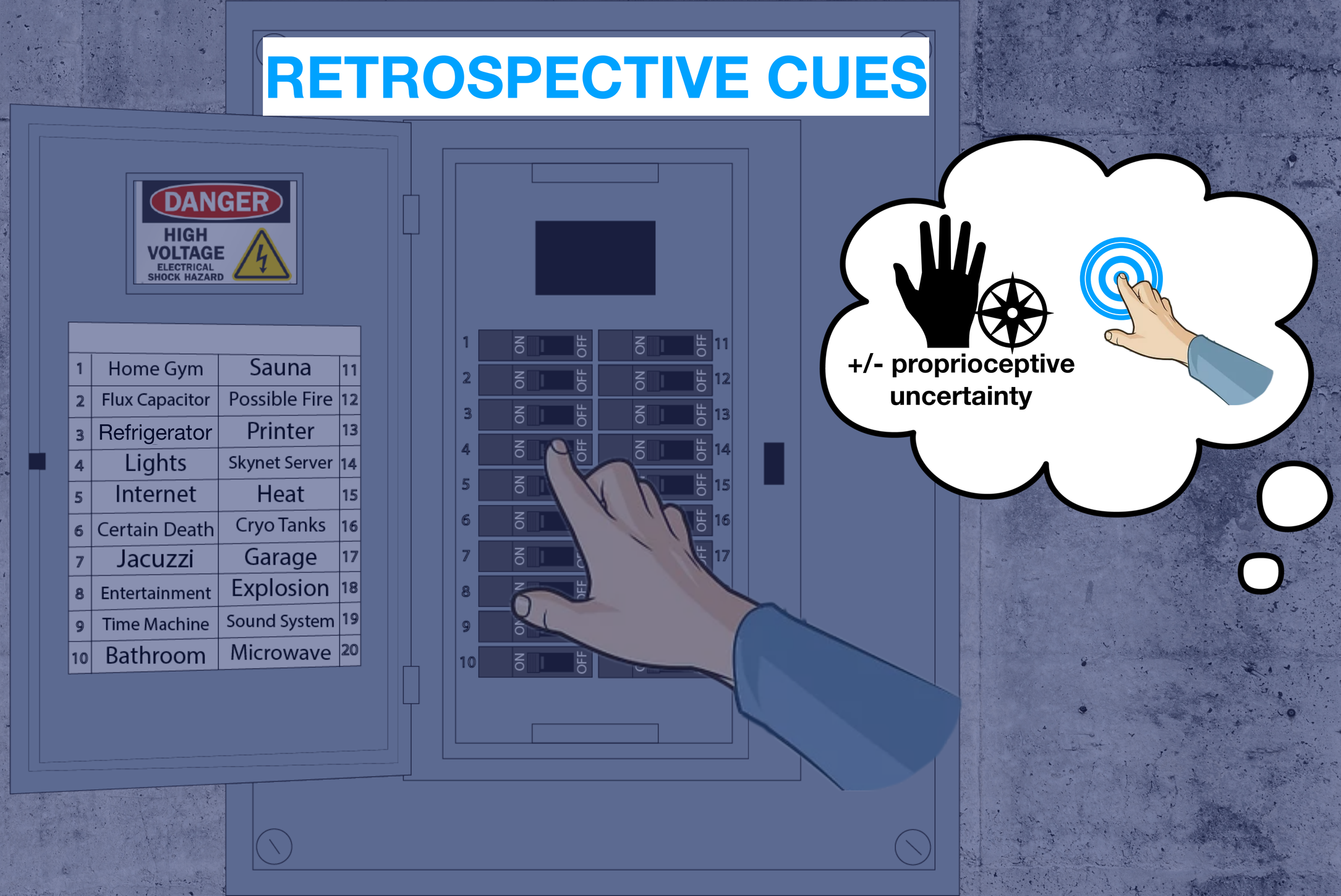
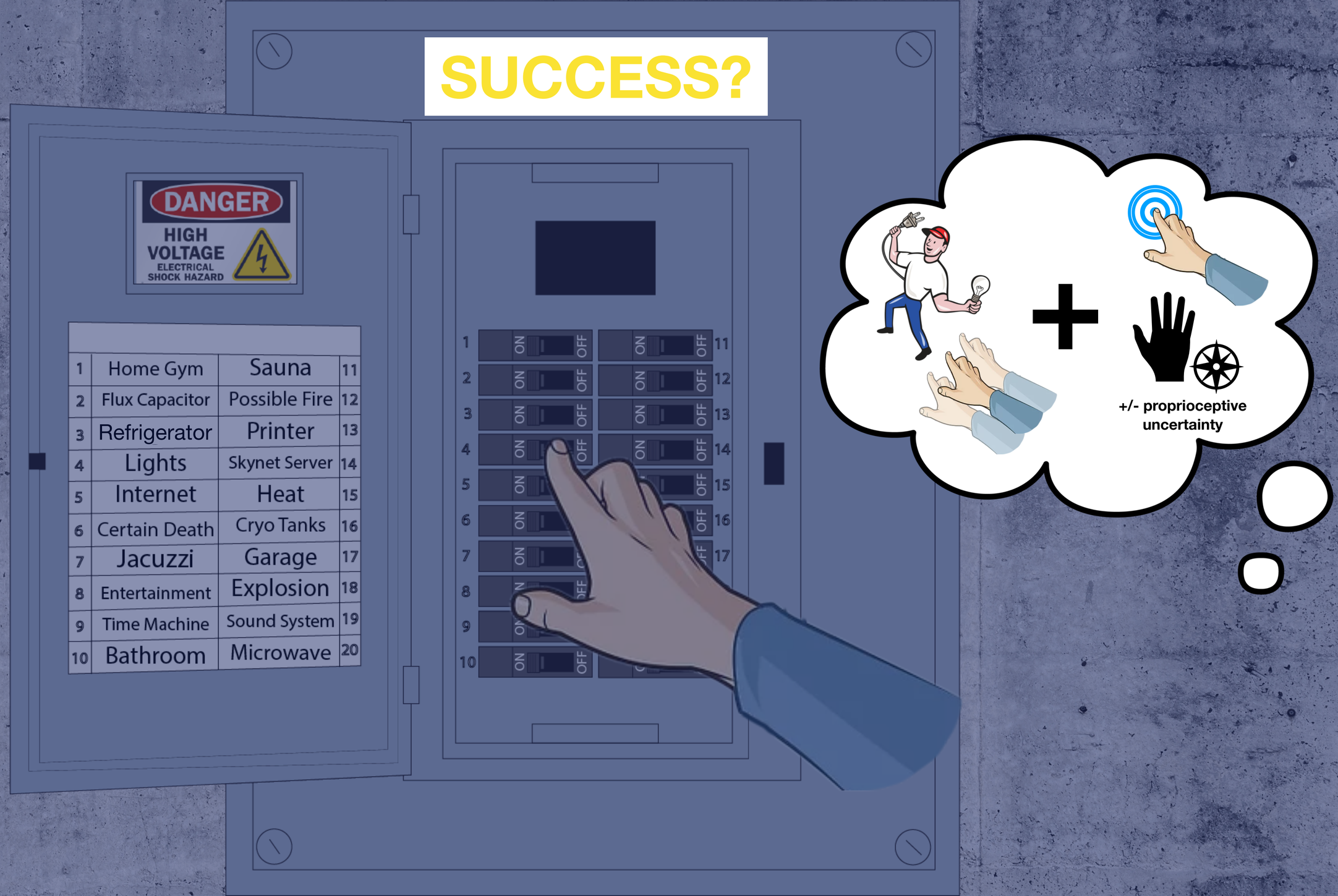


SUCCESS?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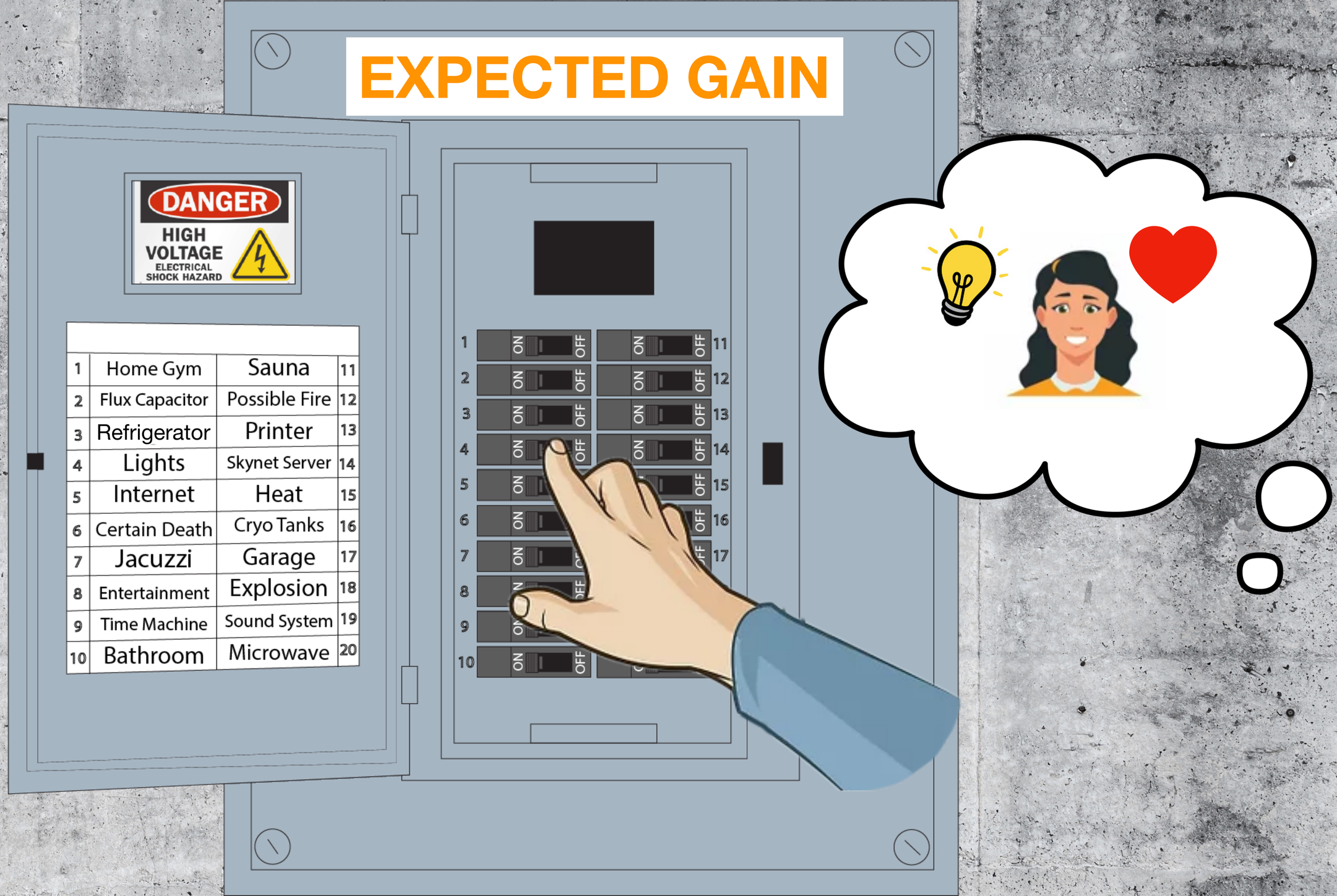
+/- proprioceptive uncertainty

EXPECTED GAIN



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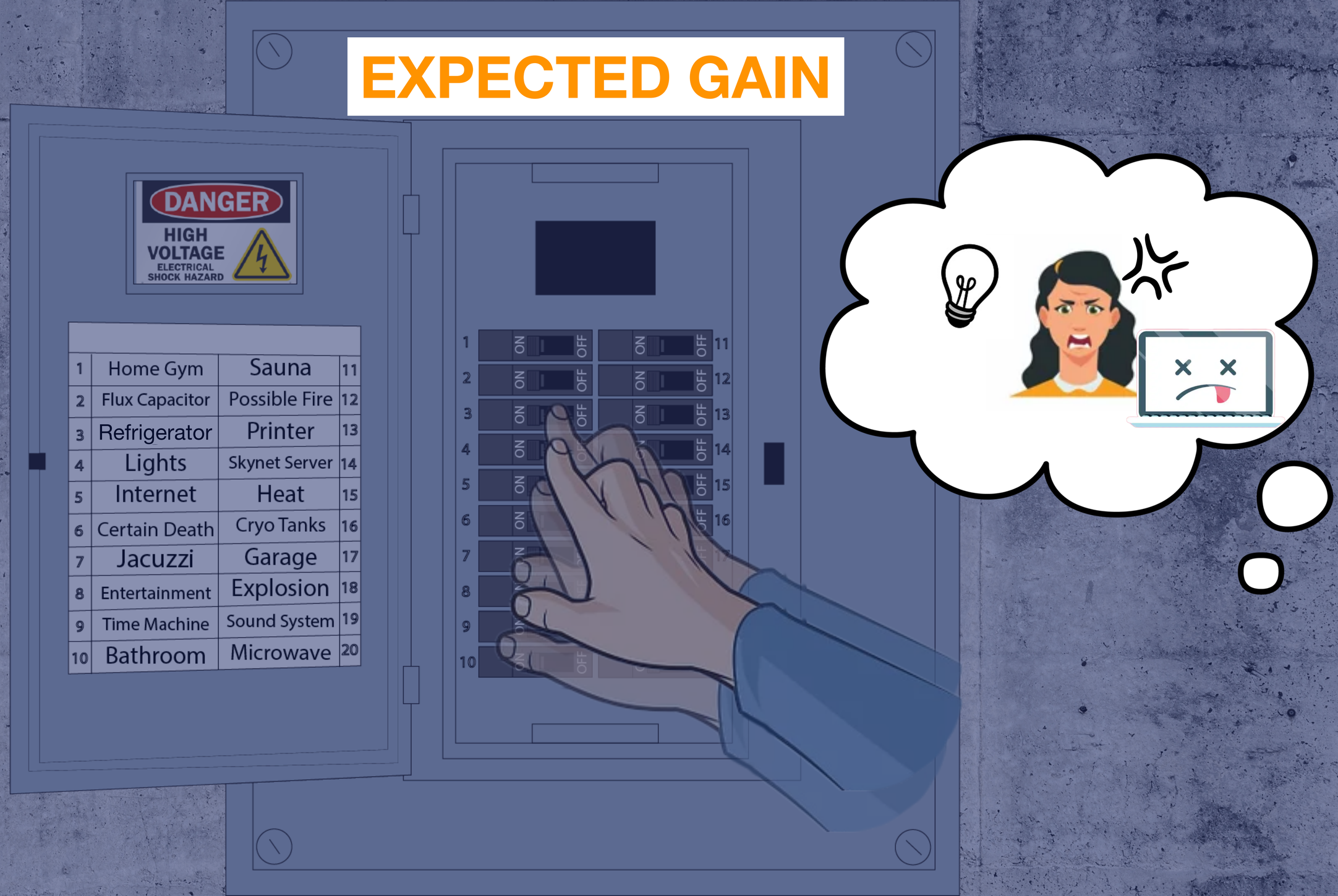
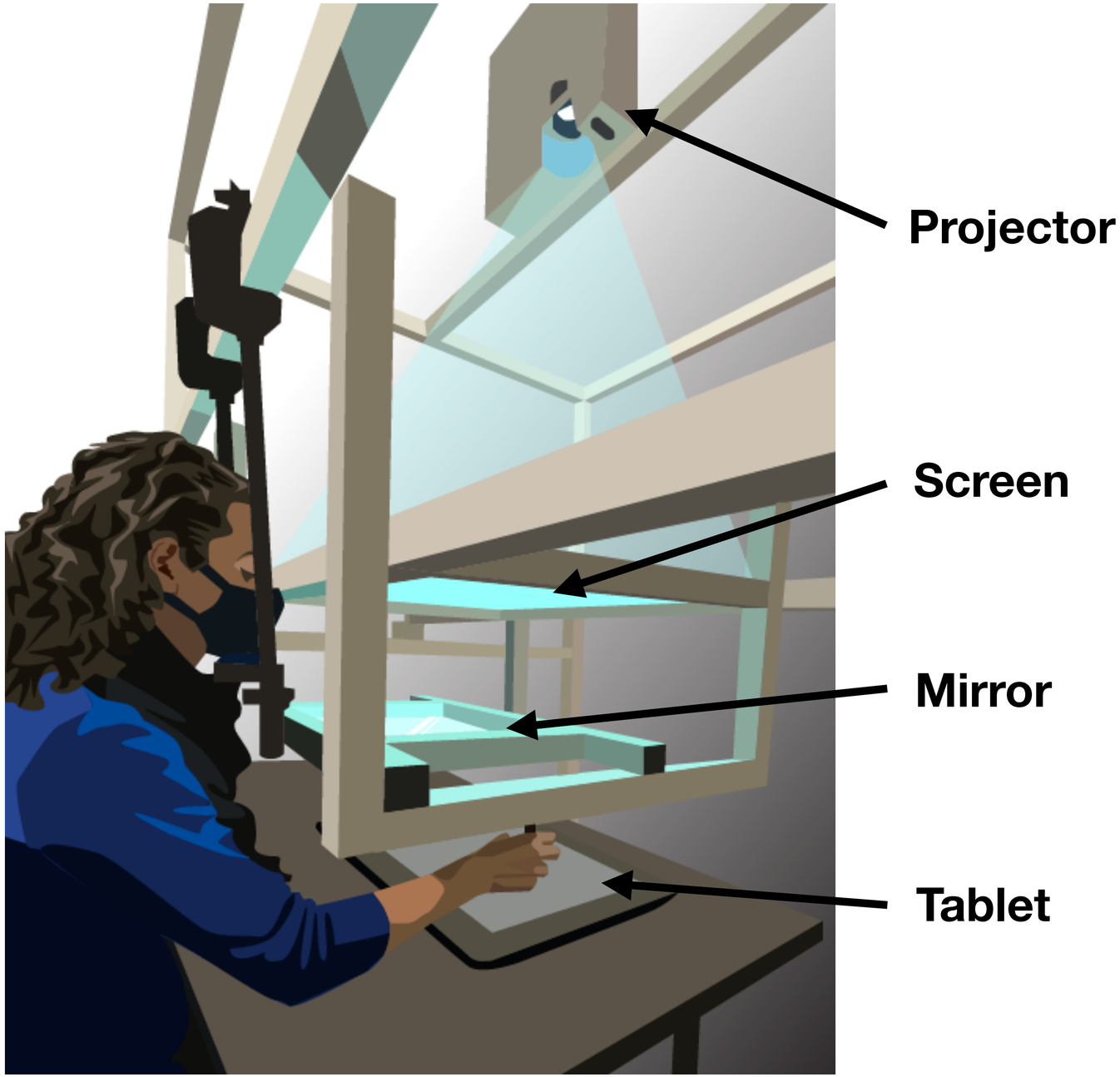


- How do the cues at these two time points contribute to the final sensorimotor confidence judgment?
- Are they always incorporated together or do people depend only on one or the other cue?

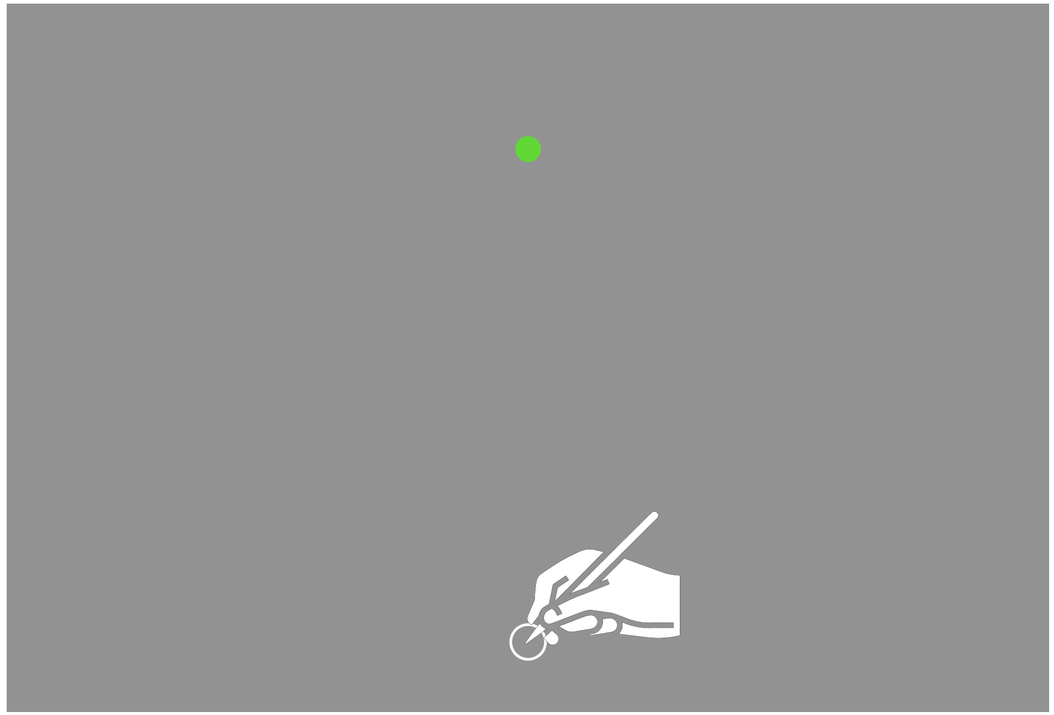

Projector
Screen
Mirror
Tablet

Motor Awareness Task to Estimate Proprioceptive Noise

How well can you estimate the location of your hand in space?

Purpose: To independently measure the participant's proprioceptive noise.

Task: Reach repeatedly to the same point and report the perceived end-points of the unseen reaches using a mouse



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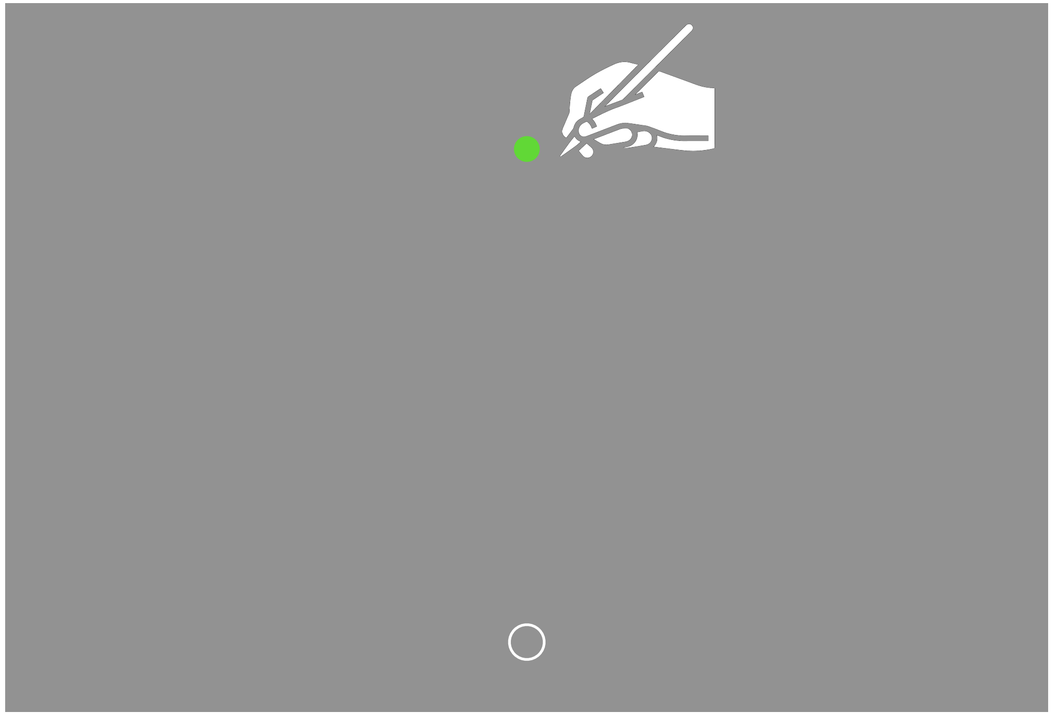

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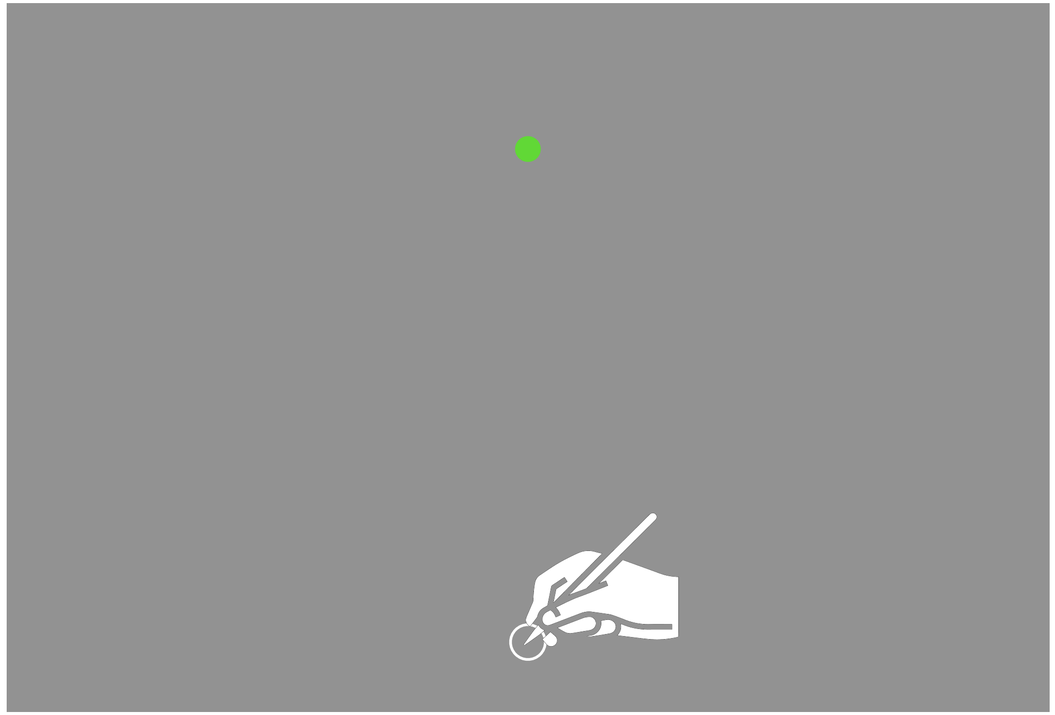

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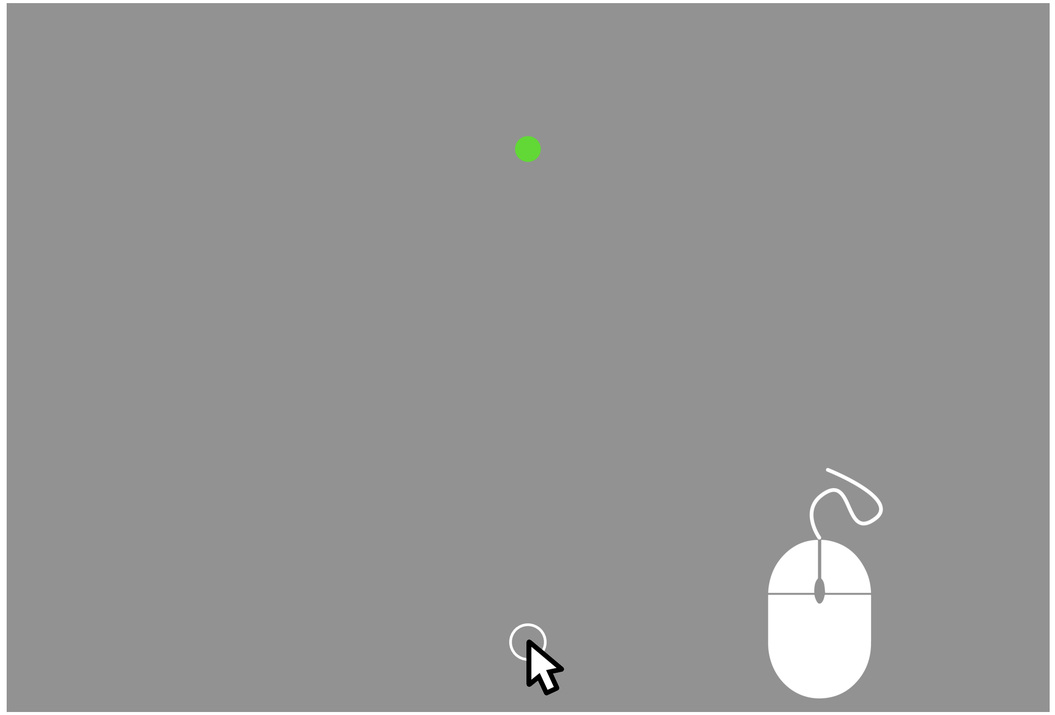

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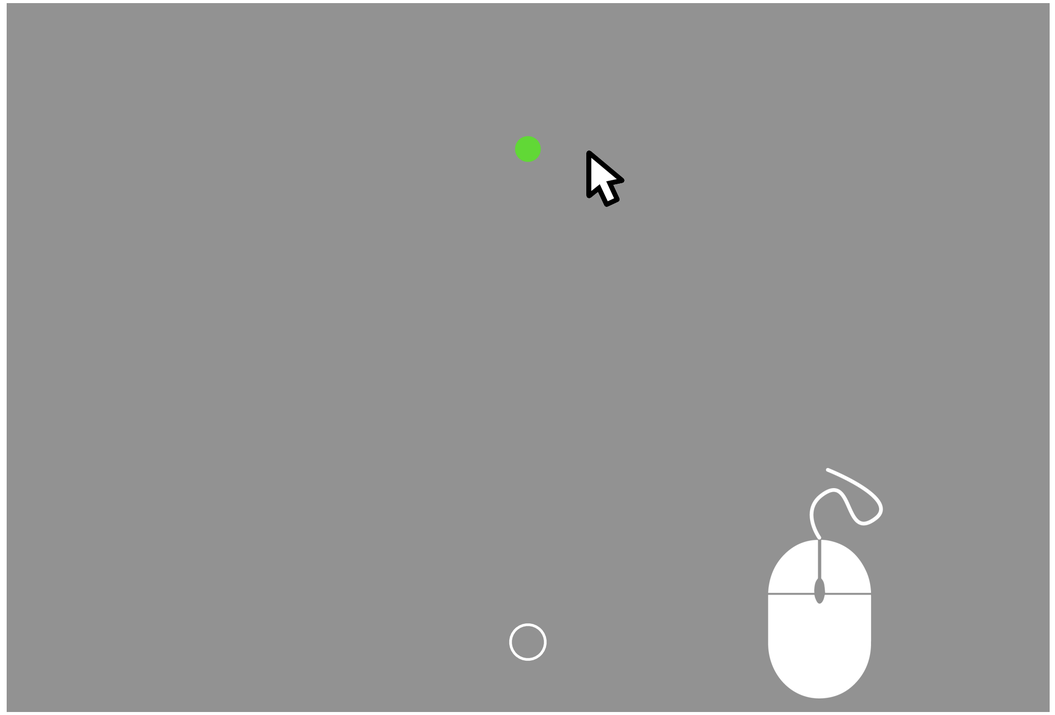

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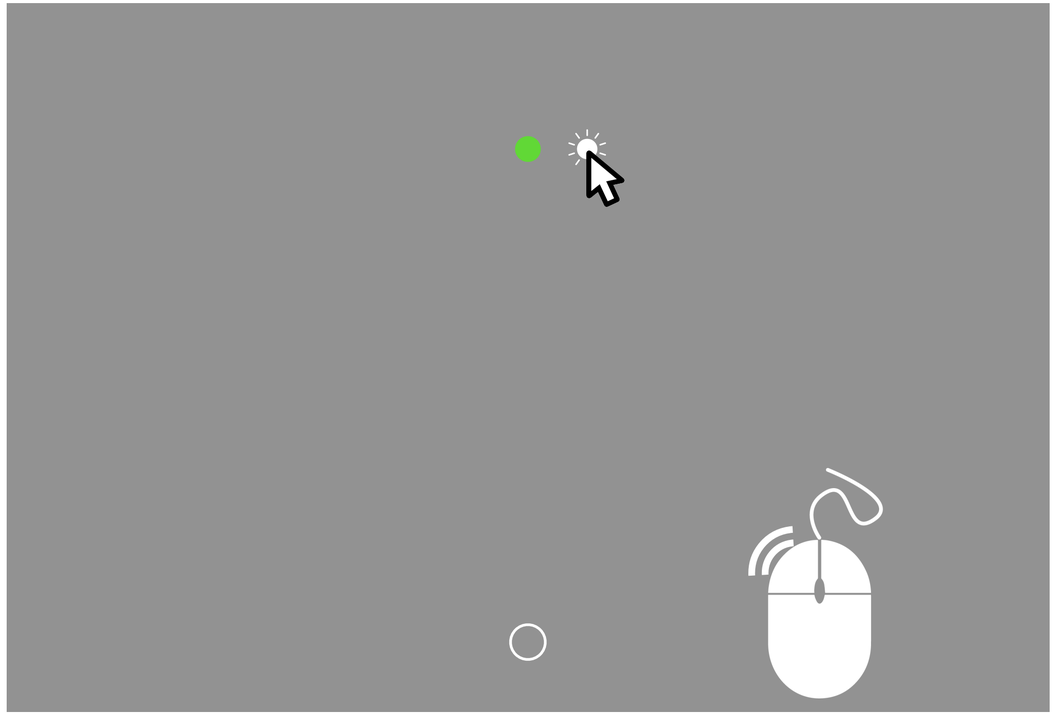

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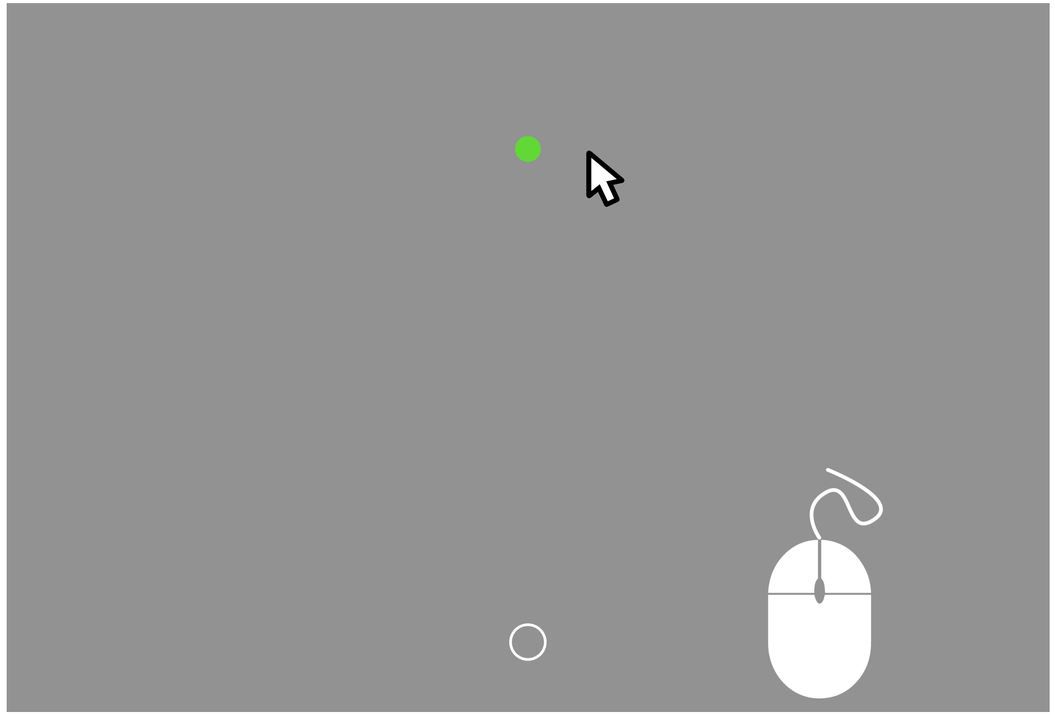

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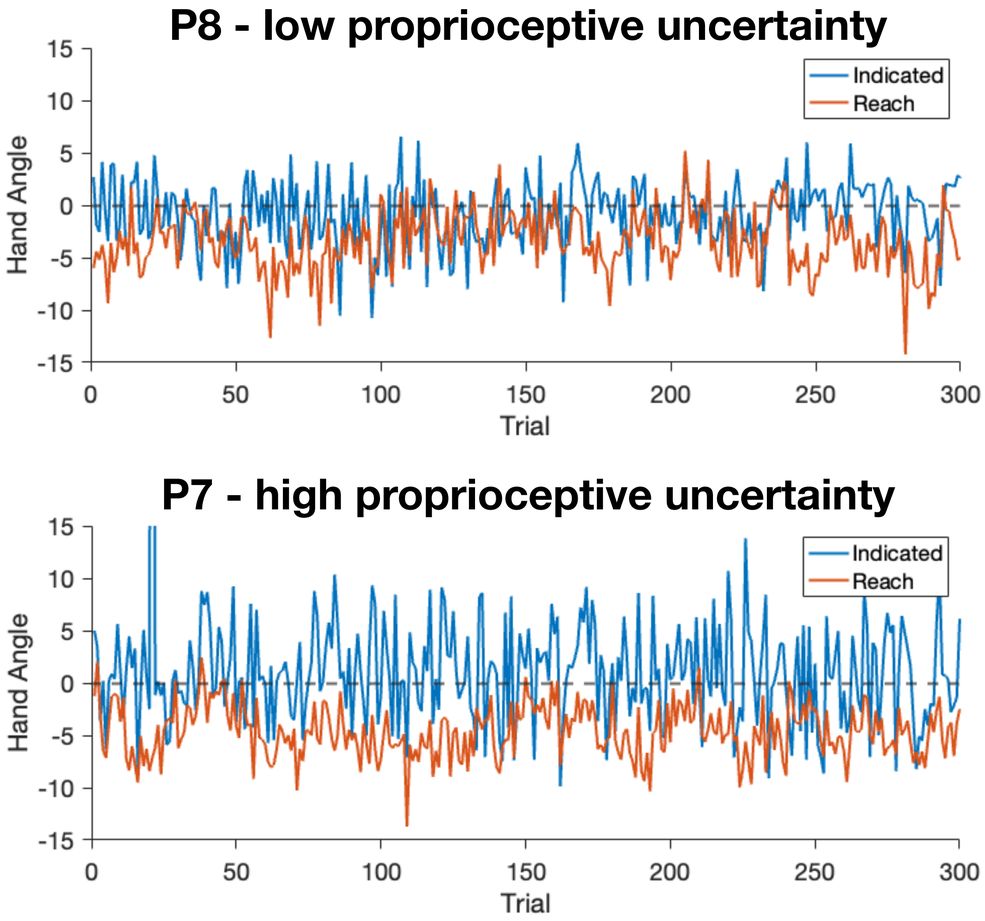
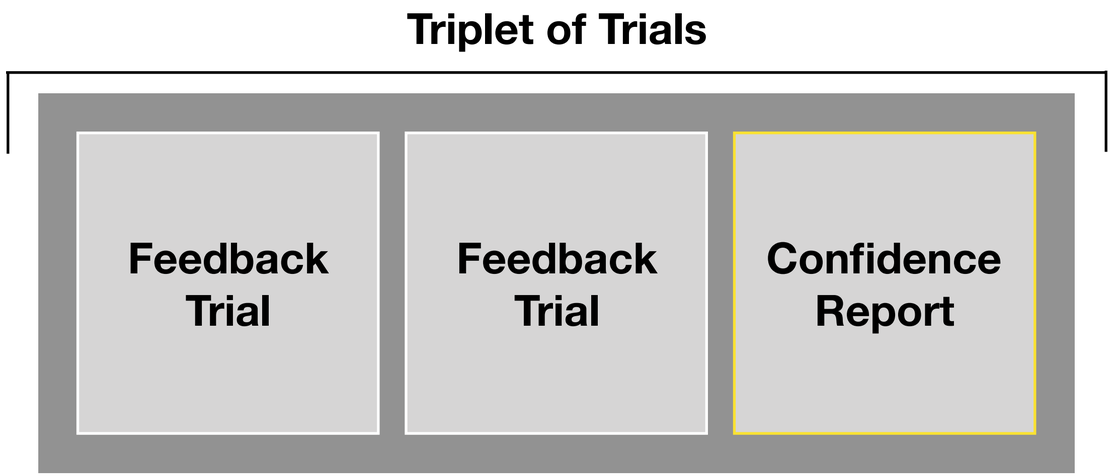


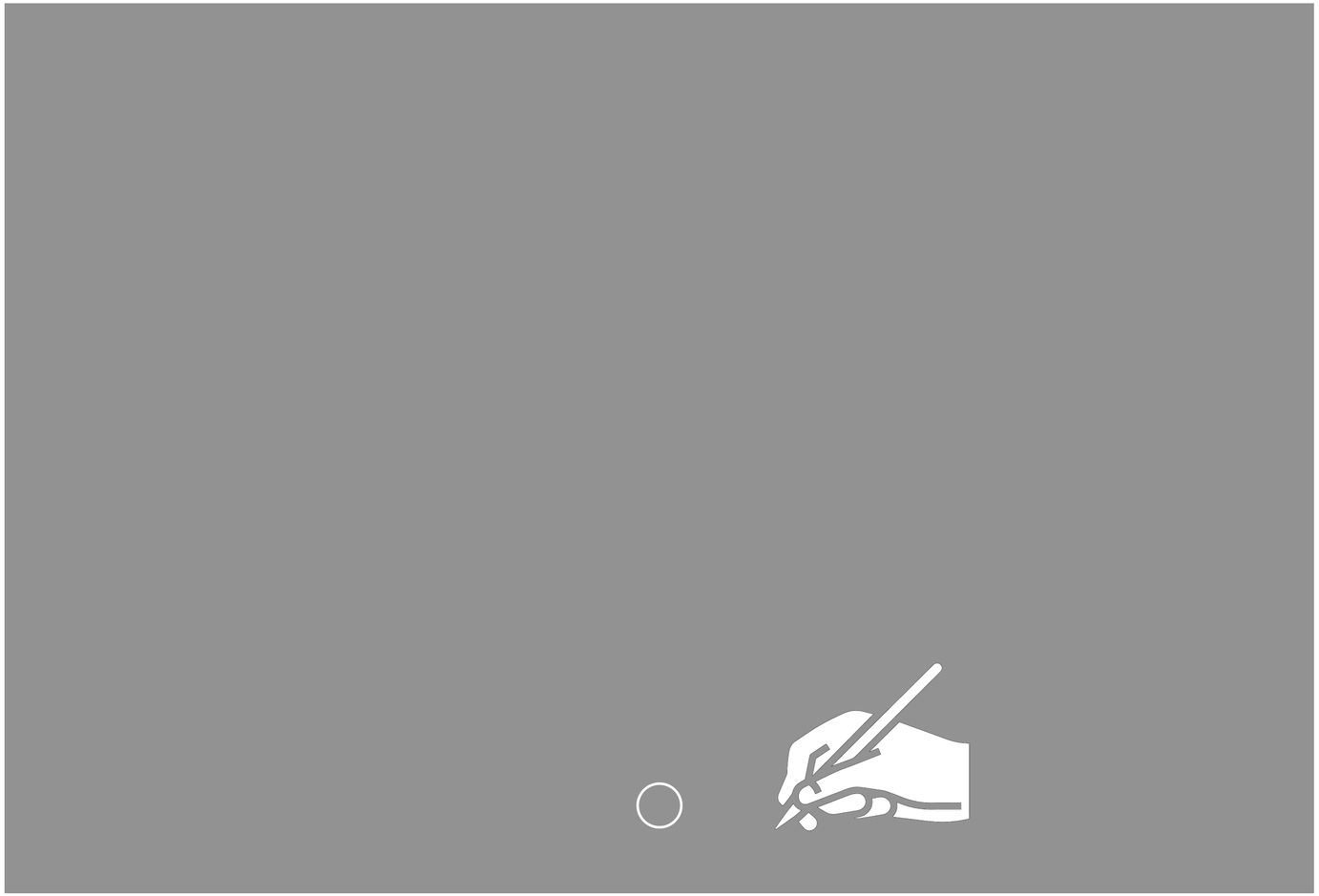
Confidence Judgment Experiment

Task: Report of confidence on unseen reaches to a visually cued target location.

Feedback: Presented on the two trials prior to each confidence judgment.



Experimental Paradigm



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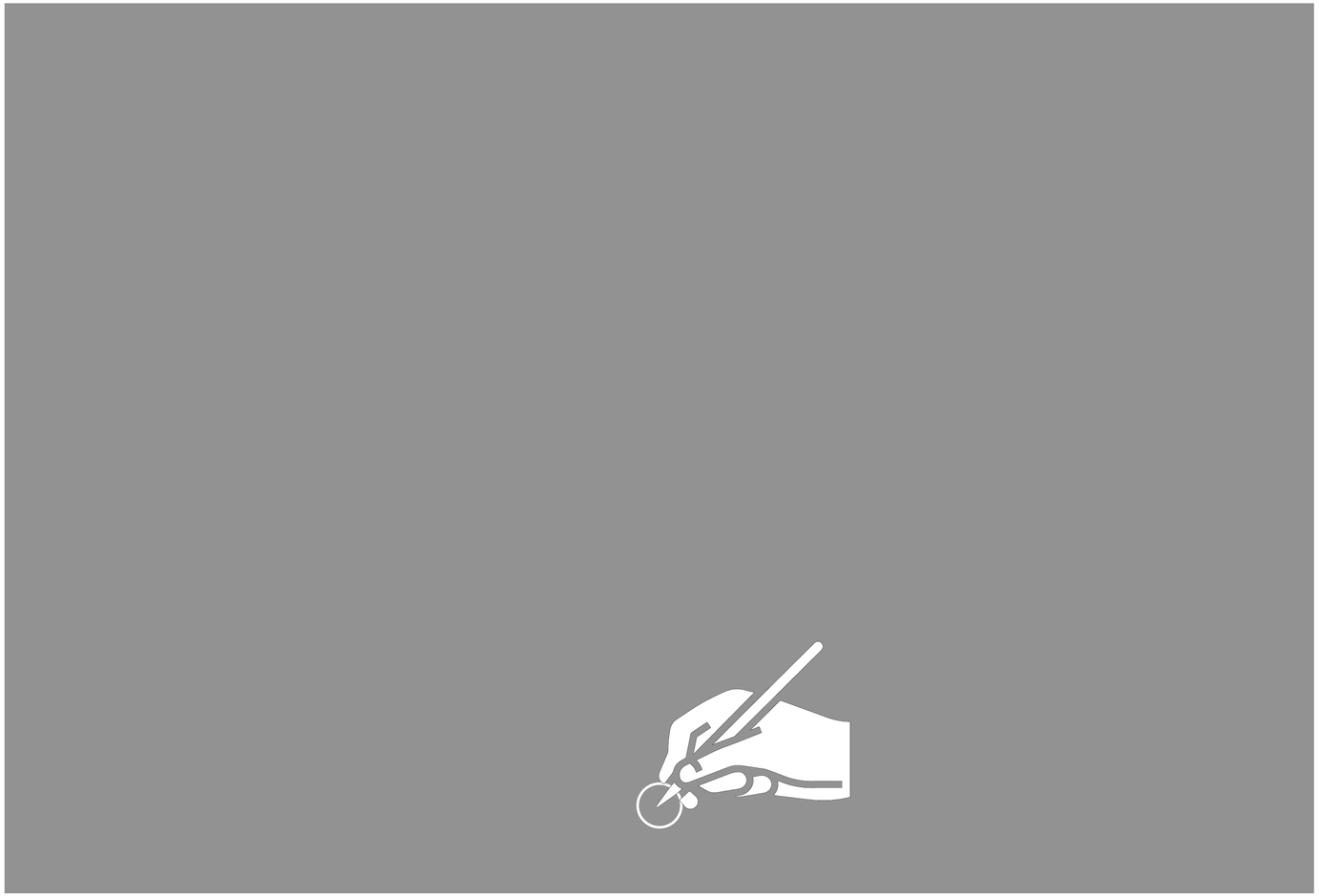

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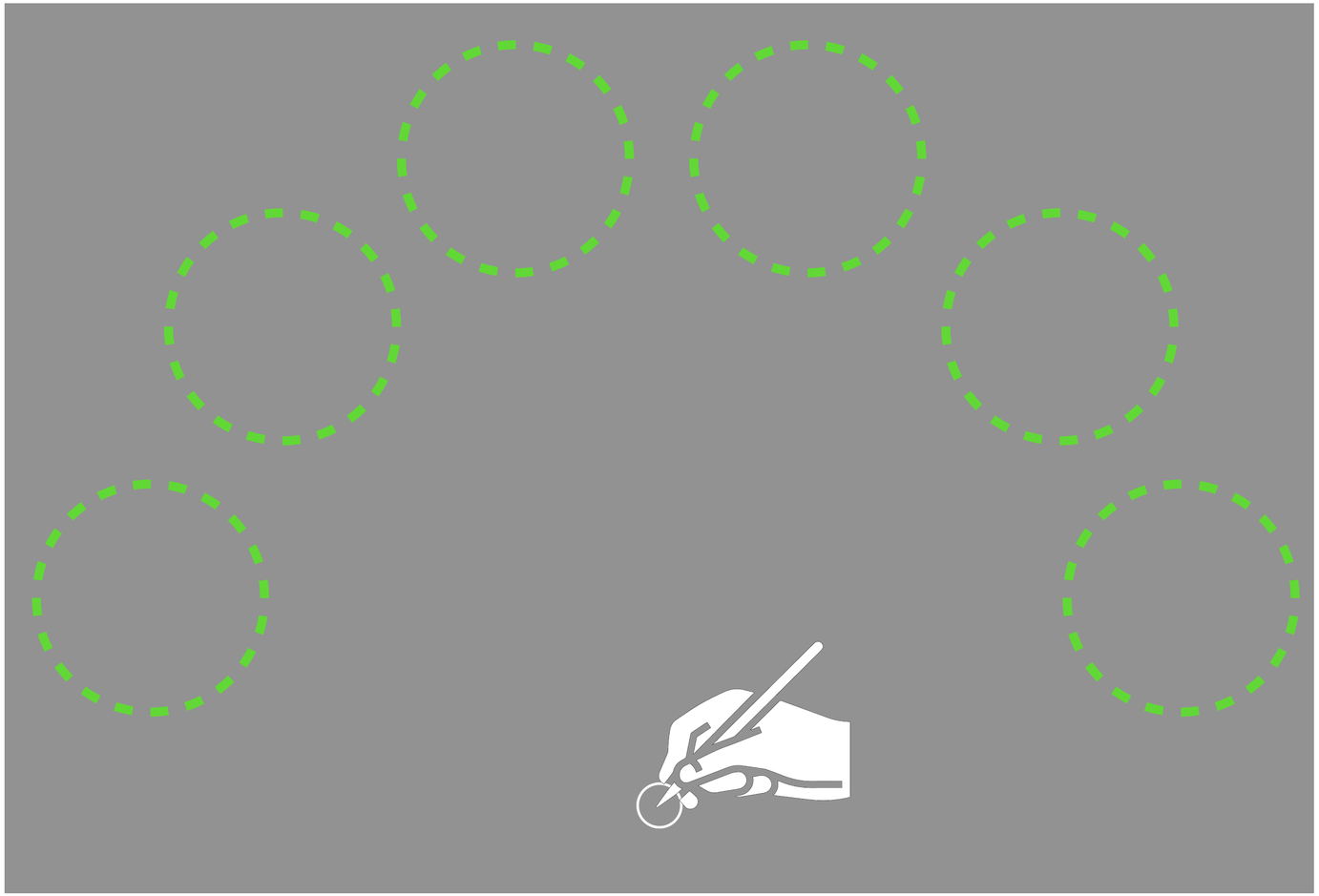

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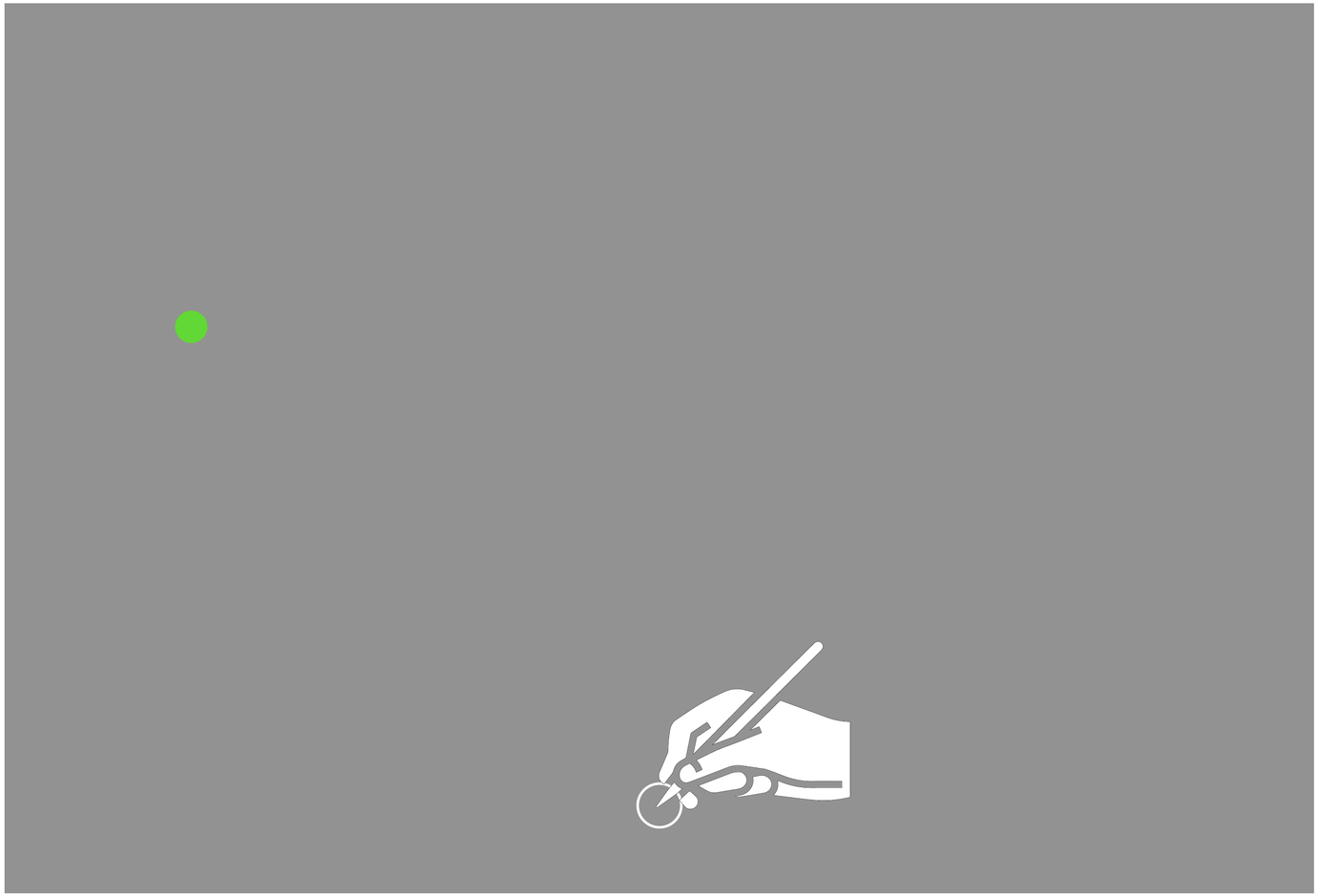

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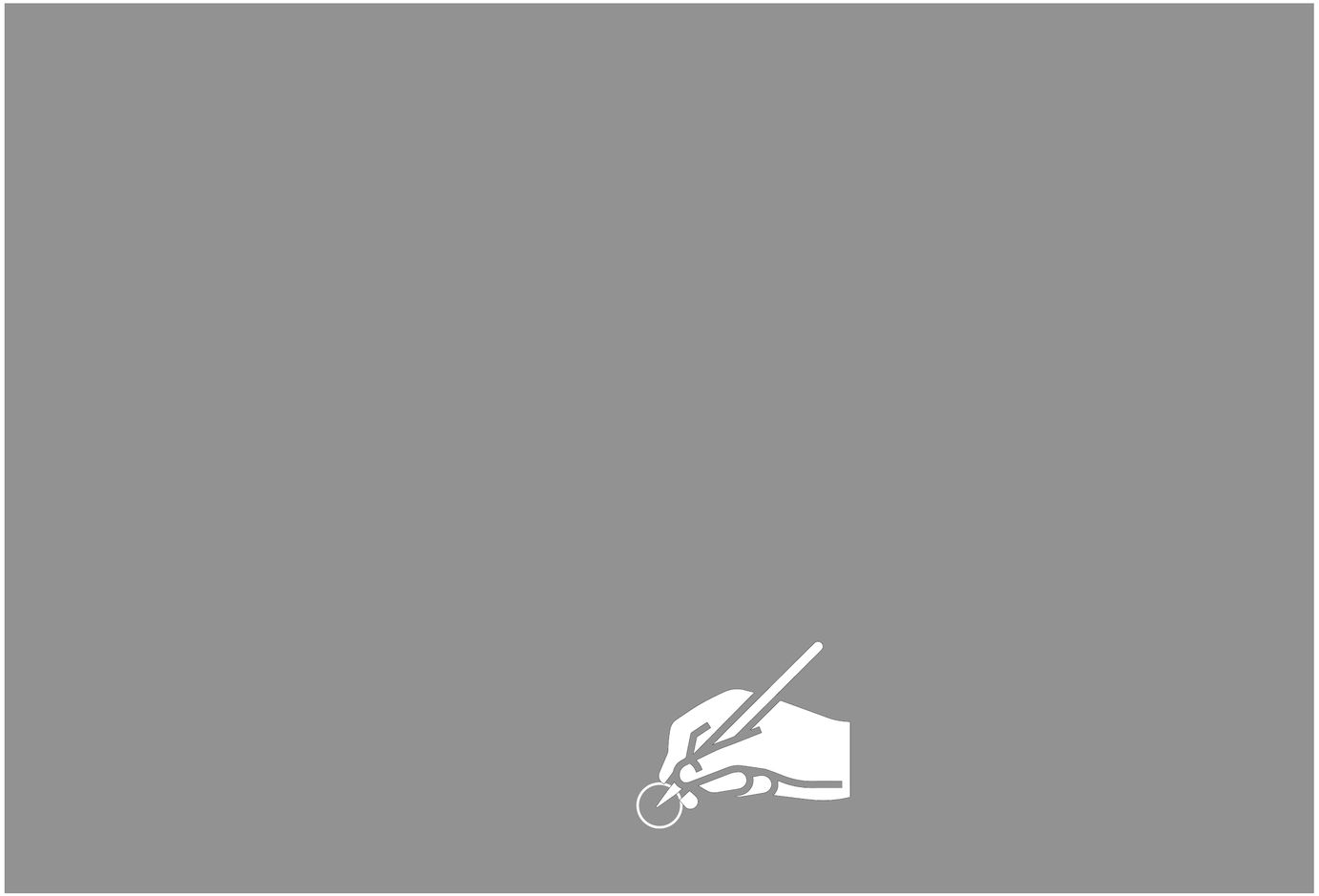

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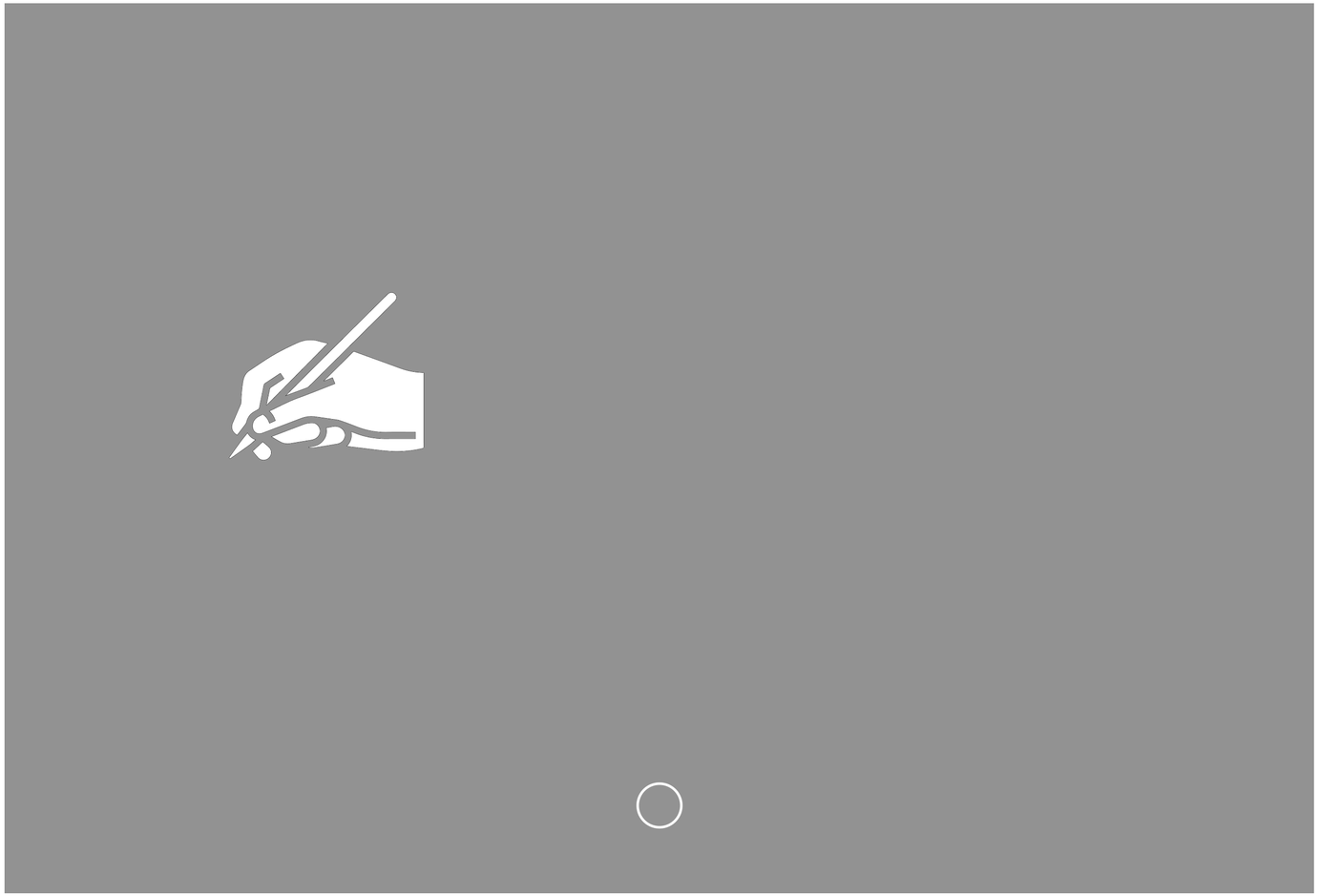

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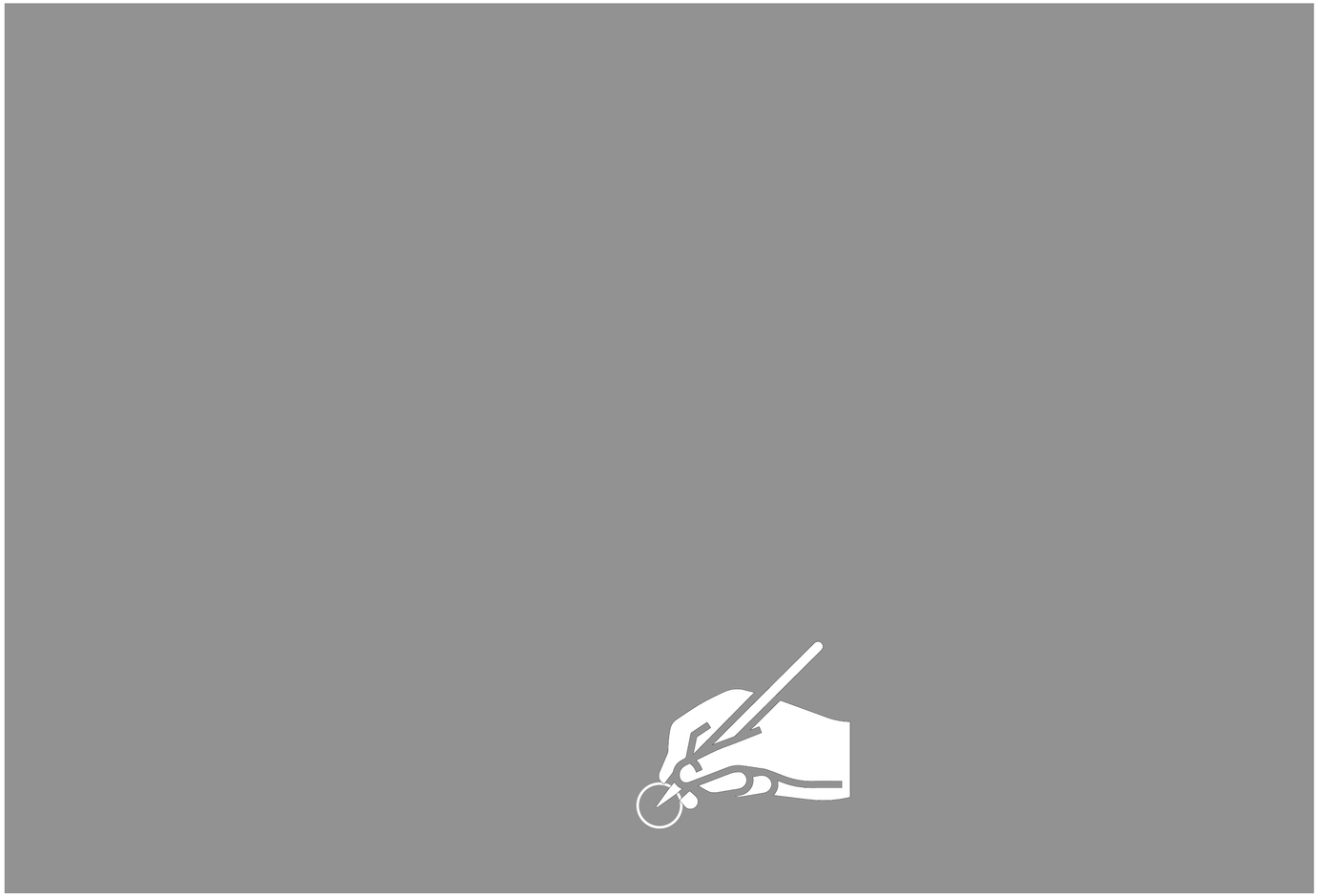

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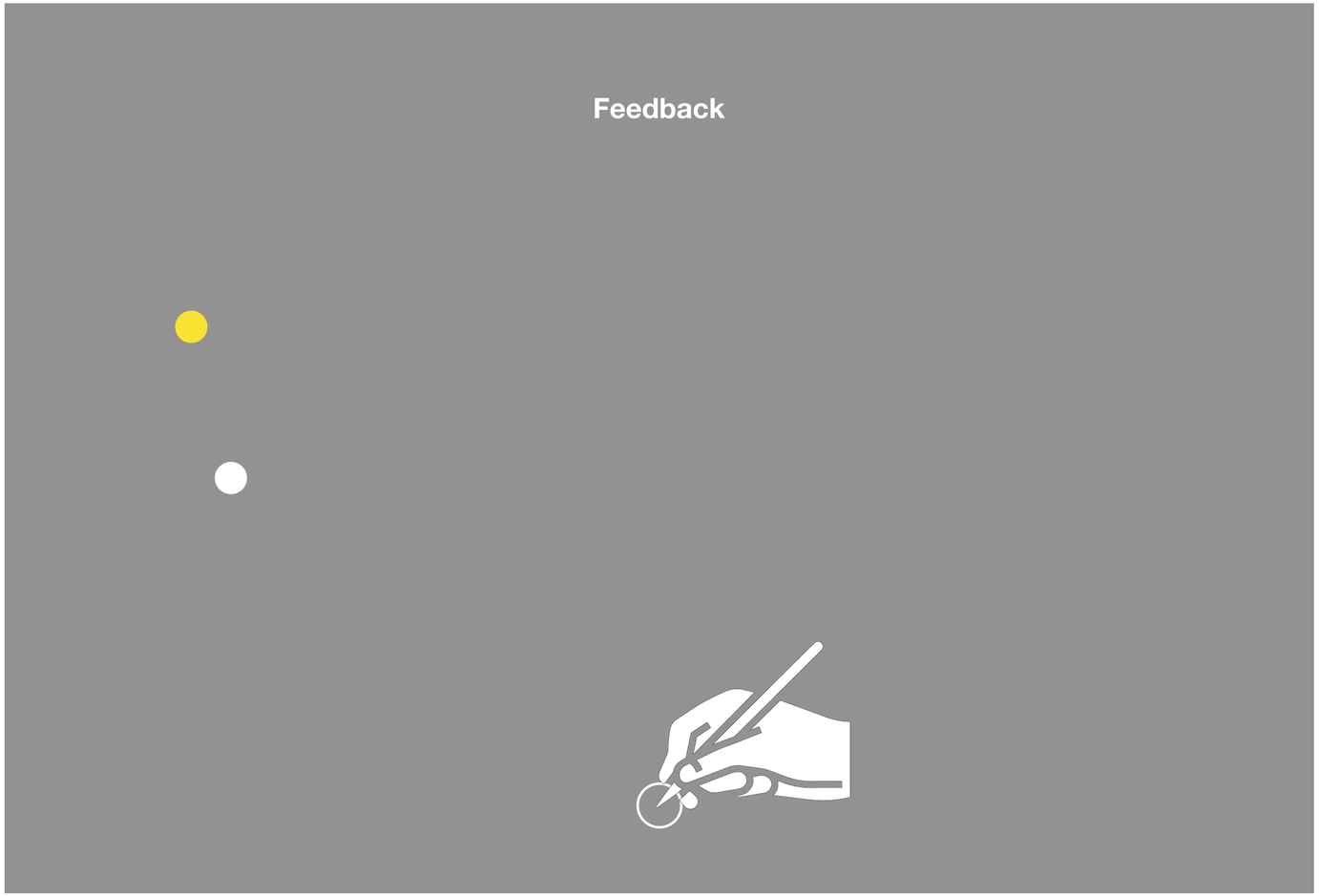

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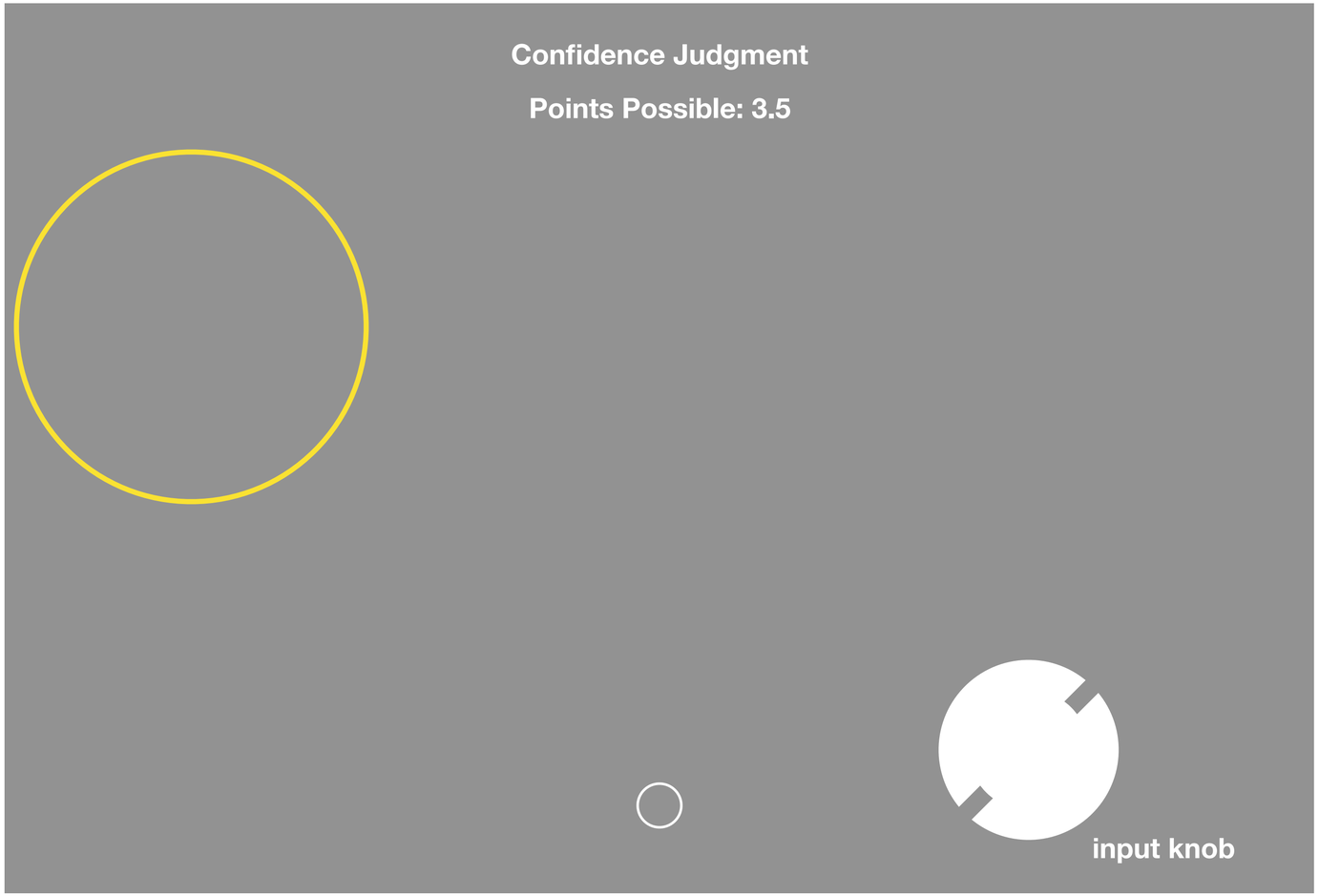

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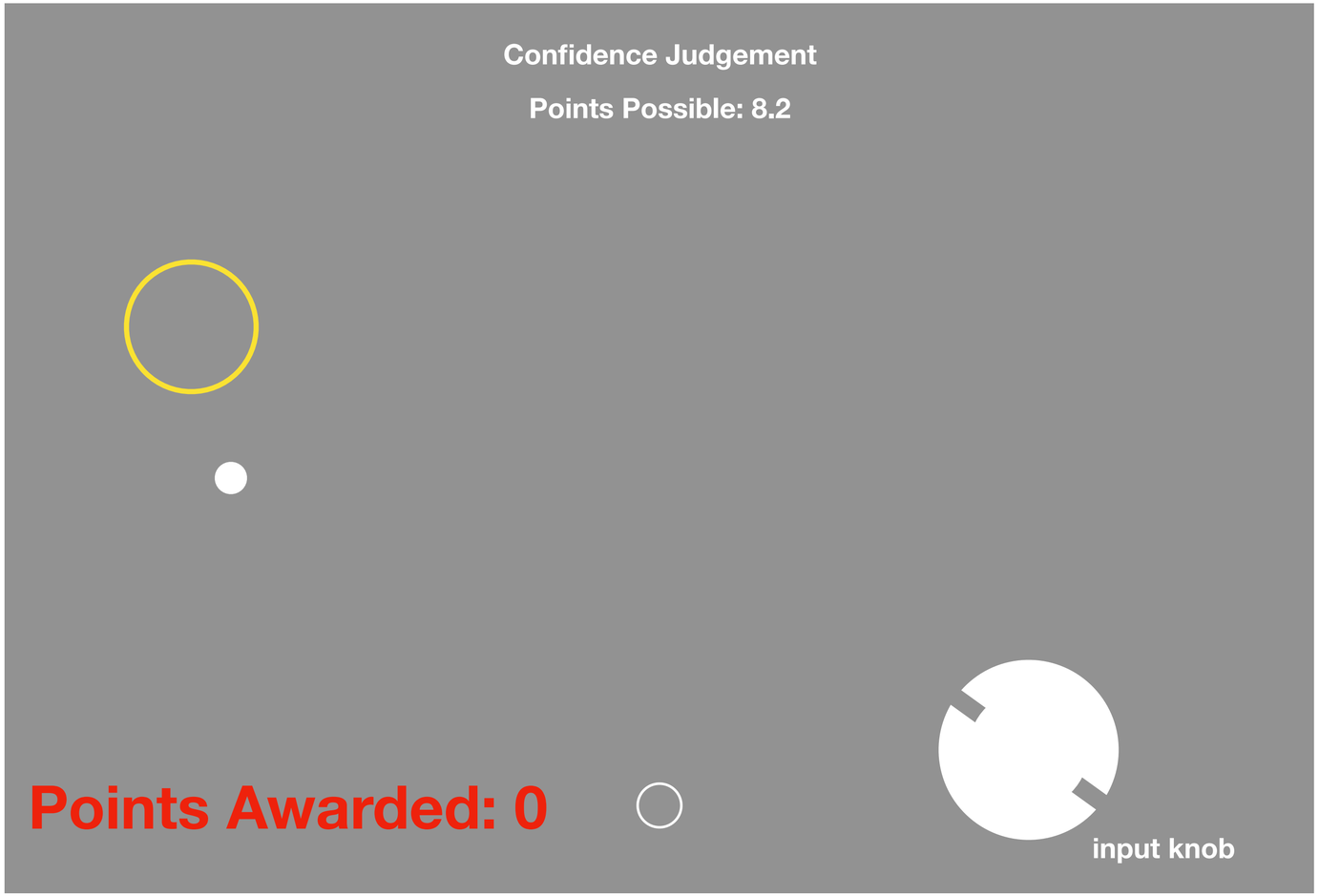

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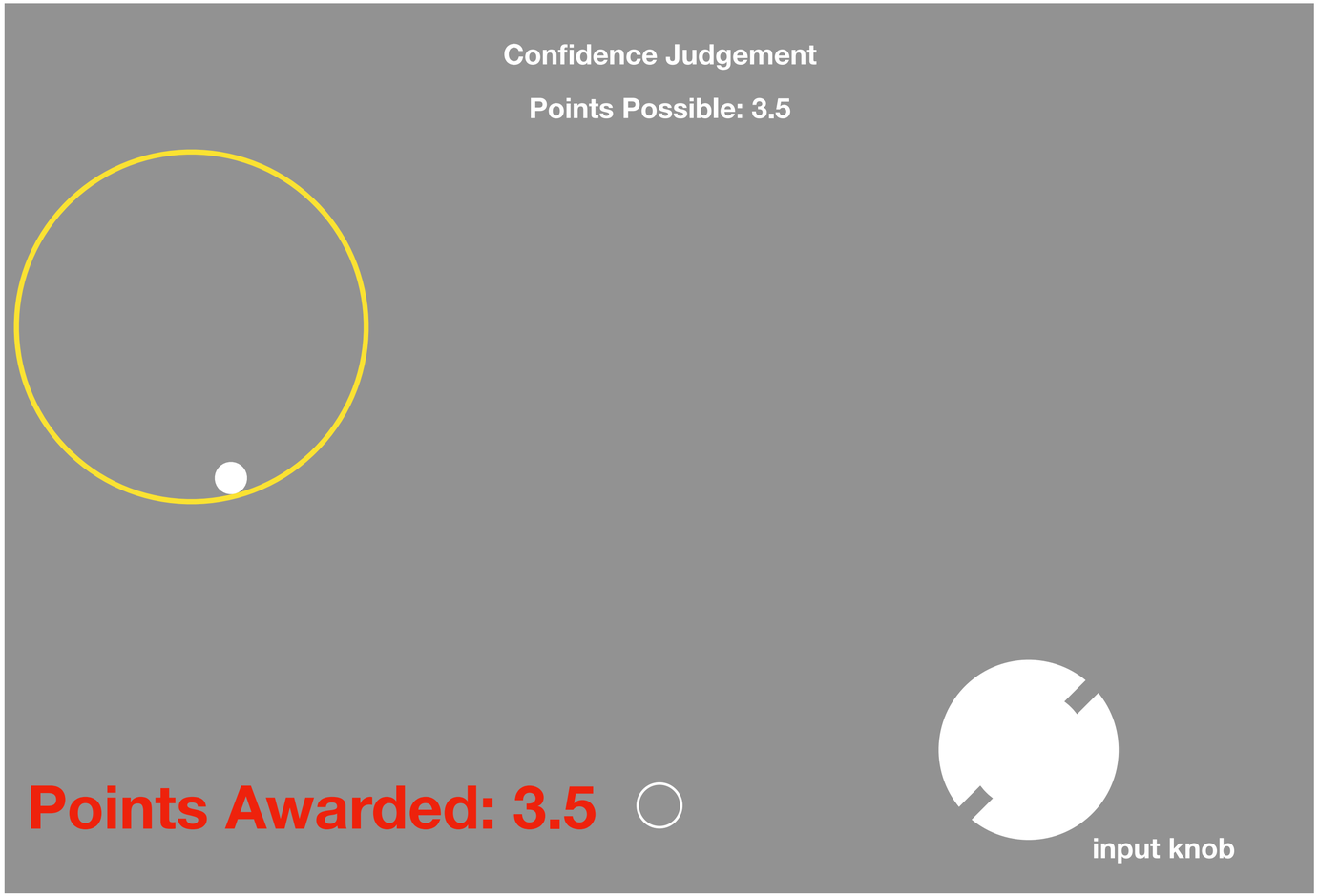
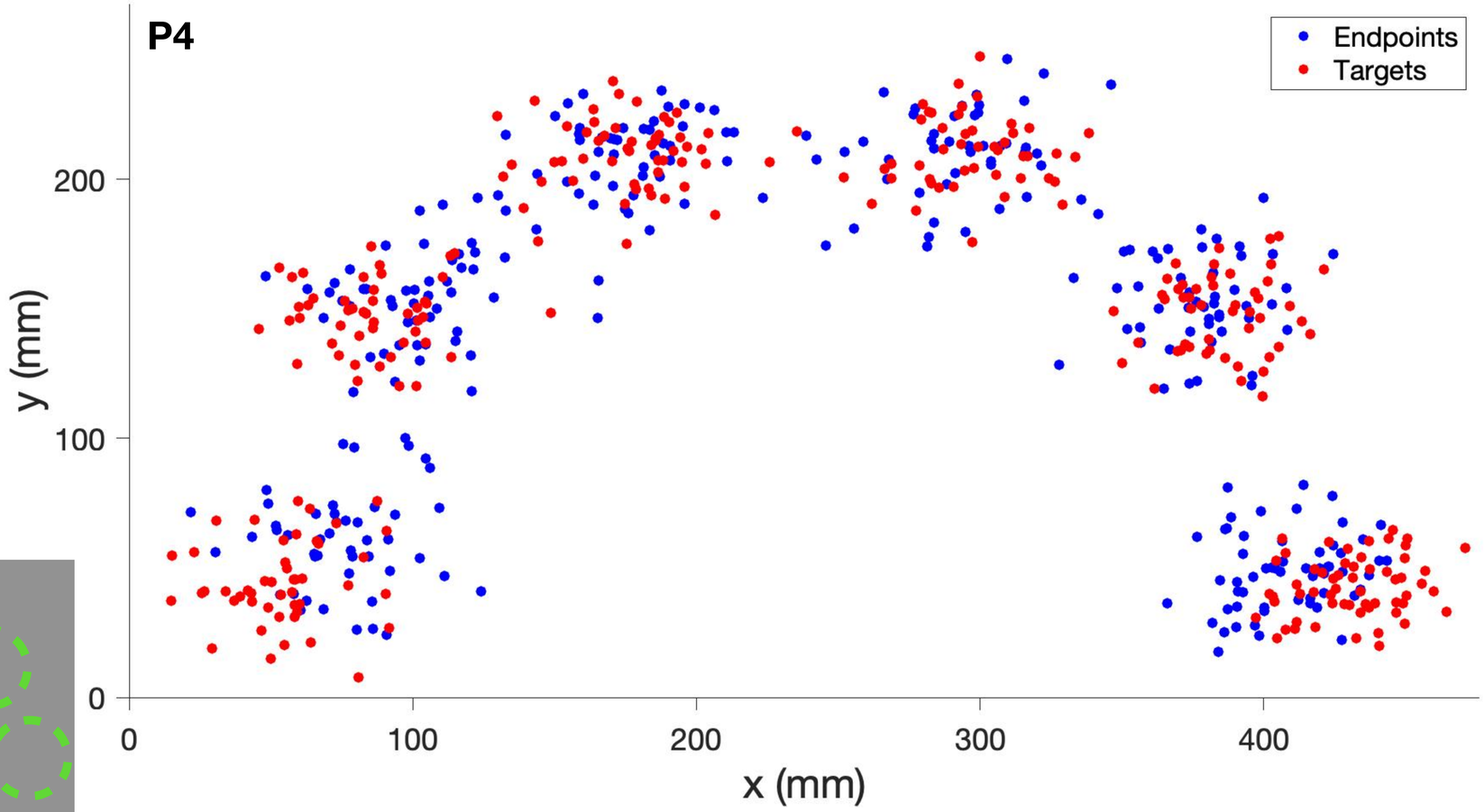
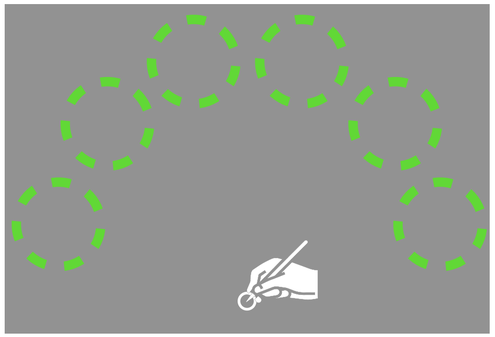


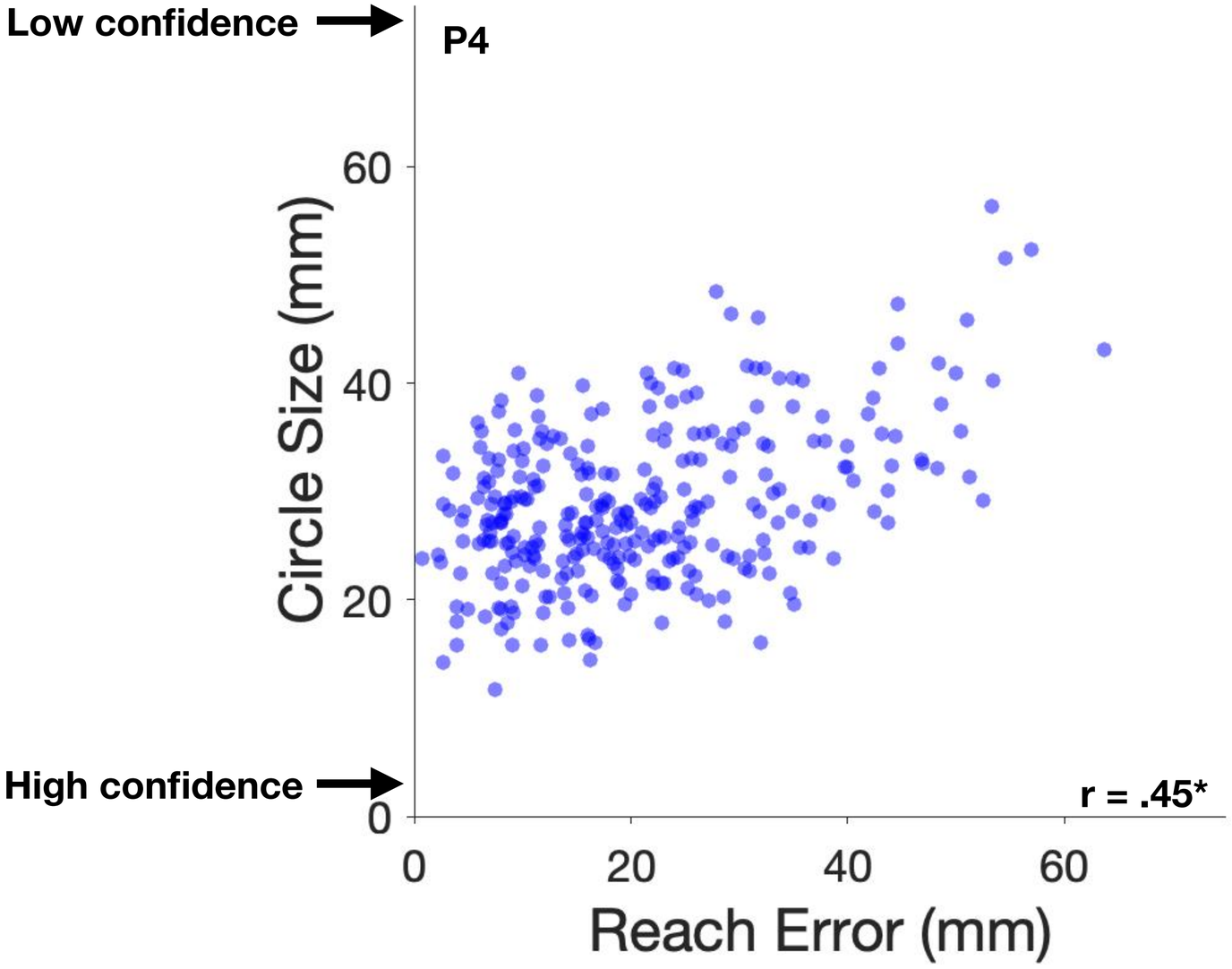
Behavioral Results

Endpoints and Targets





Confidence Performance Correlation



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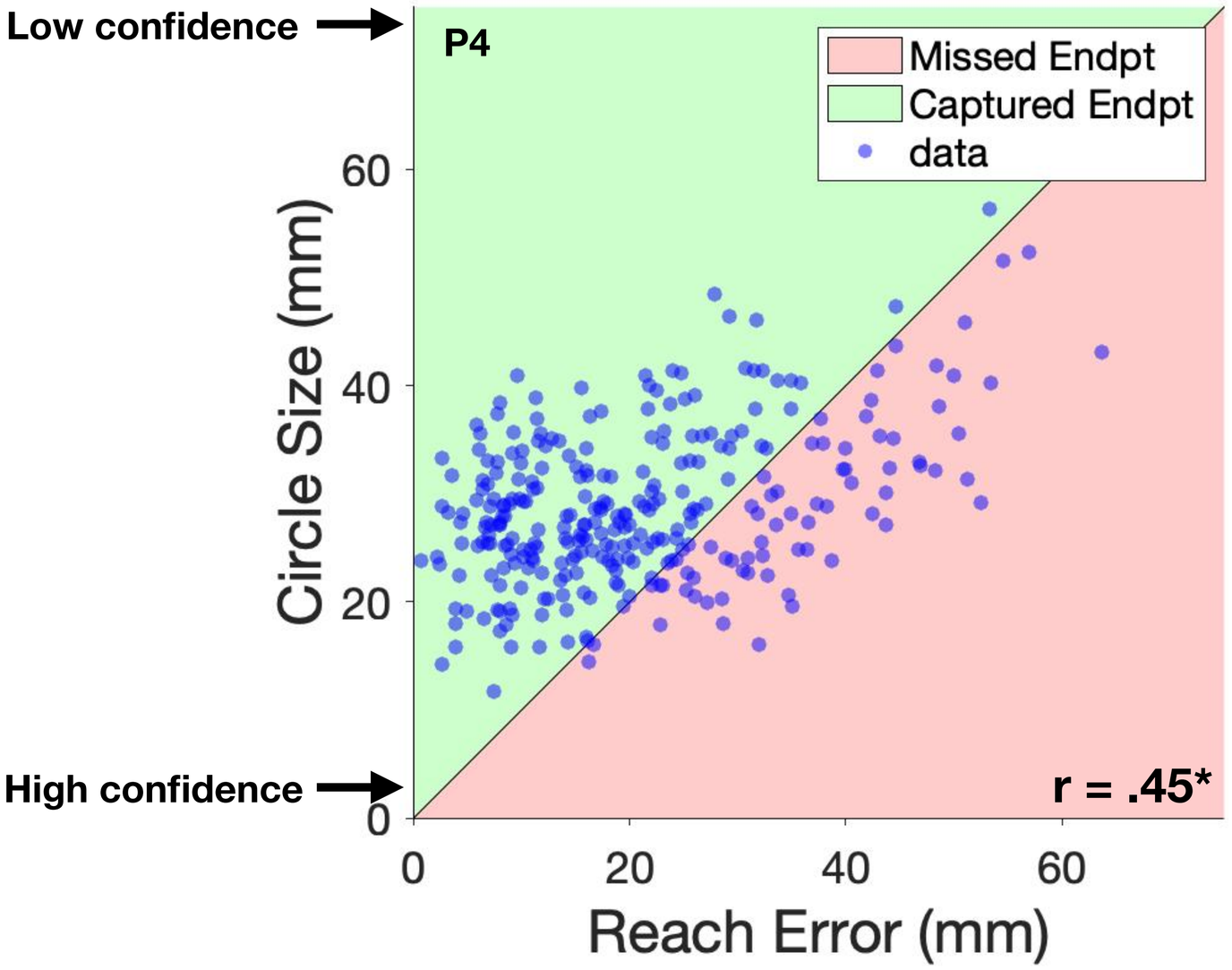

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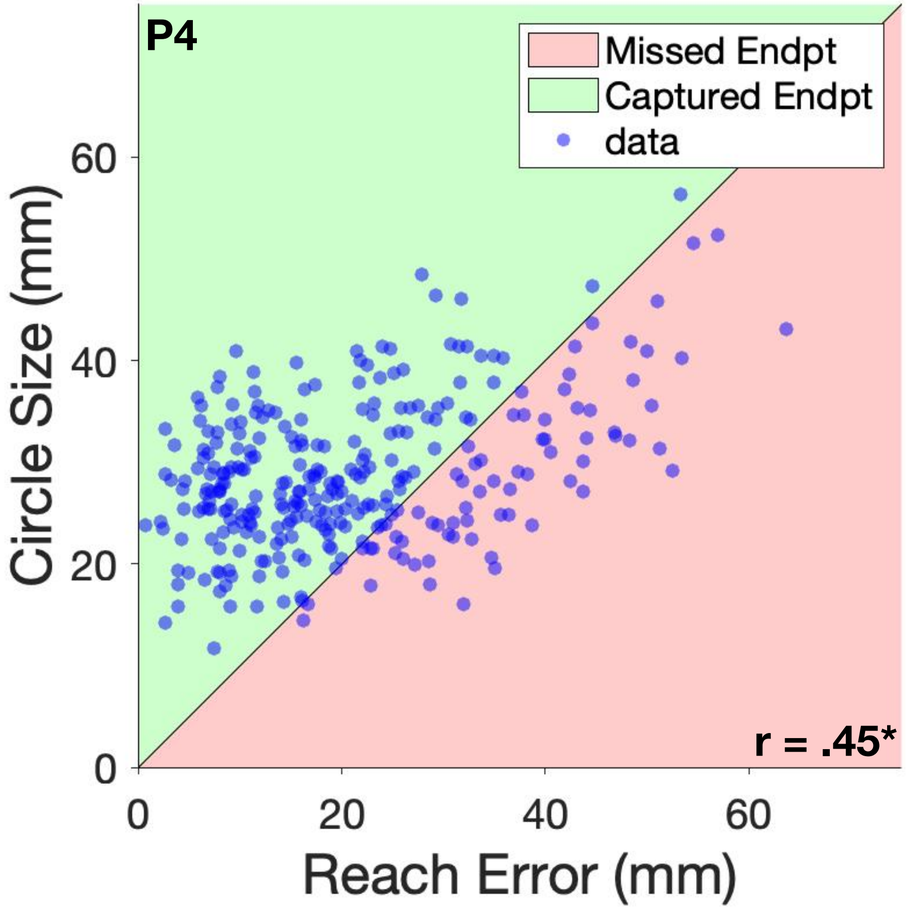

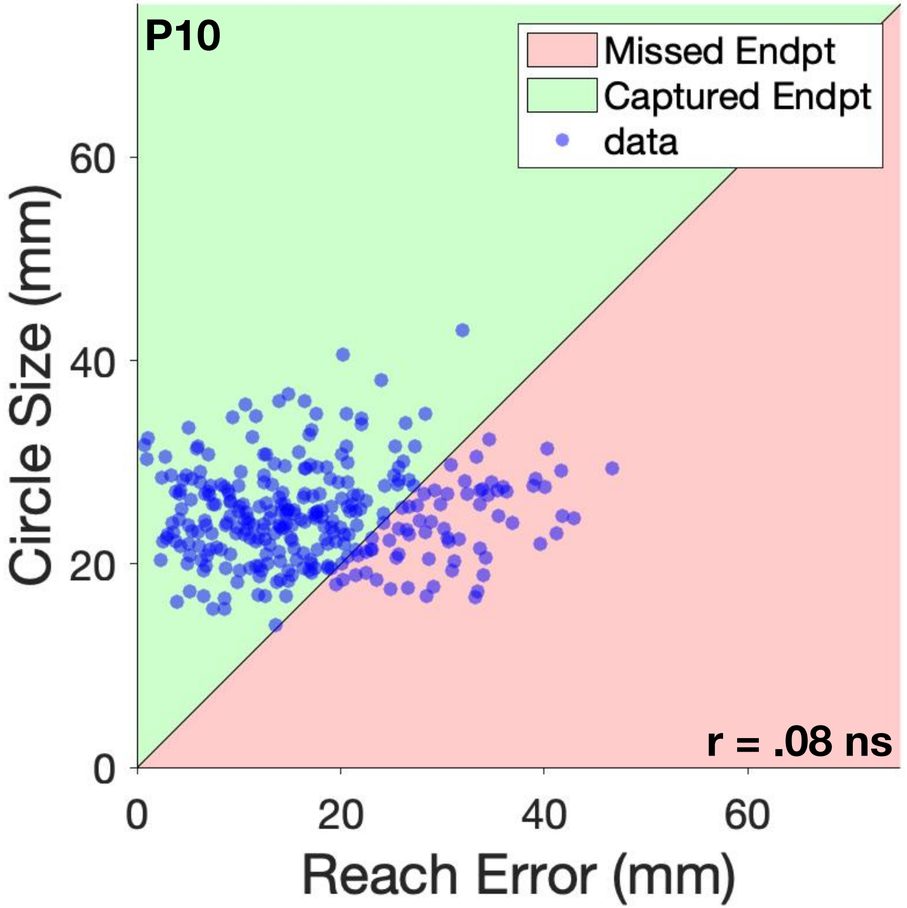

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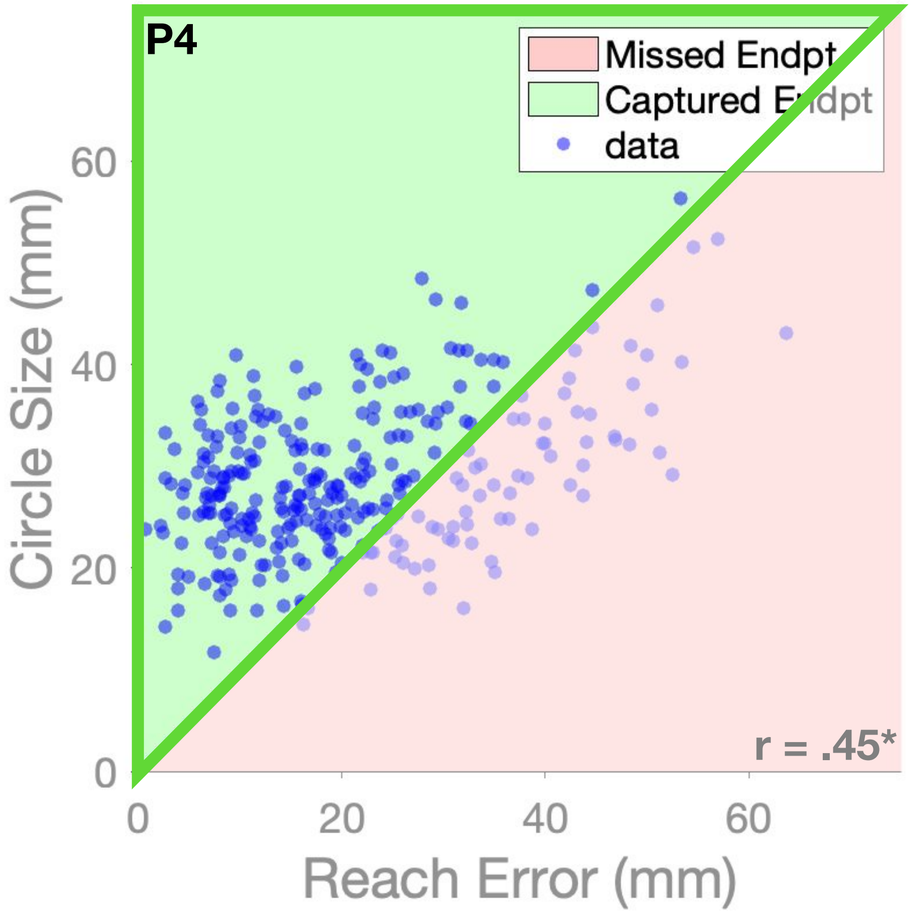
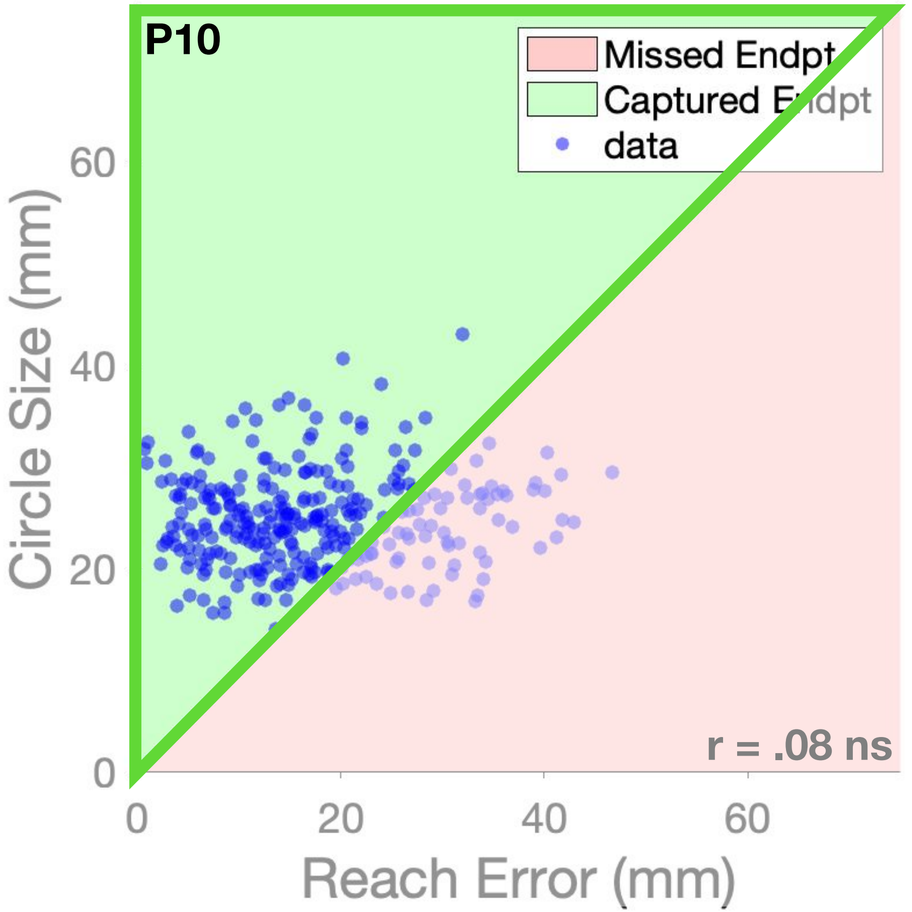
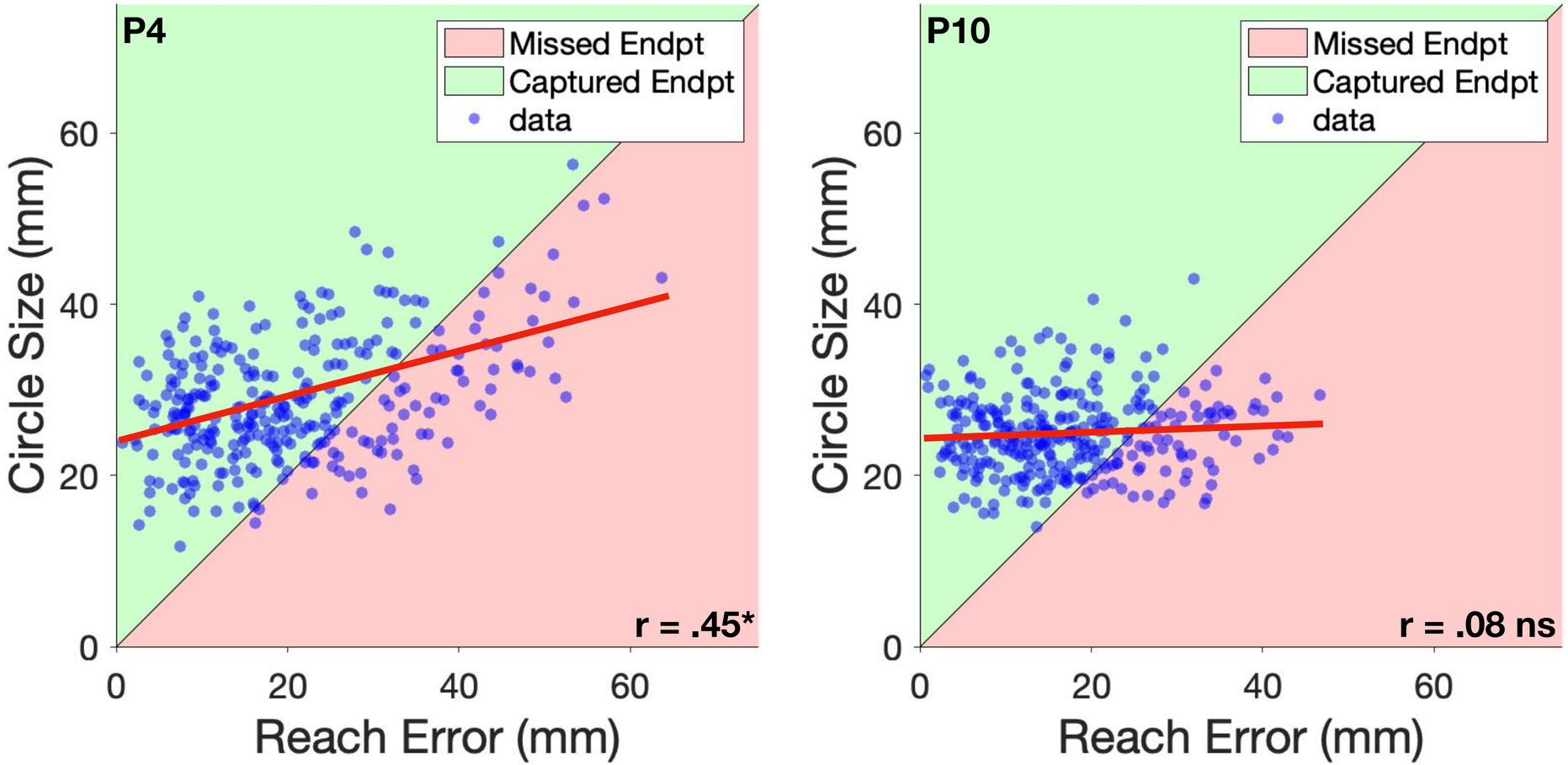




Confidence Performance Correlation

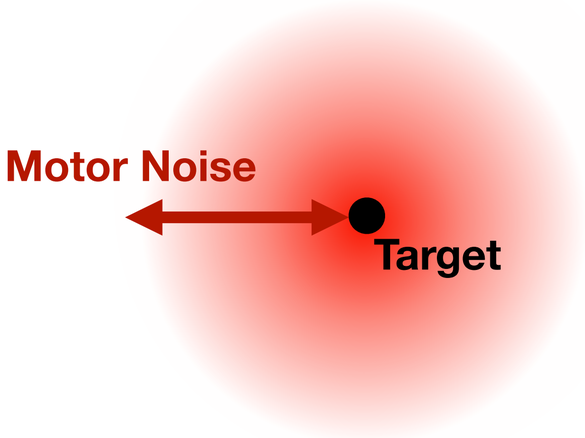


MODEL PARAMETERS

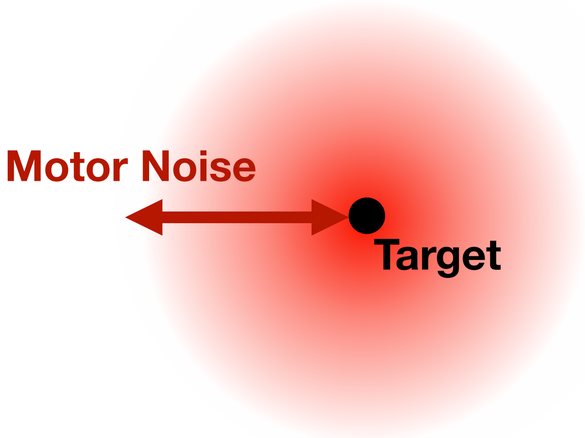
MODELS	Prospective Cues	Retrospective Cues	Setting Noise
Ideal Observer	✓	✓	✓
Retrospective Observer	✗	✓	✓
Prospective Observer	✓	✗	✓

Ideal Observer Model

Ideal Observer Model

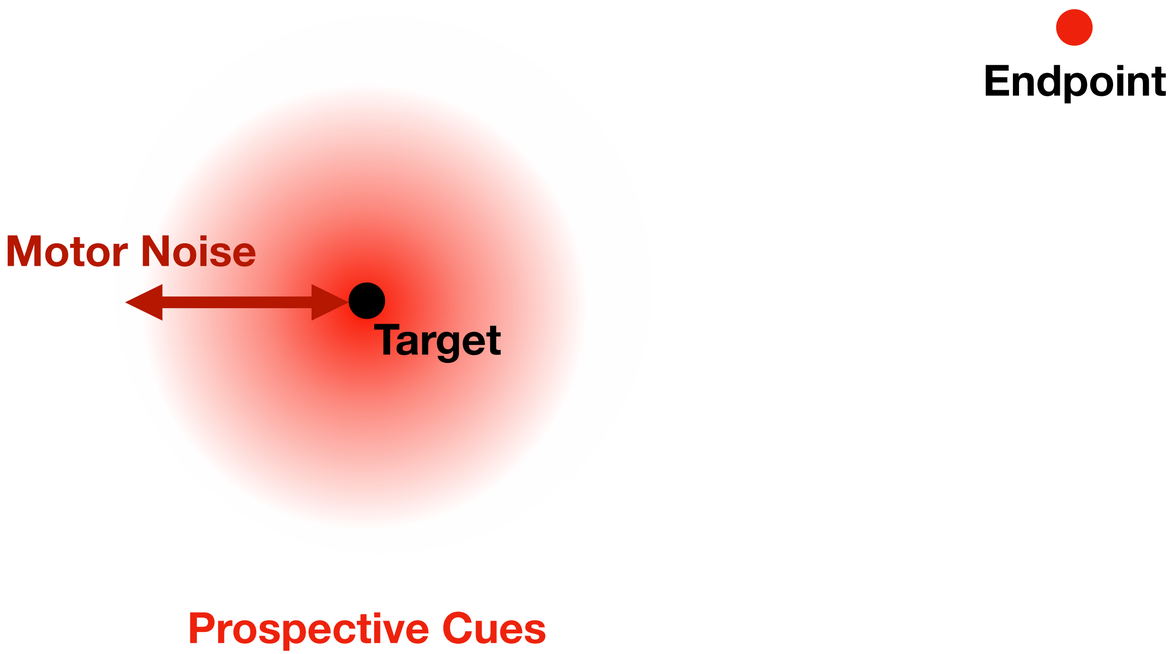


Ideal Observer Model

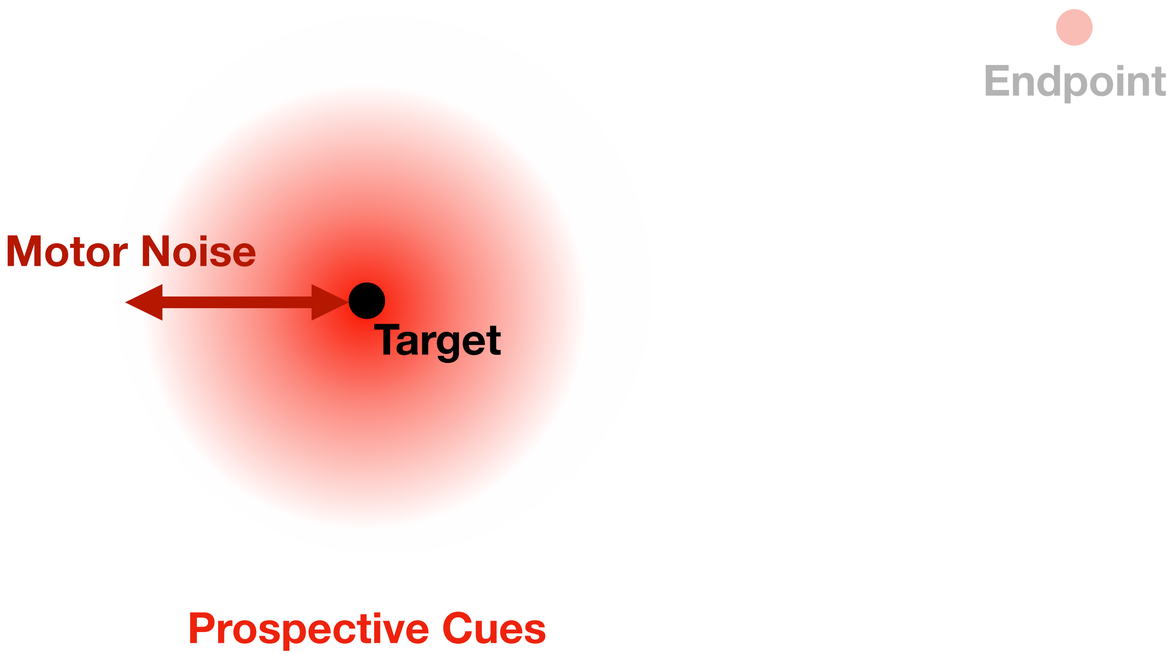


Prospective Cues

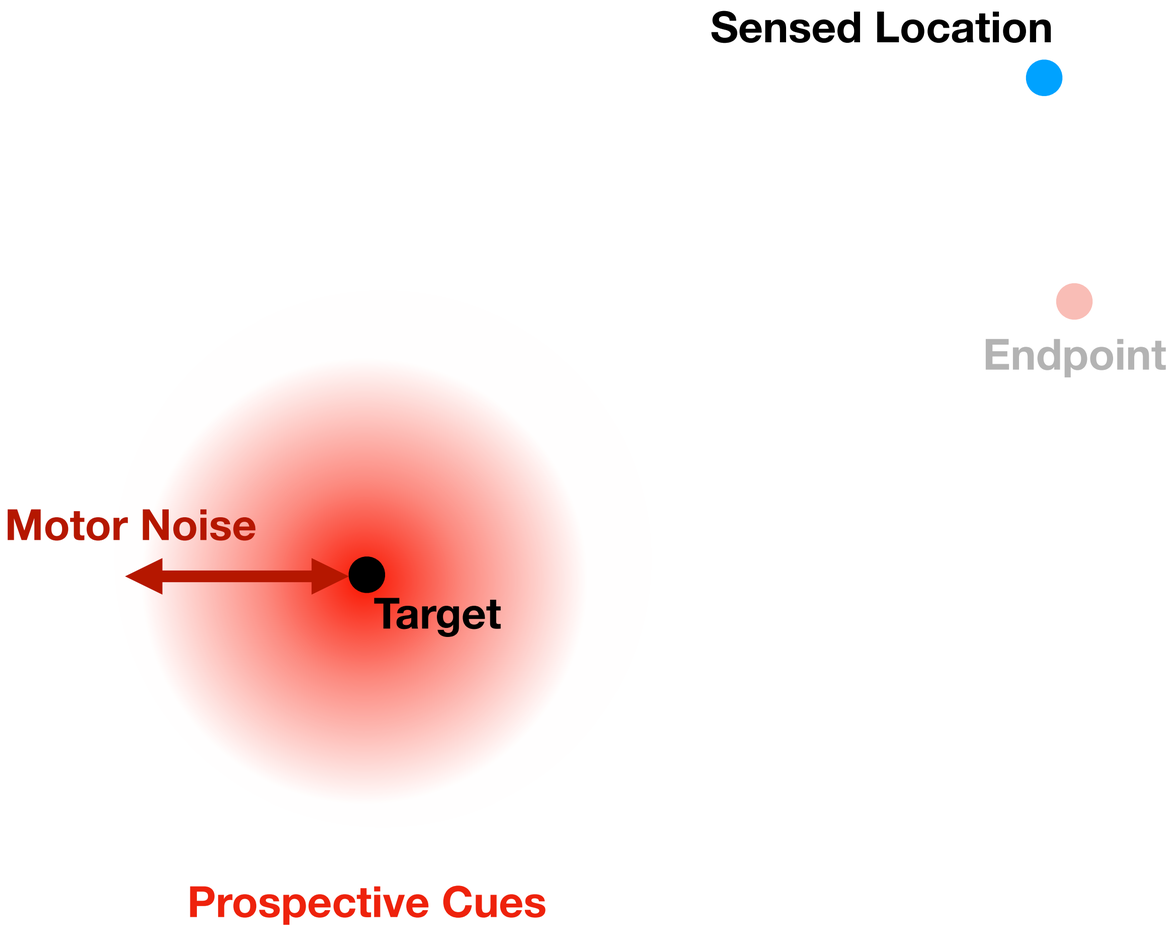
Ideal Observer Model



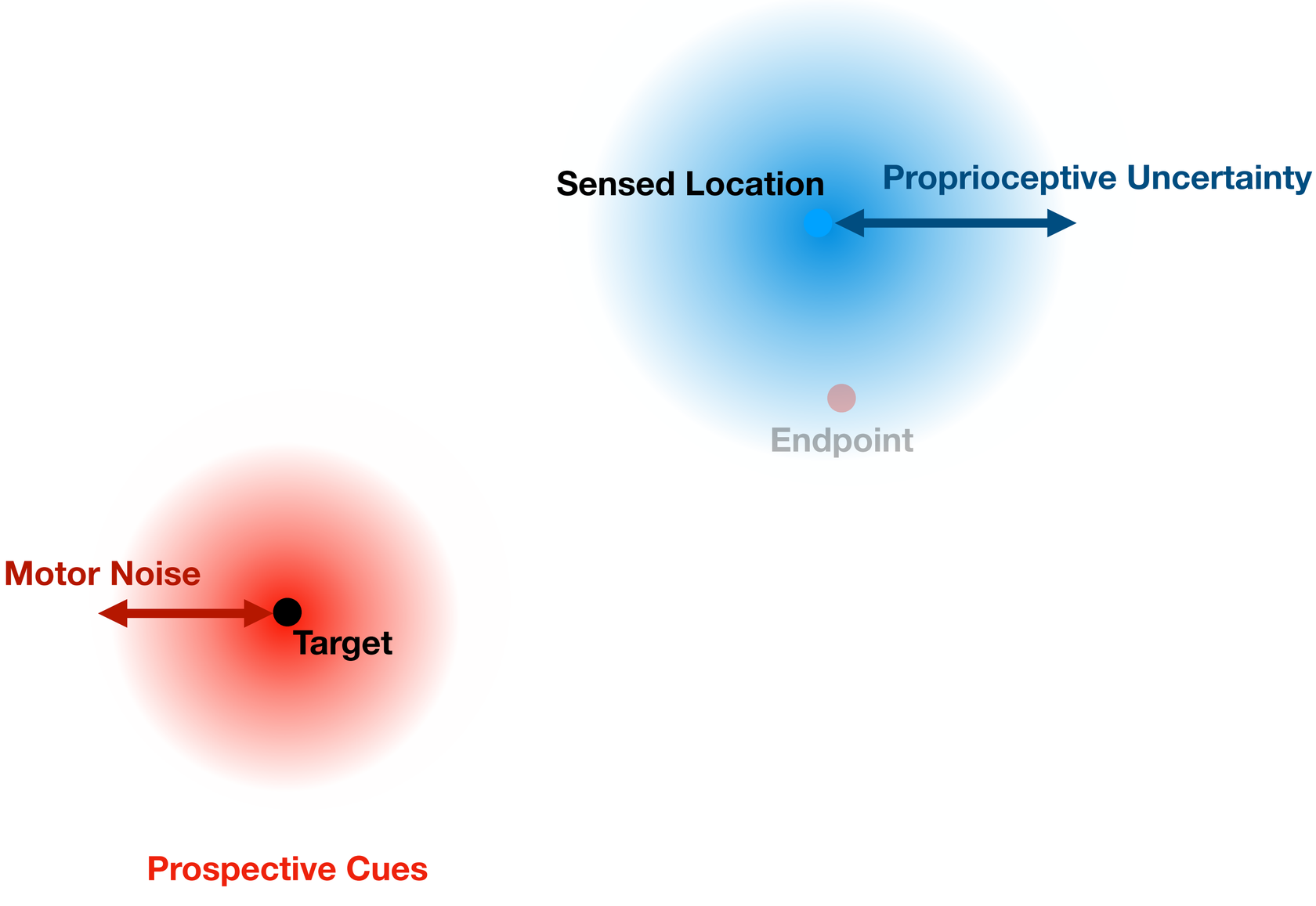
Ideal Observer Model



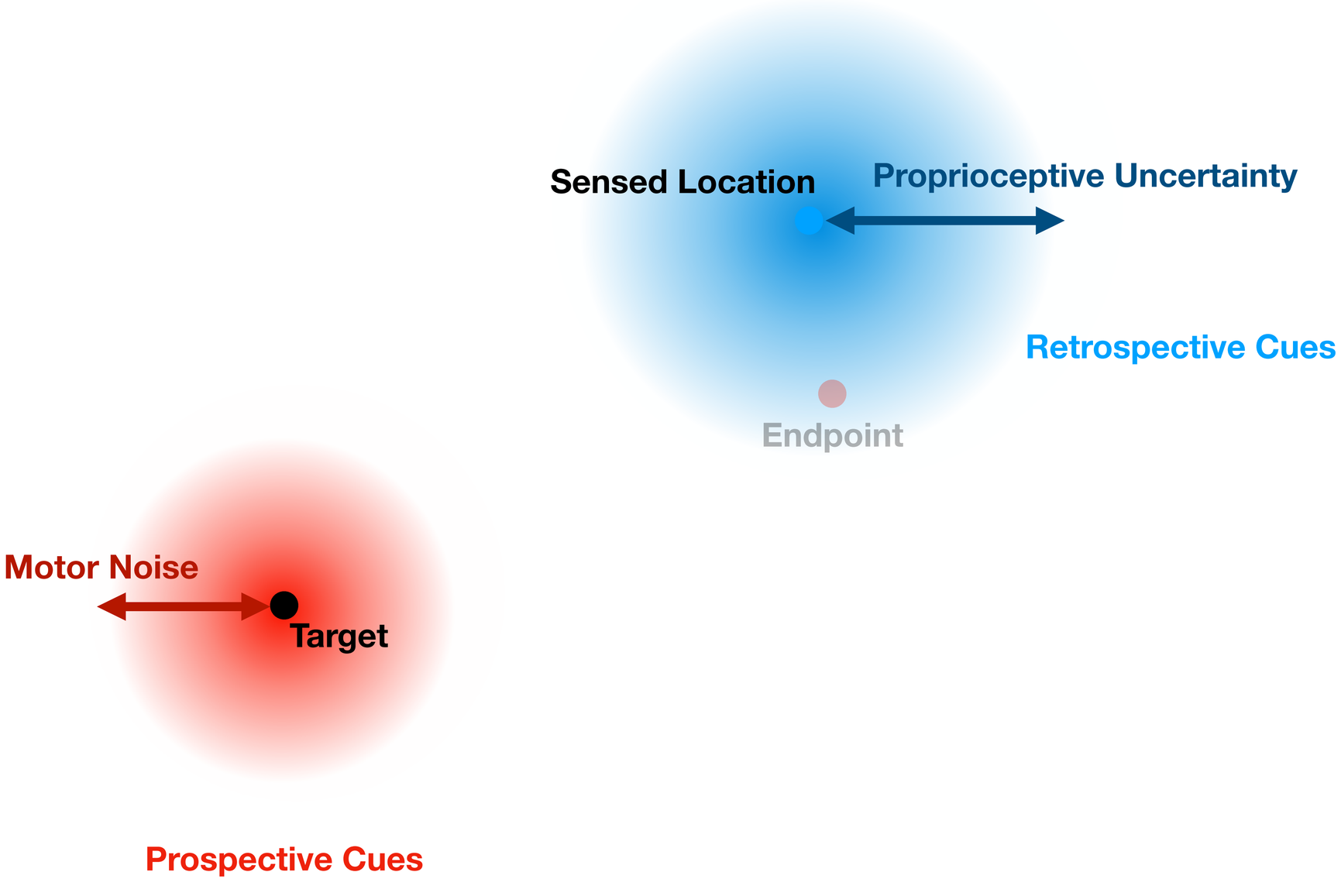
Ideal Observer Model



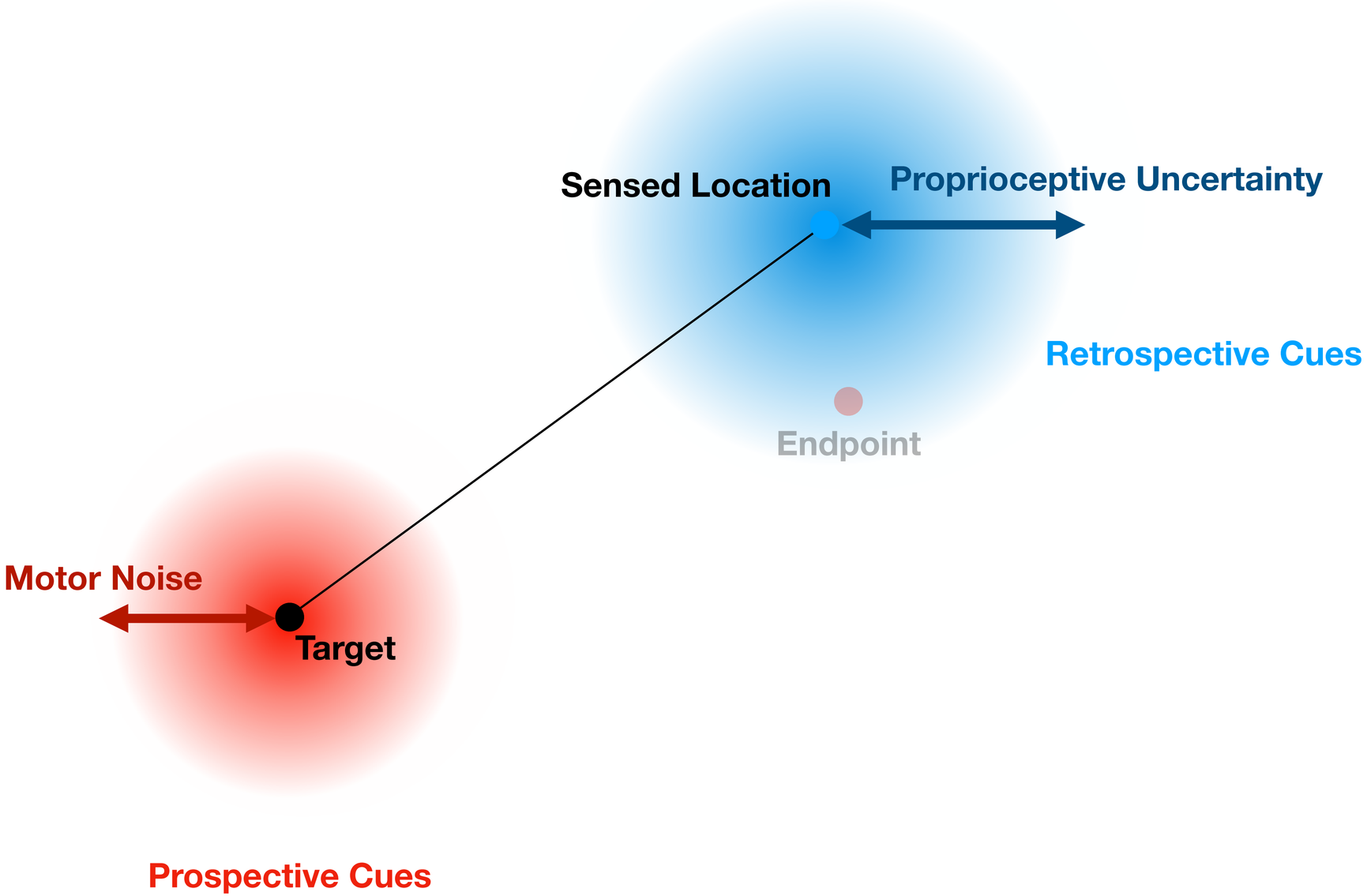
Ideal Observer Model



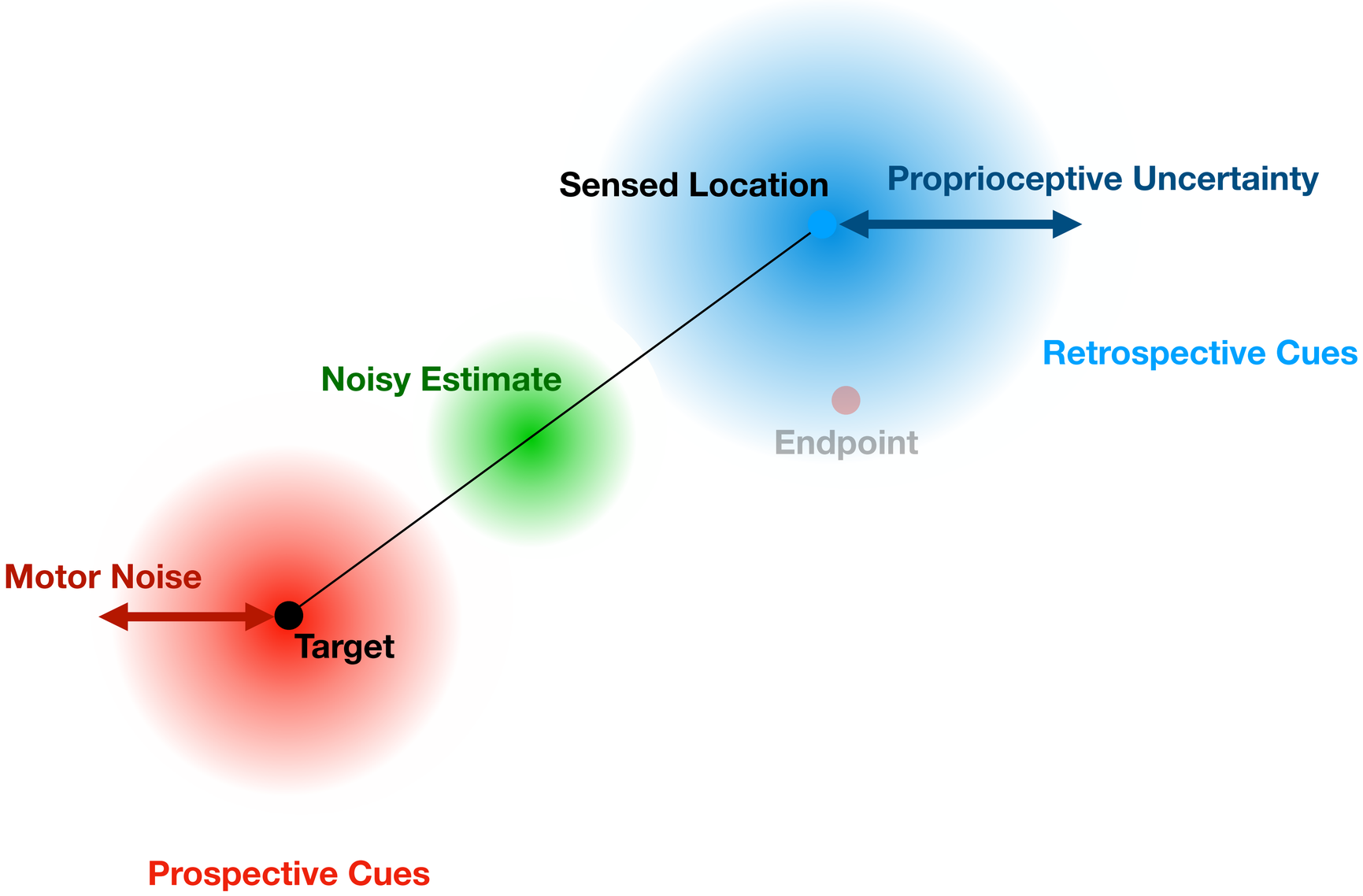
Ideal Observer Model



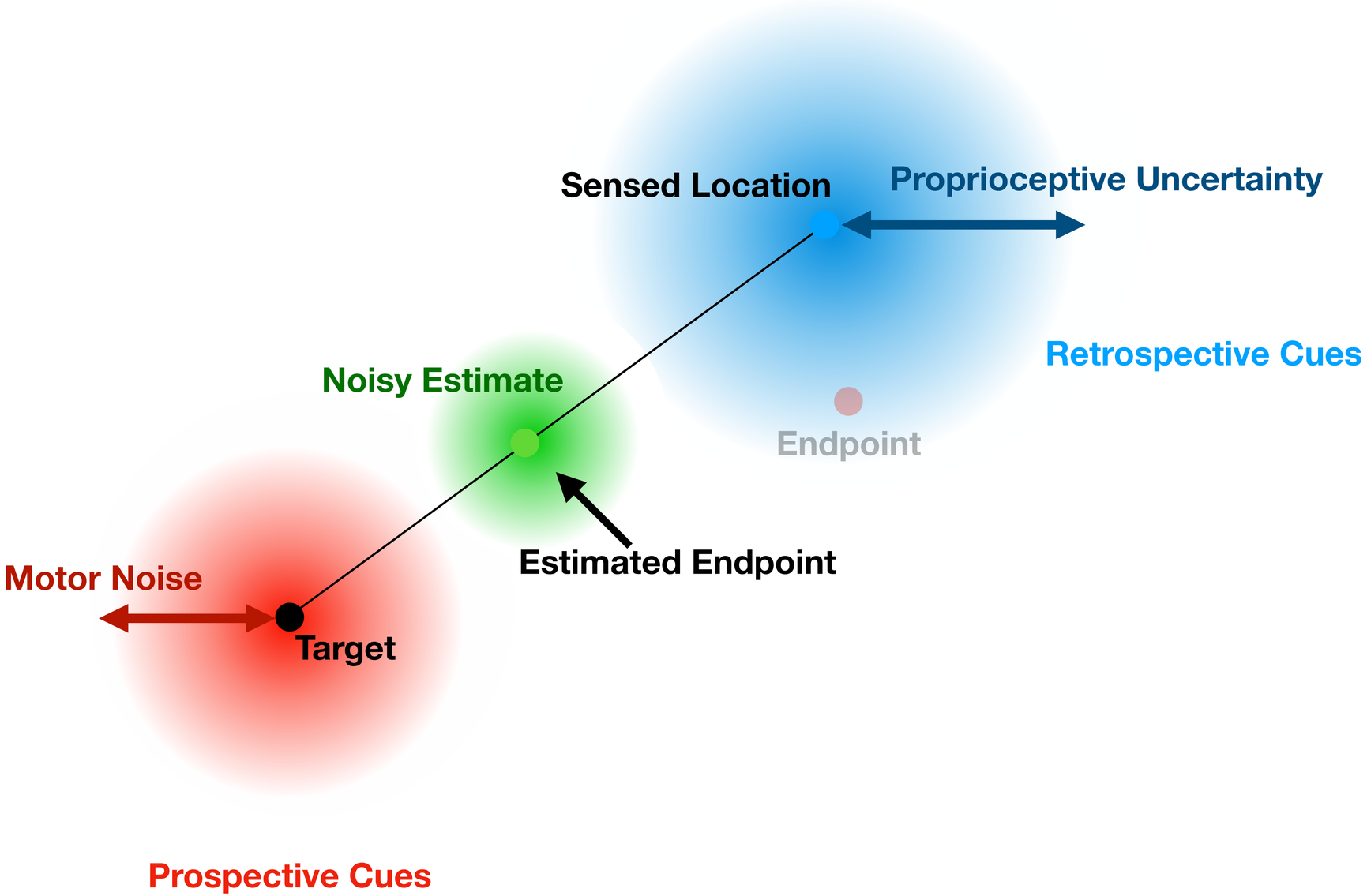
Ideal Observer Model



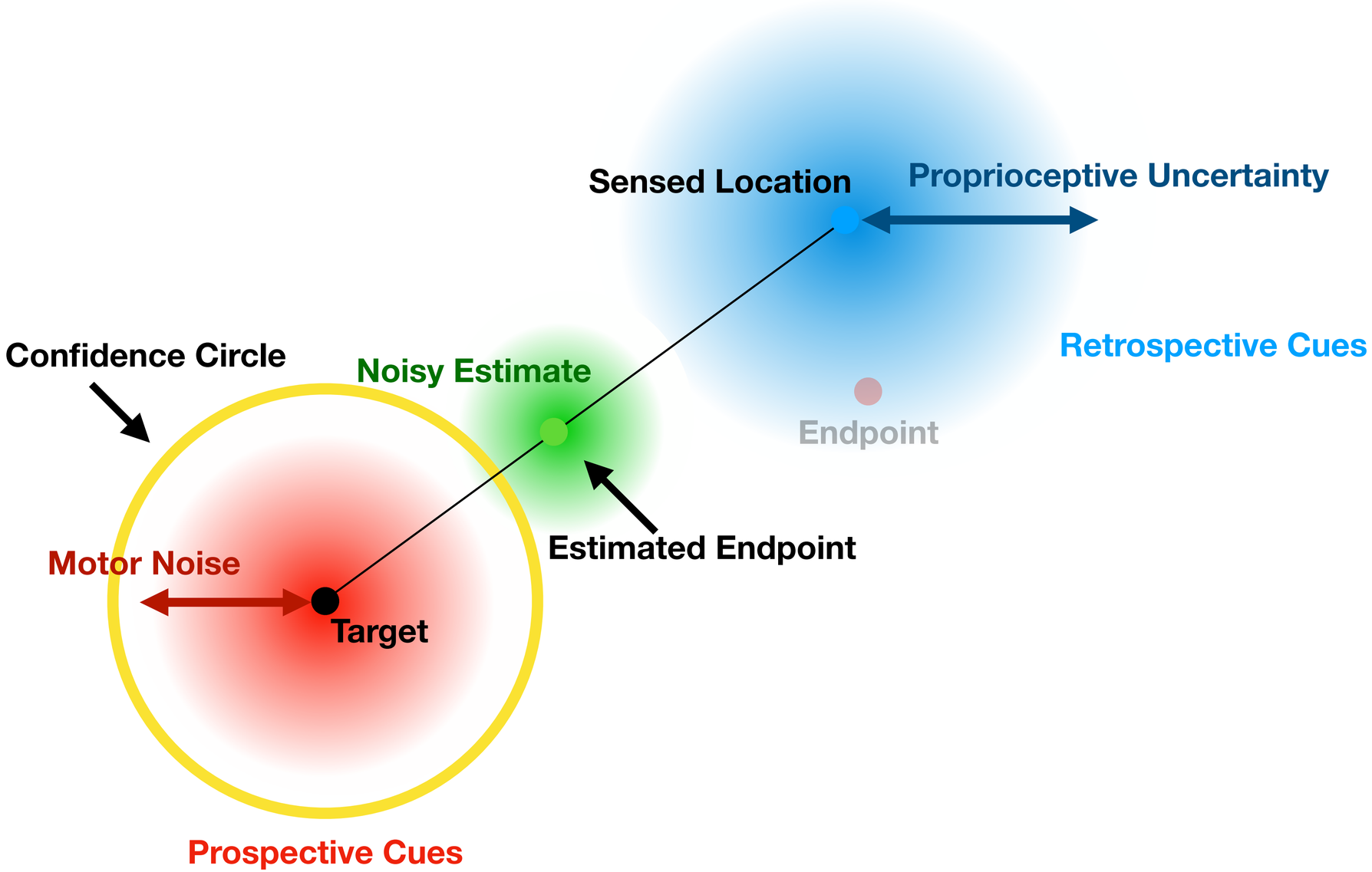
Ideal Observer Model



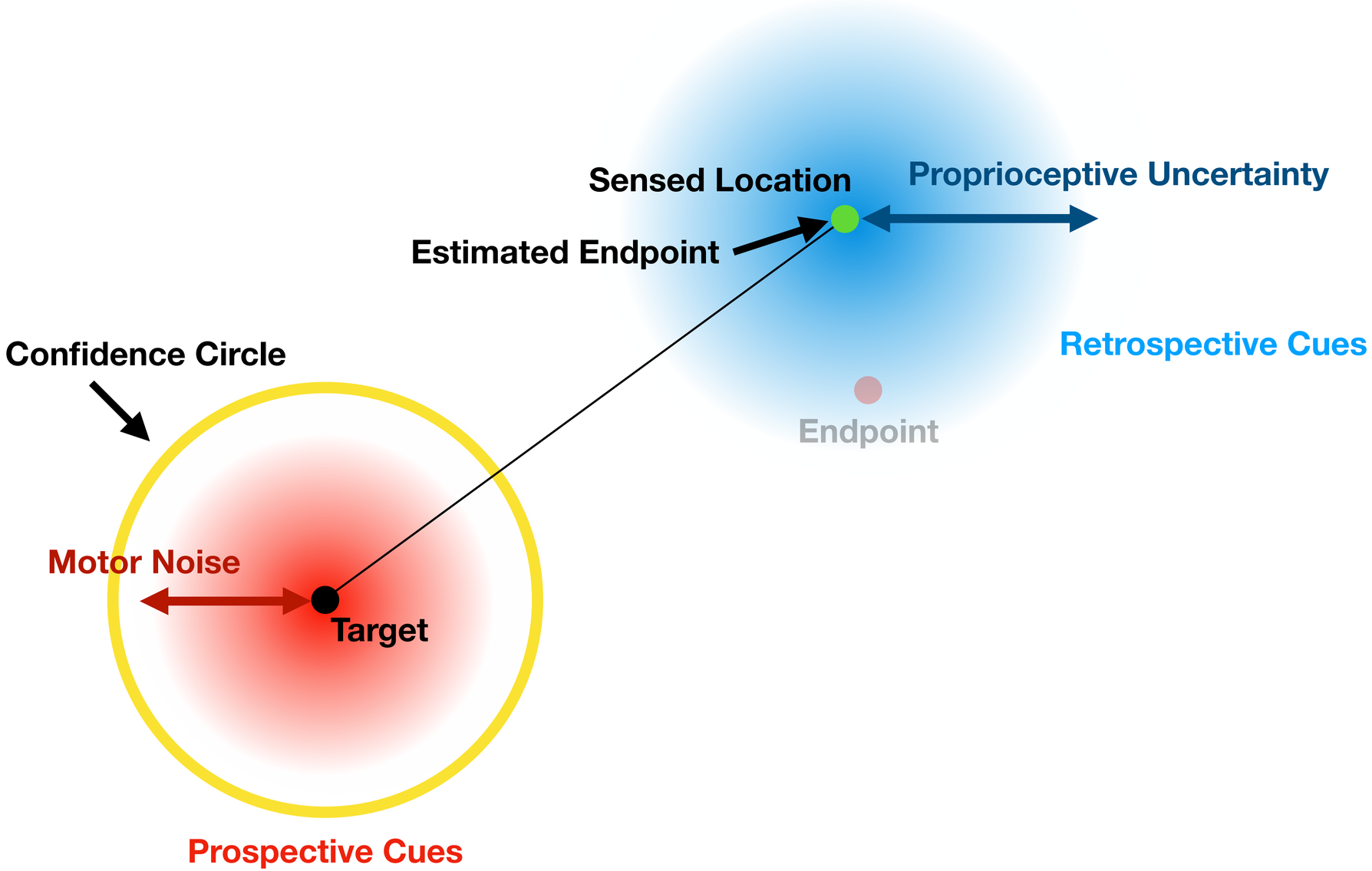
Ideal Observer Model



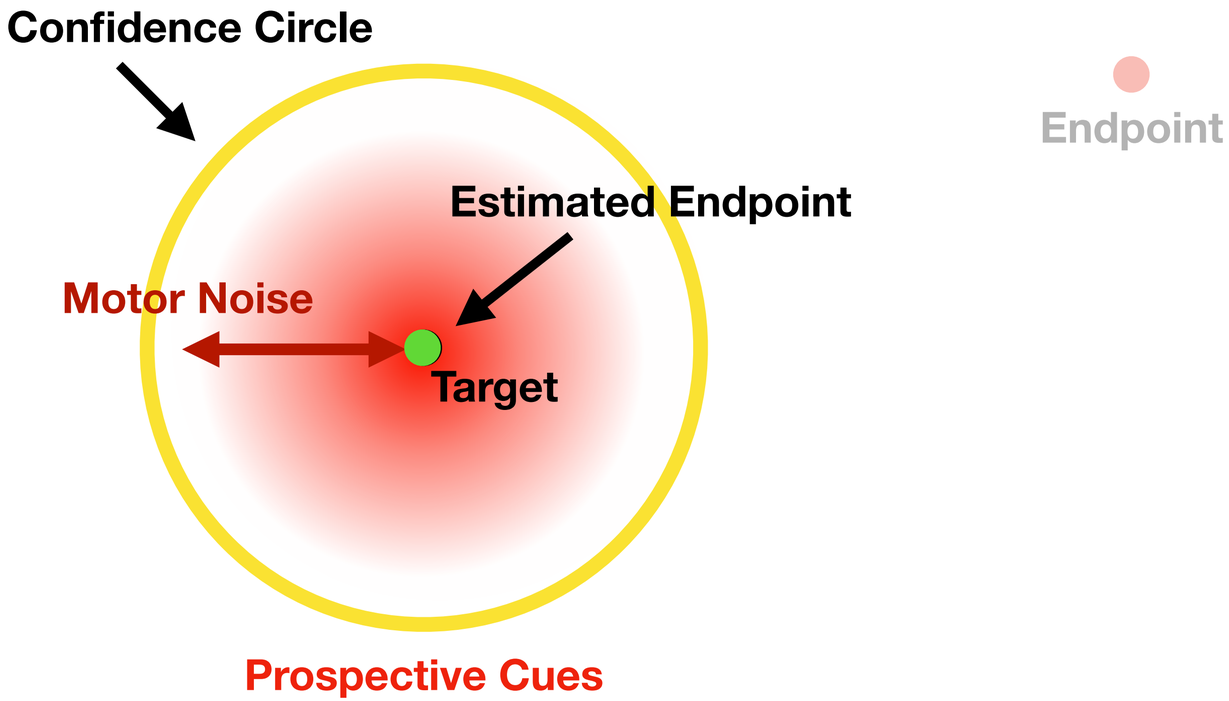
Ideal Observer Model



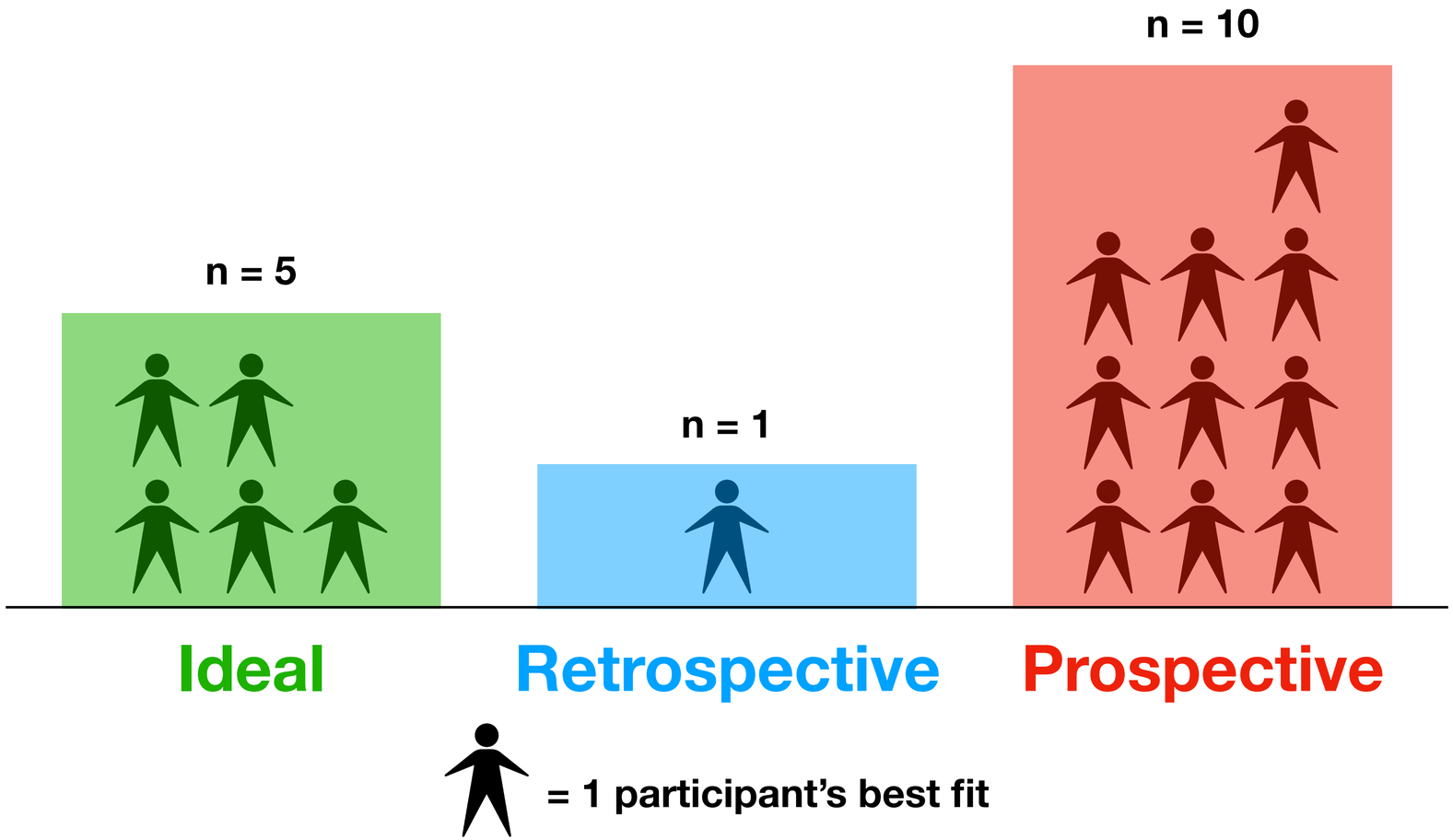
Retrospective Observer Model



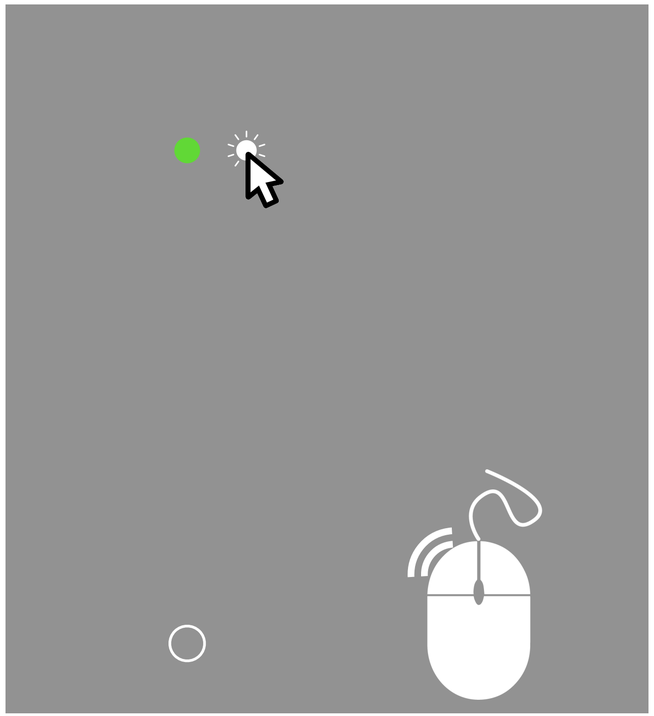
Prospective Observer Model



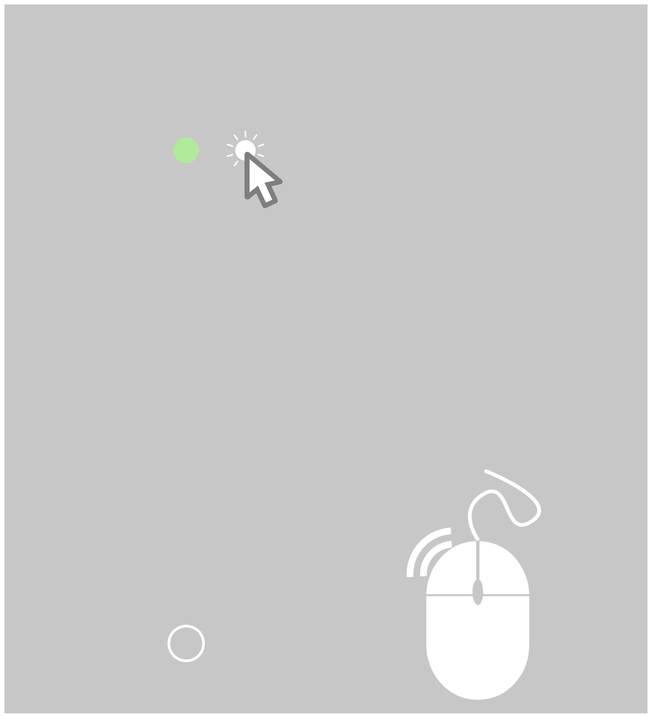
BIC Model Comparison

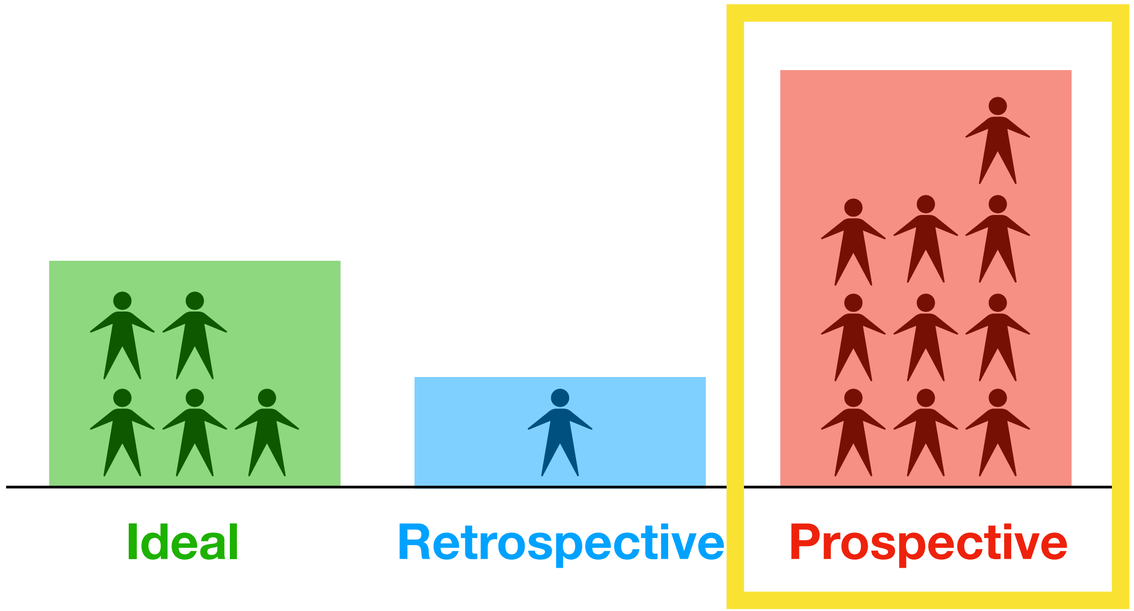


- Observers can use proprioception when prompted

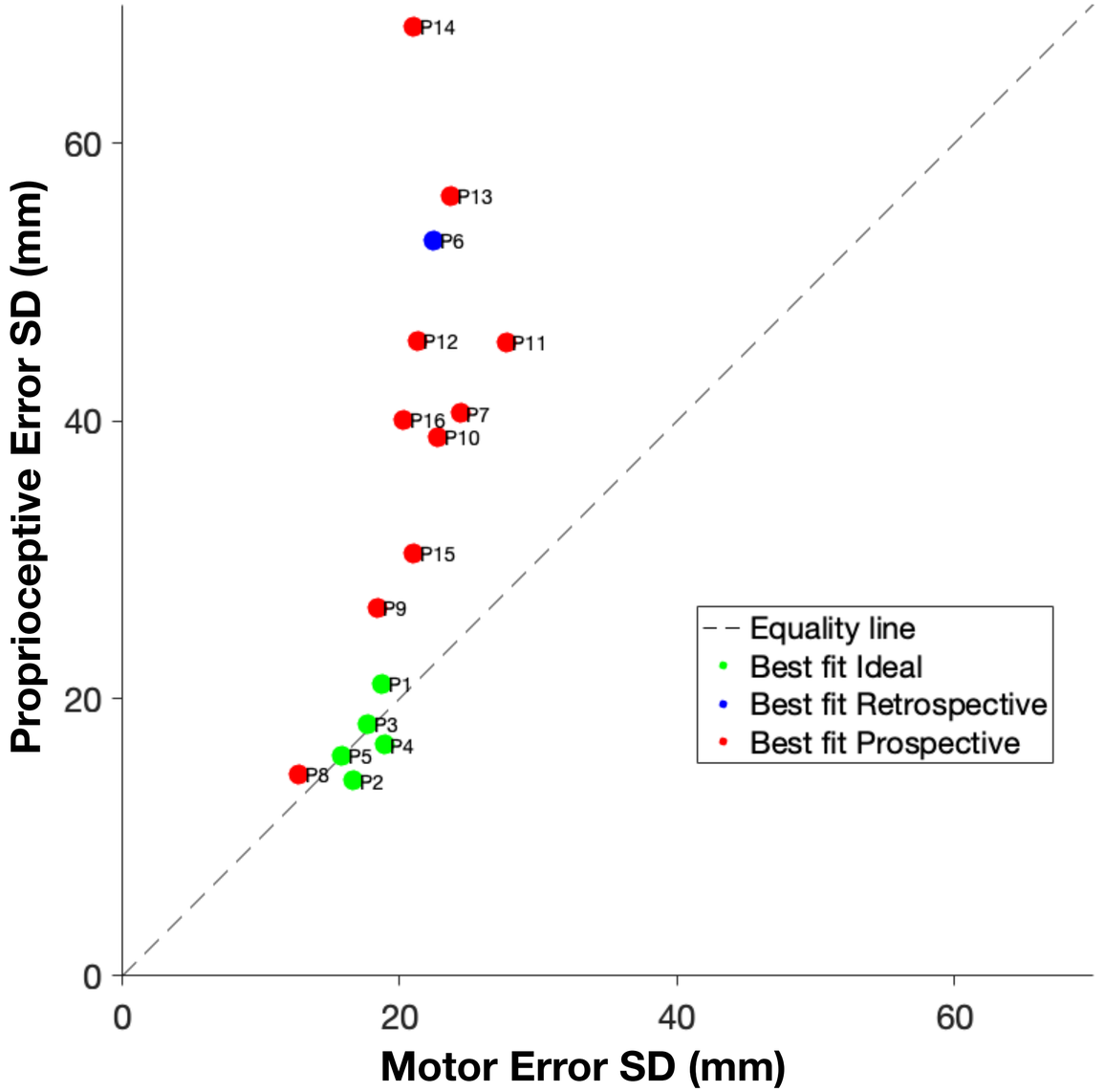


- Observers can use proprioception when prompted
- Proprioceptive information not always used when making a sensorimotor confidence judgment

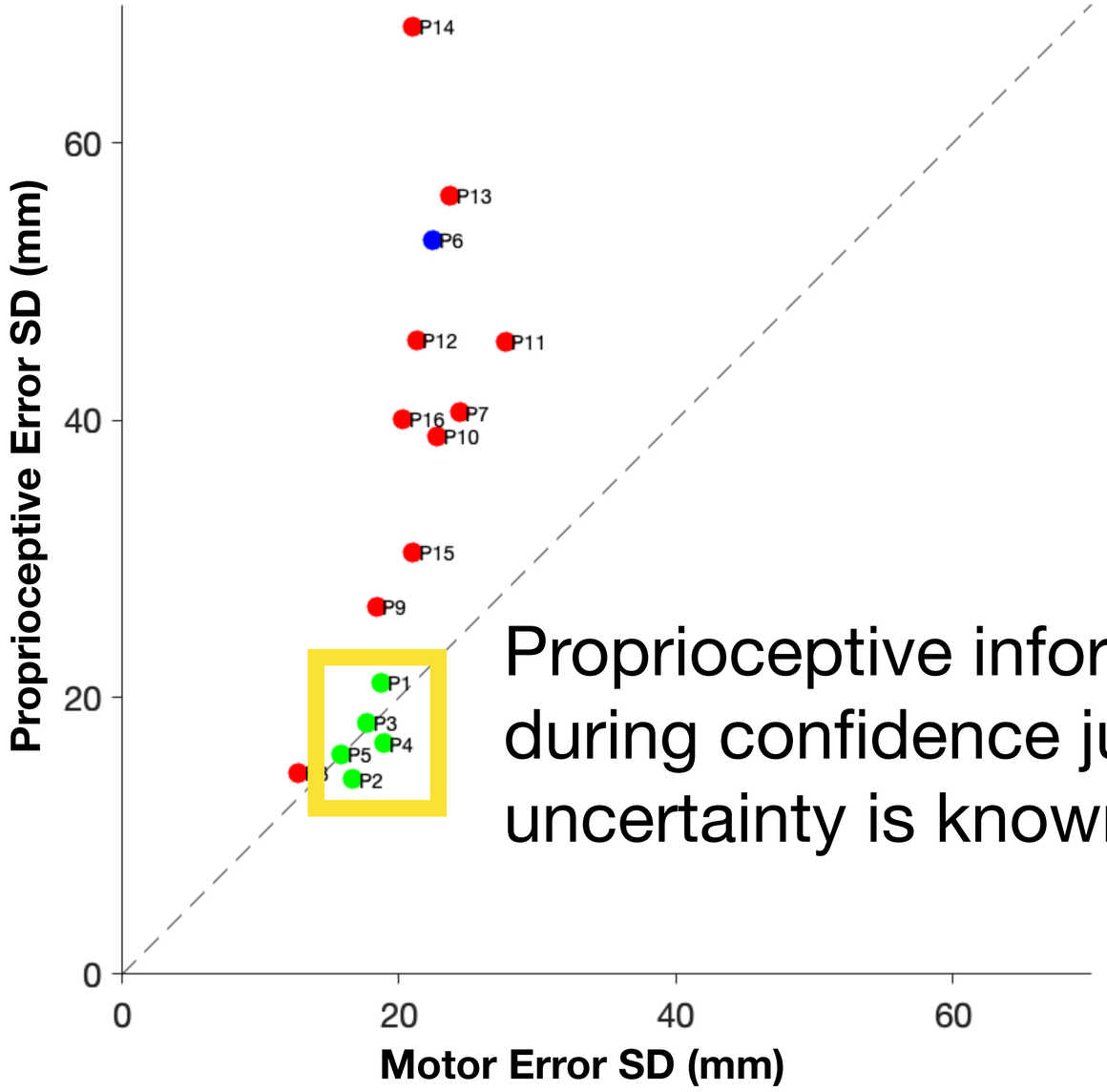




Best Fit Model Parameters

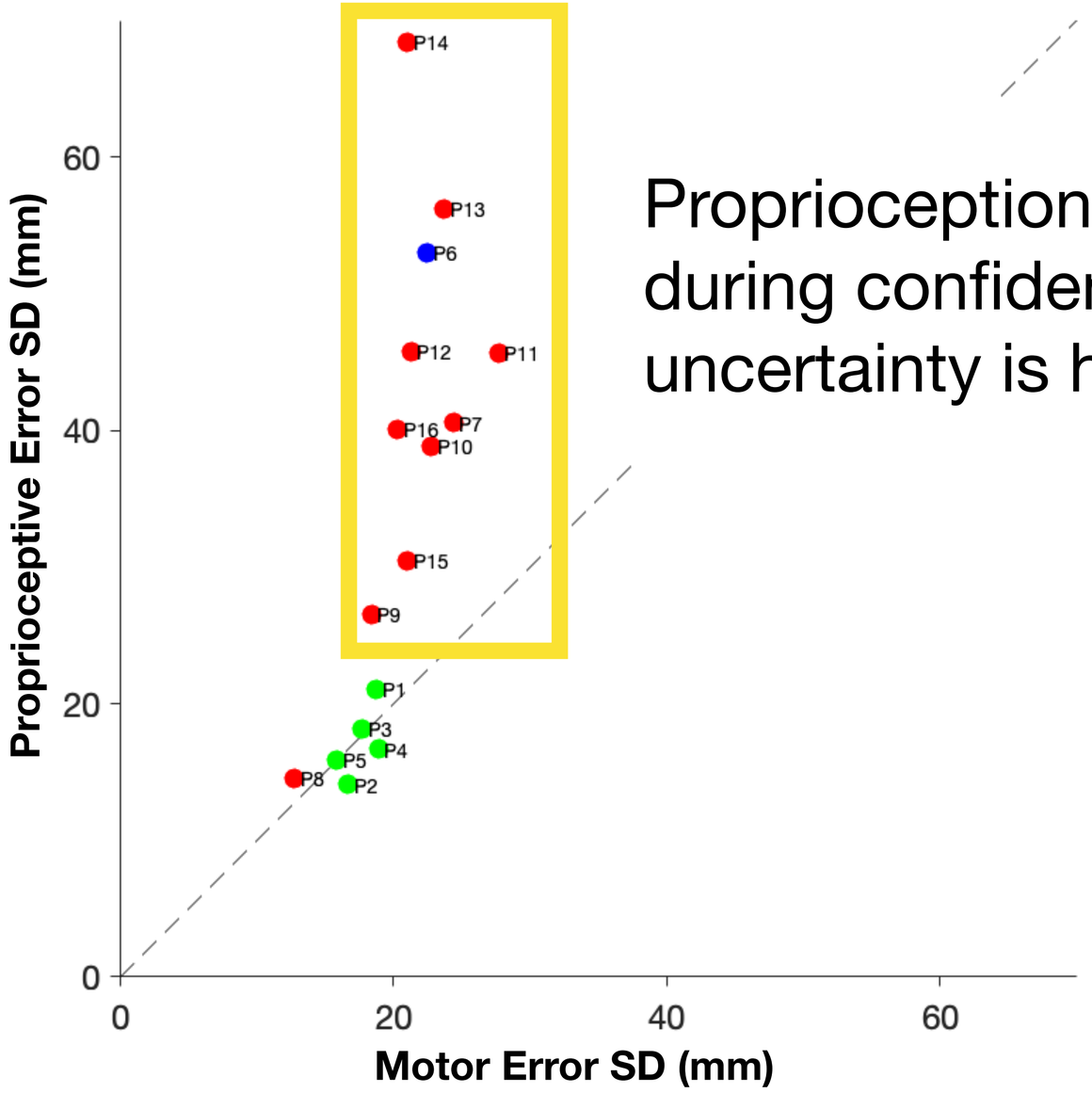


Best Fit Model Parameters



Proprioceptive information is used during confidence judgment when uncertainty is known to be low

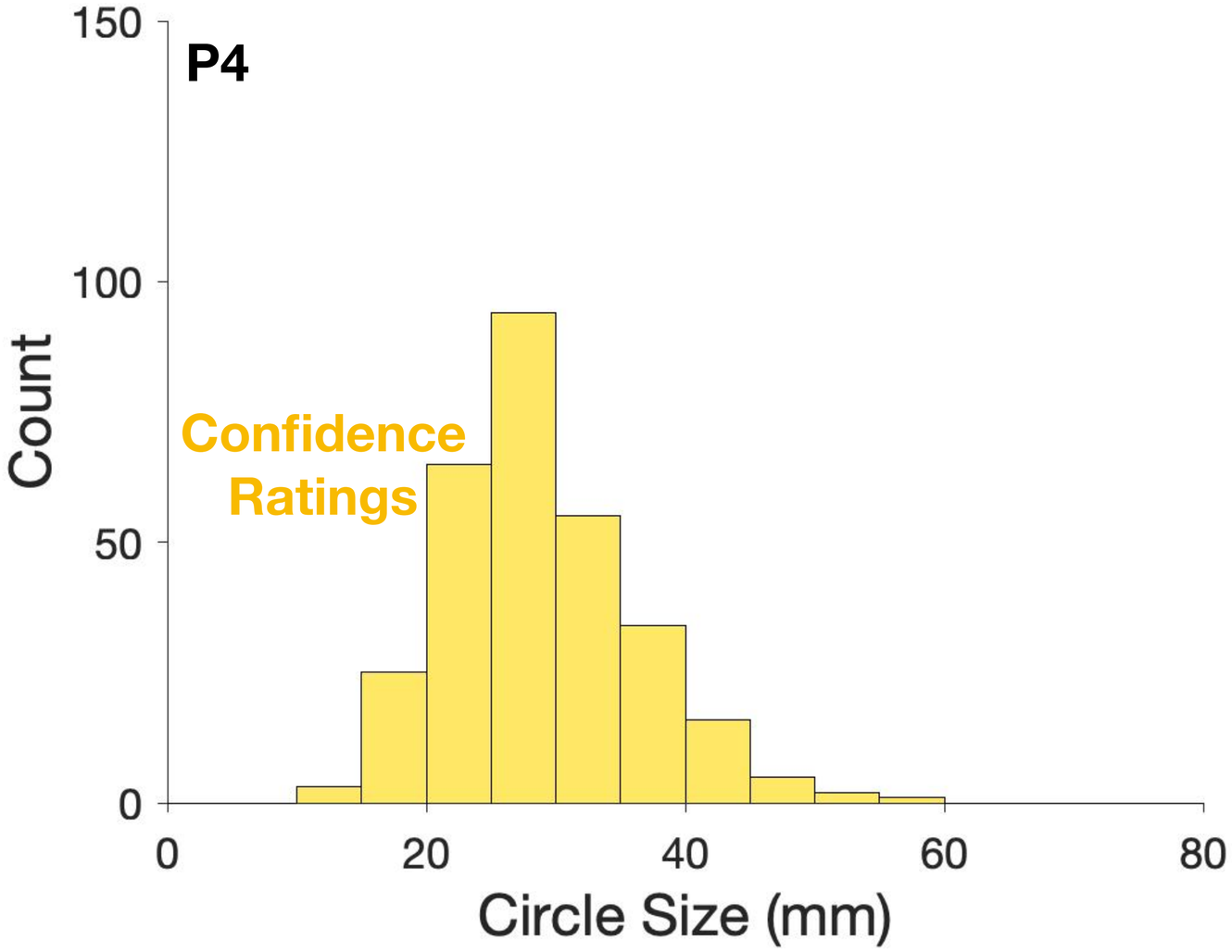
Best Fit Model Parameters



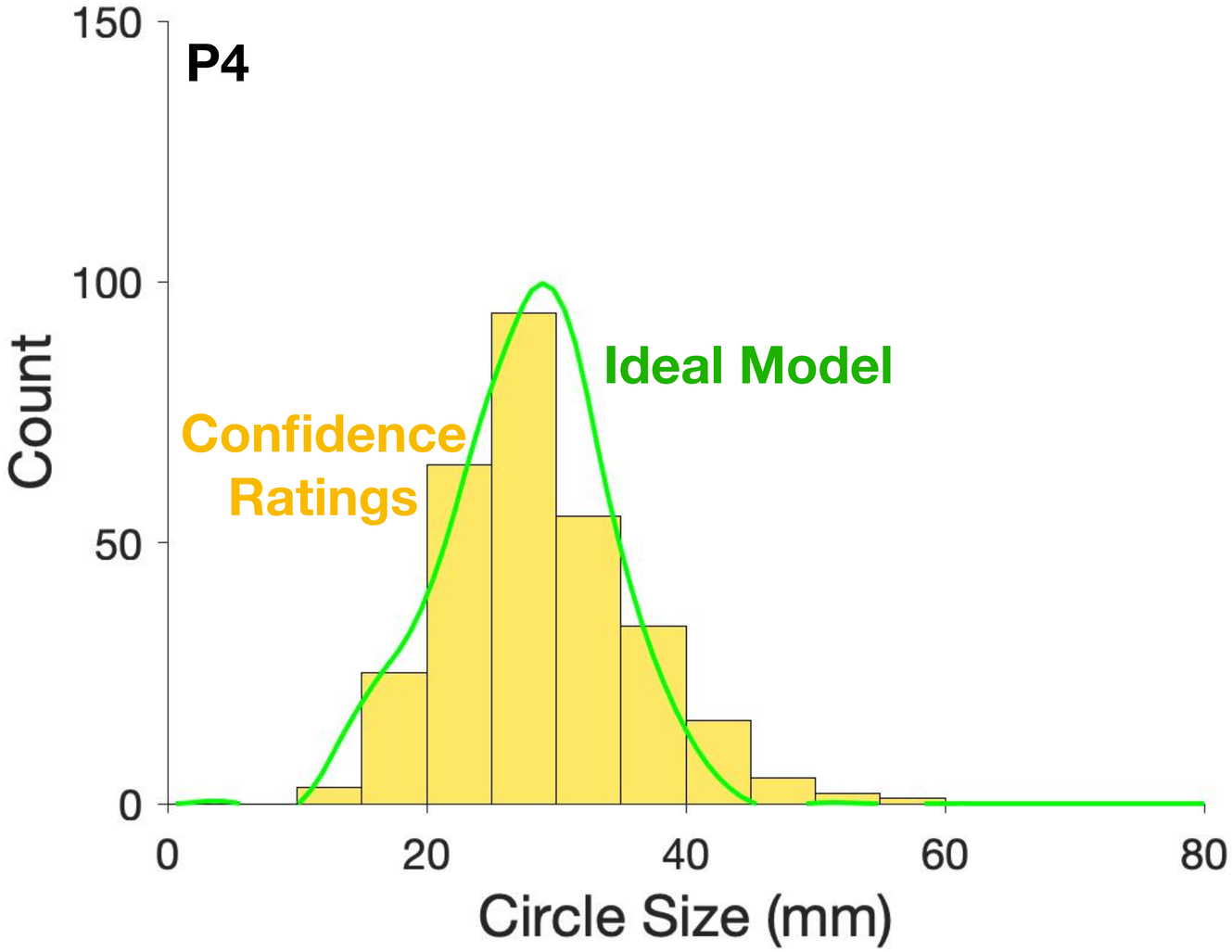
Proprioception is not always used during confidence judgments when uncertainty is high

Comparing the models to data

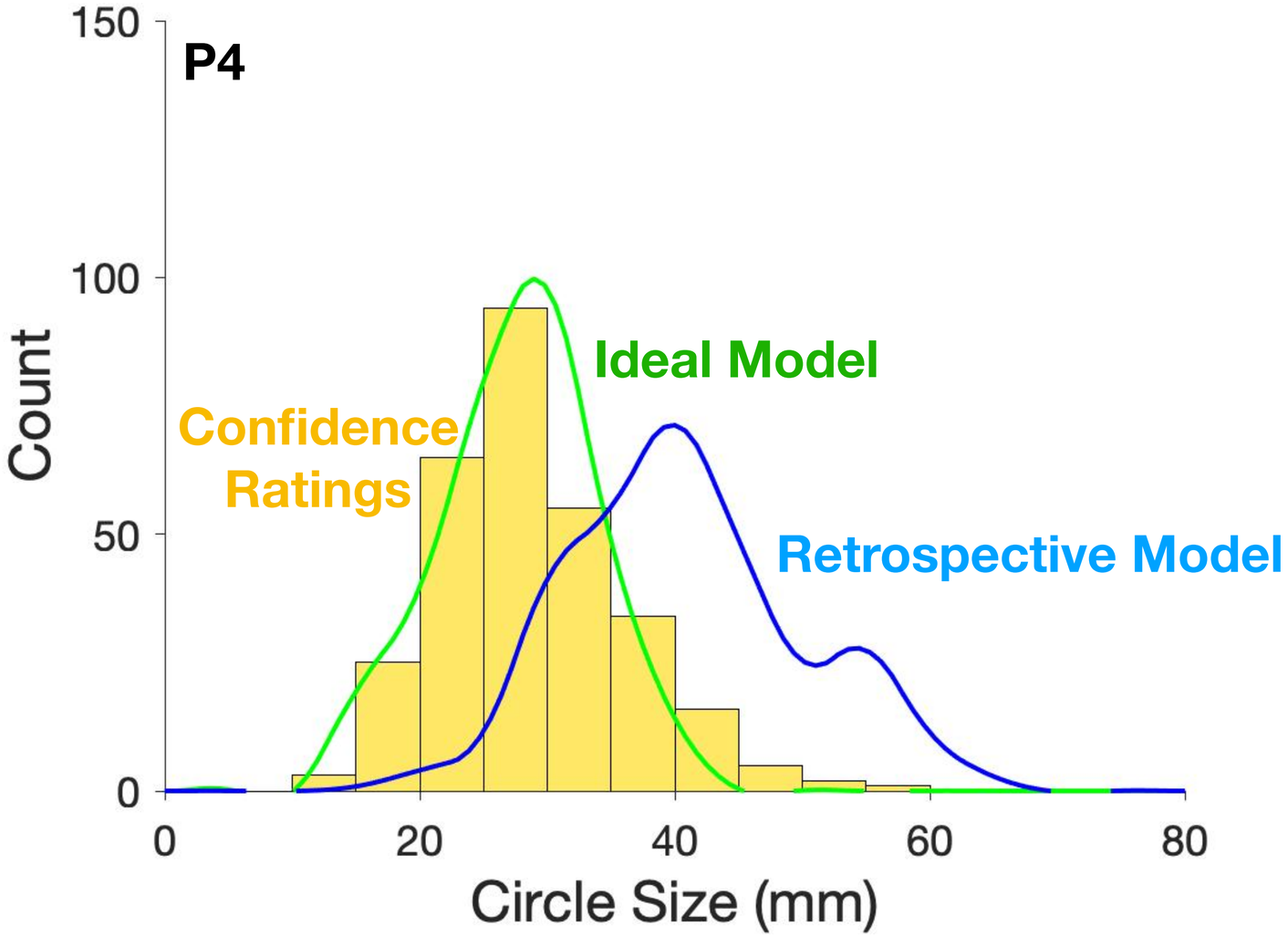
Model Predictions of Confidence



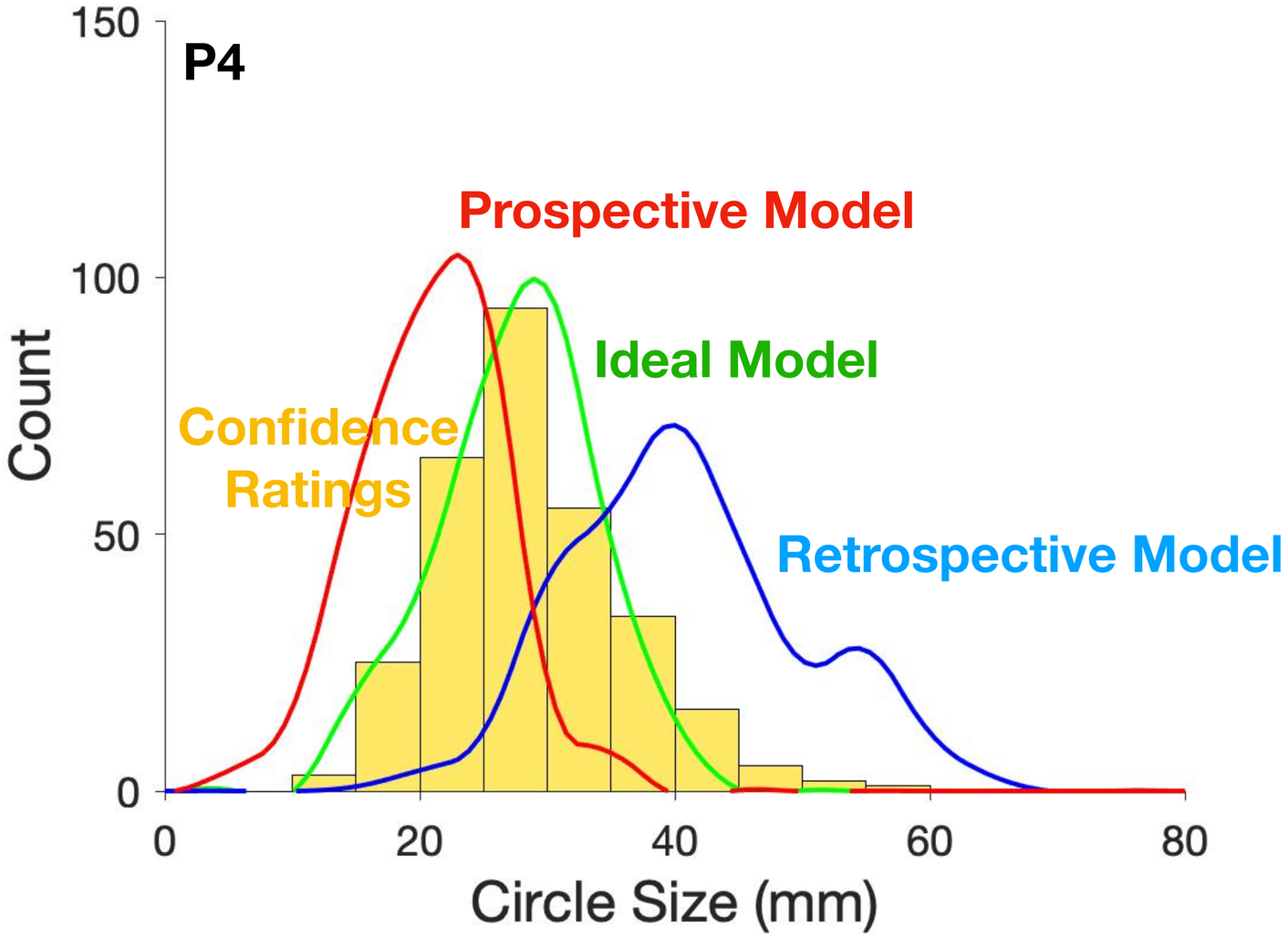
Model Predictions of Confidence



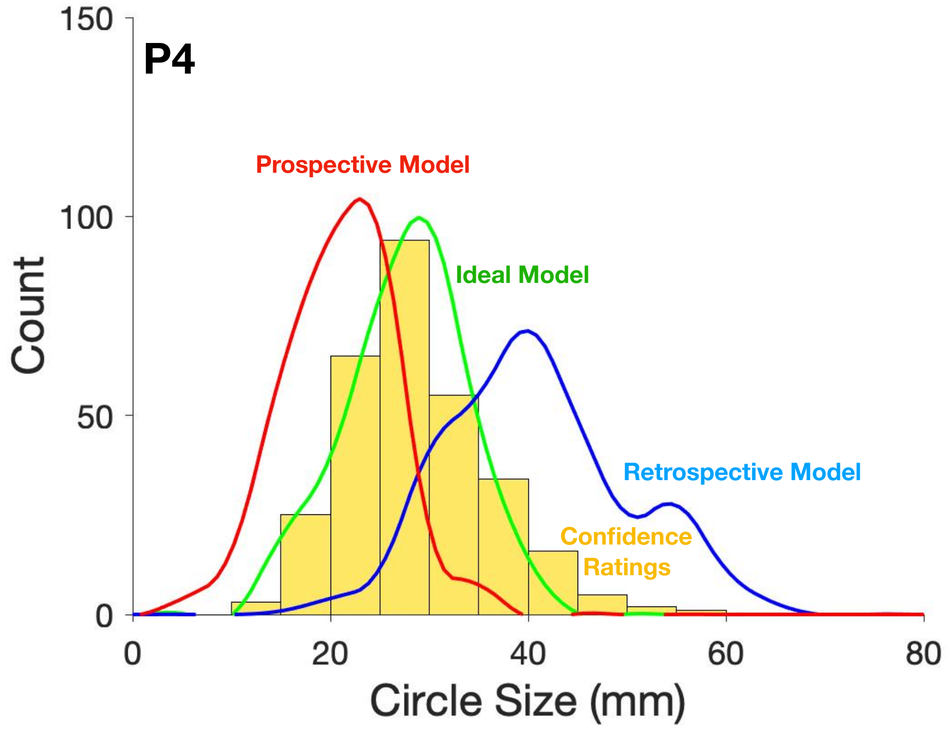
Model Predictions of Confidence

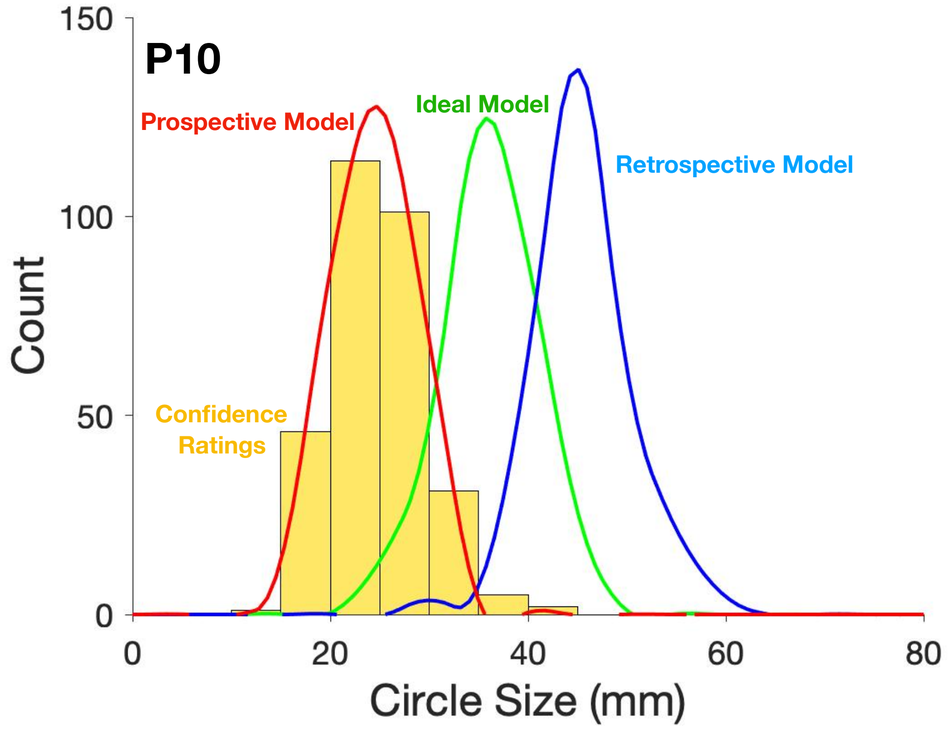


Model Predictions of Confidence

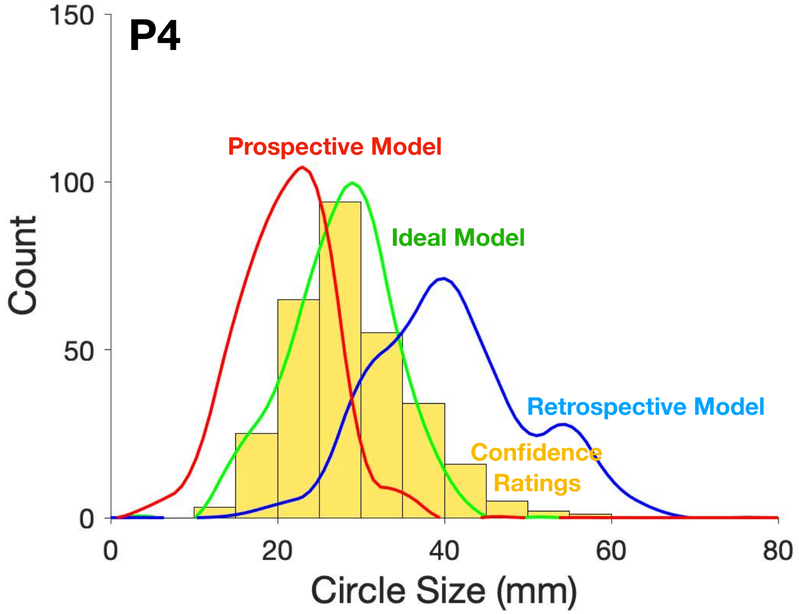


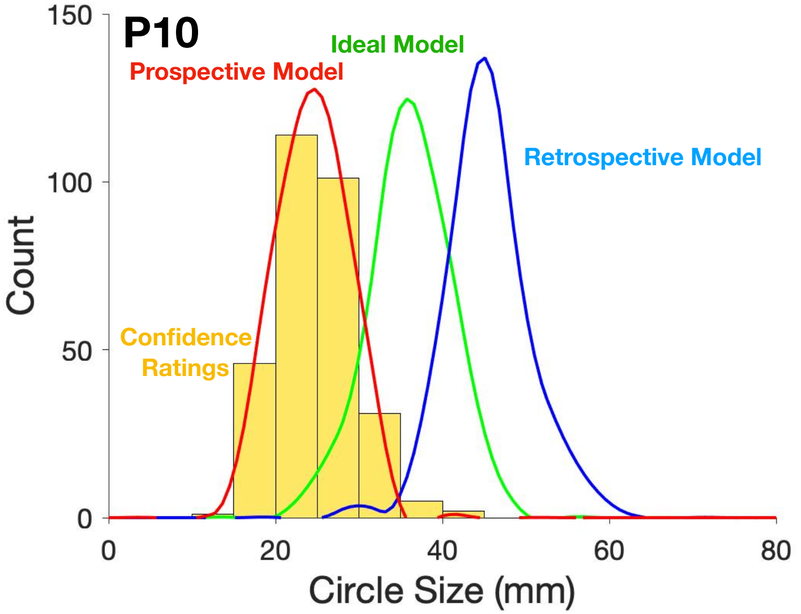
Model Predictions of Confidence

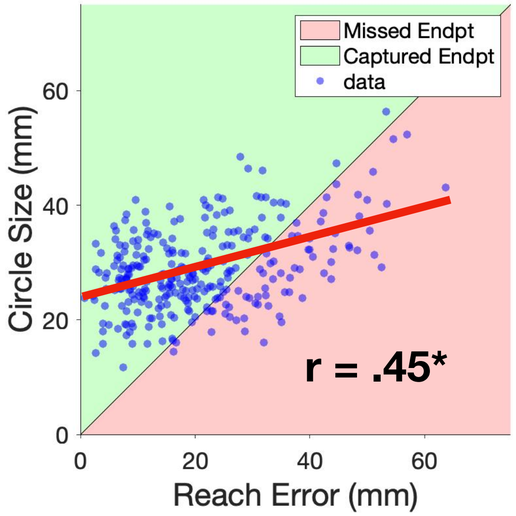


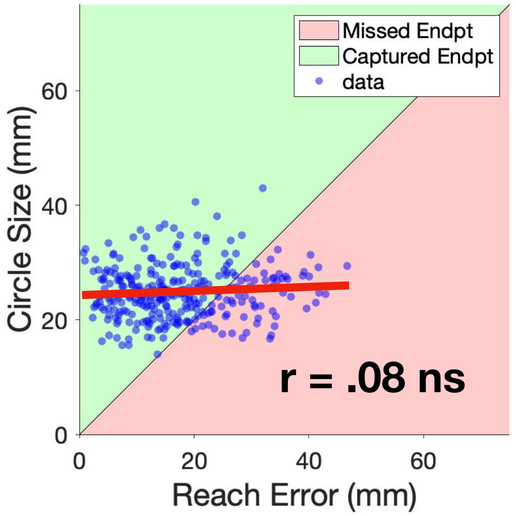


Model Predictions of Confidence

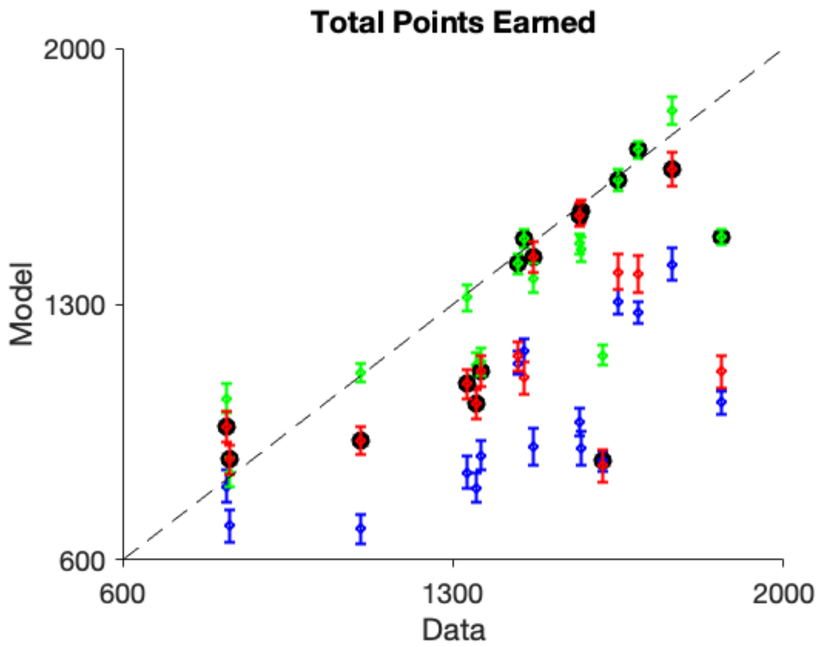






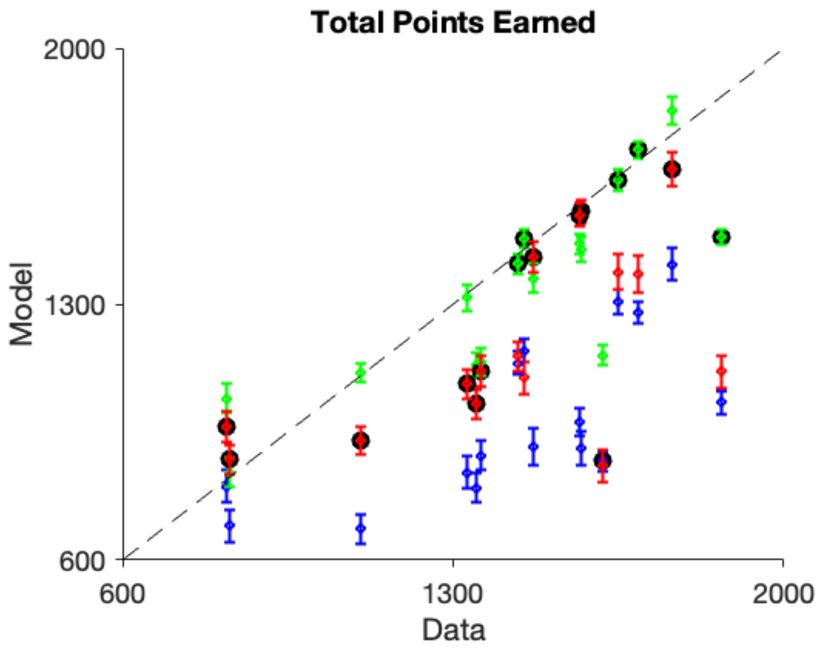


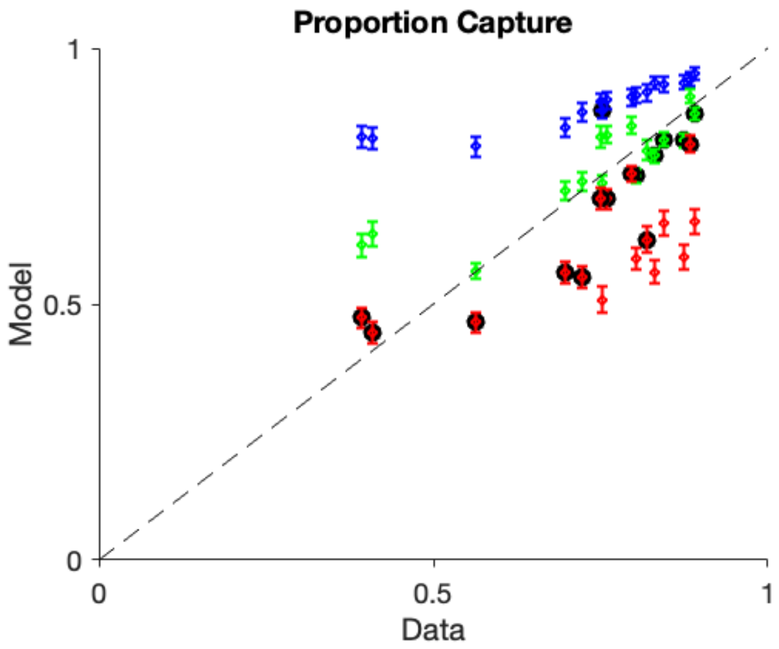
Behavioral Simulations



- Ideal Model
- Retrospective Model
- Prospective Model
- Best Fit Model

Behavioral Simulations





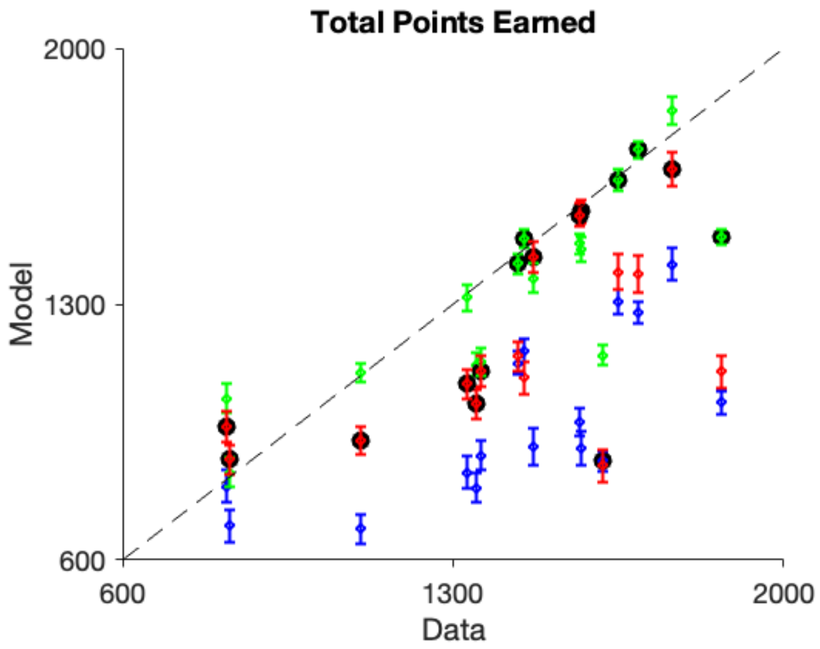
Ideal Model

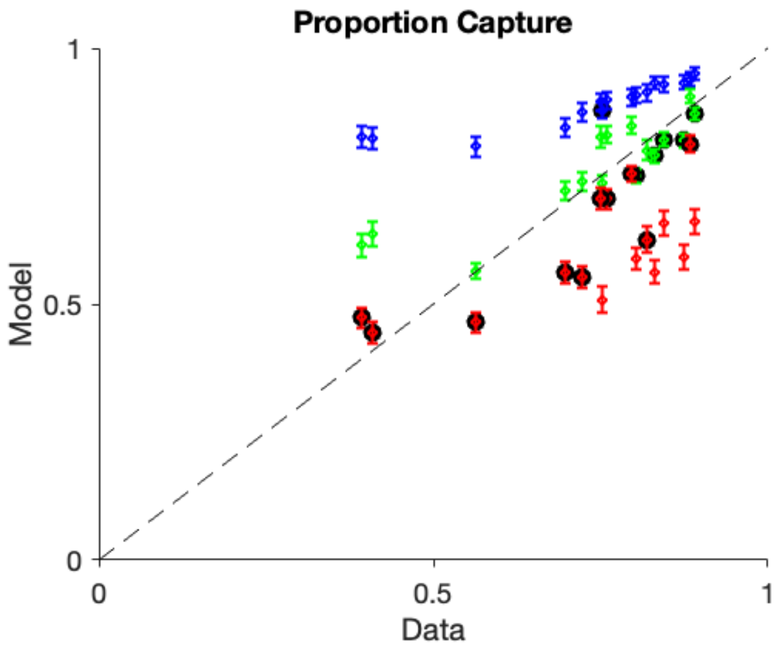
Retrospective Model

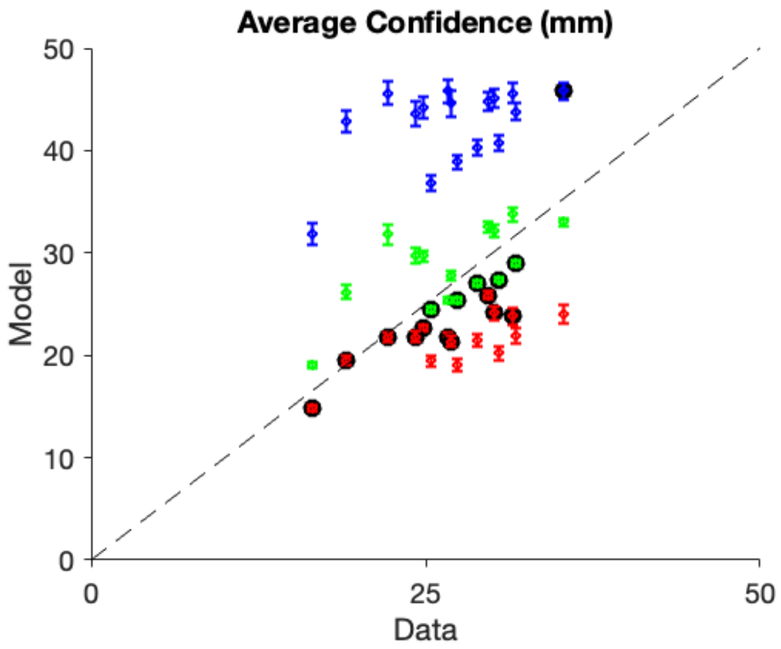
Prospective Model

Best Fit Model

Behavioral Simulations







Ideal Model

Retrospective Model

Prospective Model

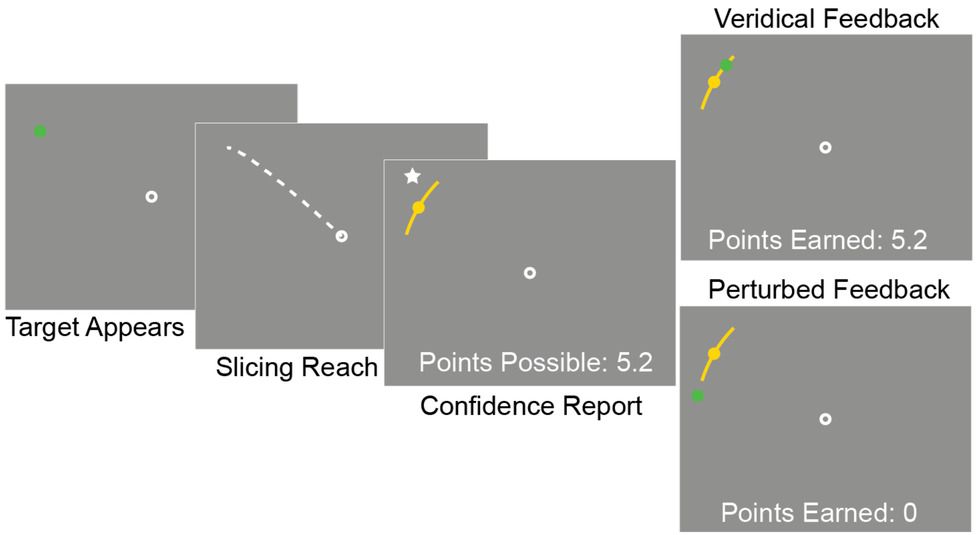
Best Fit Model

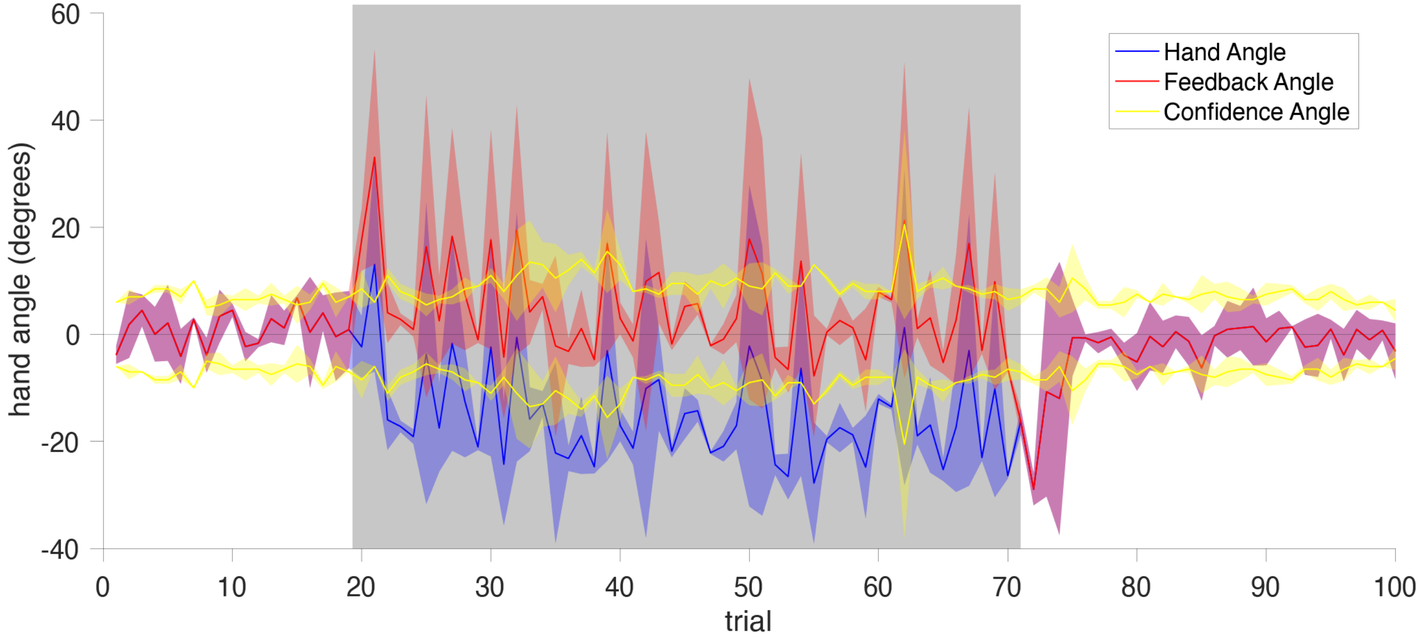
Motor noise

Proprioceptive uncertainty

Awareness of one’s own perceptual noise is taken into account when weighing which inputs to consider during a sensorimotor confidence judgment

Upcoming Research





Thank you!

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