A Visual Approach towards Knowledge Engineering and Understanding How Students Learn in Complex Environments

Lauren Fratamico, Sarah Perez, Ido Roll
University of British Columbia

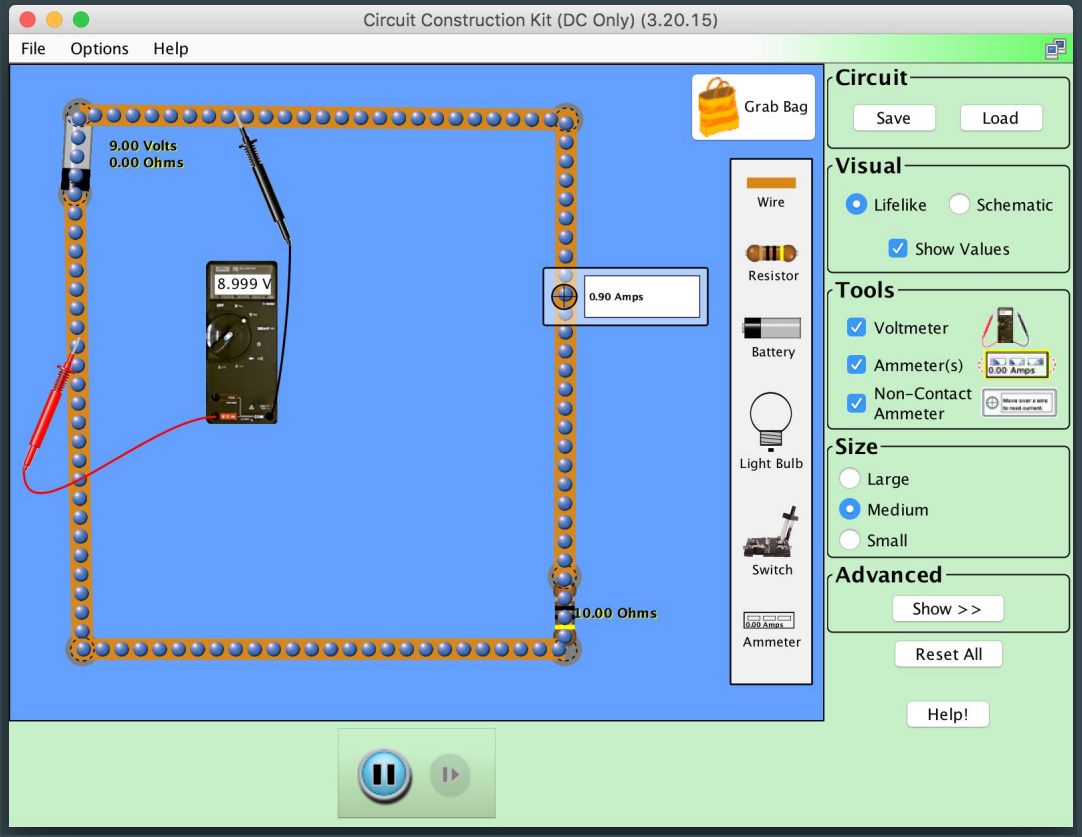
Online Learning Environments are Complex

- Diversity of instructional activities
- Variety of learners, goals, and engagement patterns
- Some support user-driven exploration (vs pre defined learning trajectories)

Would like to be able to use log data to:

- Interpret student actions
- Label student interaction patterns
- Infer intentions
- Assess learning
- Evaluate quality of engagement

For Example, PhET DC Circuit Construction Kit



- Exploratory learning environment
- Hundreds of actions available
- CCK used 4 million times/year
- Translated into 60 languages

- How to use log data to evaluate students when the design space is unlimited and the solution space is underdefined?
- How can we account for learners with diverse backgrounds and goals?

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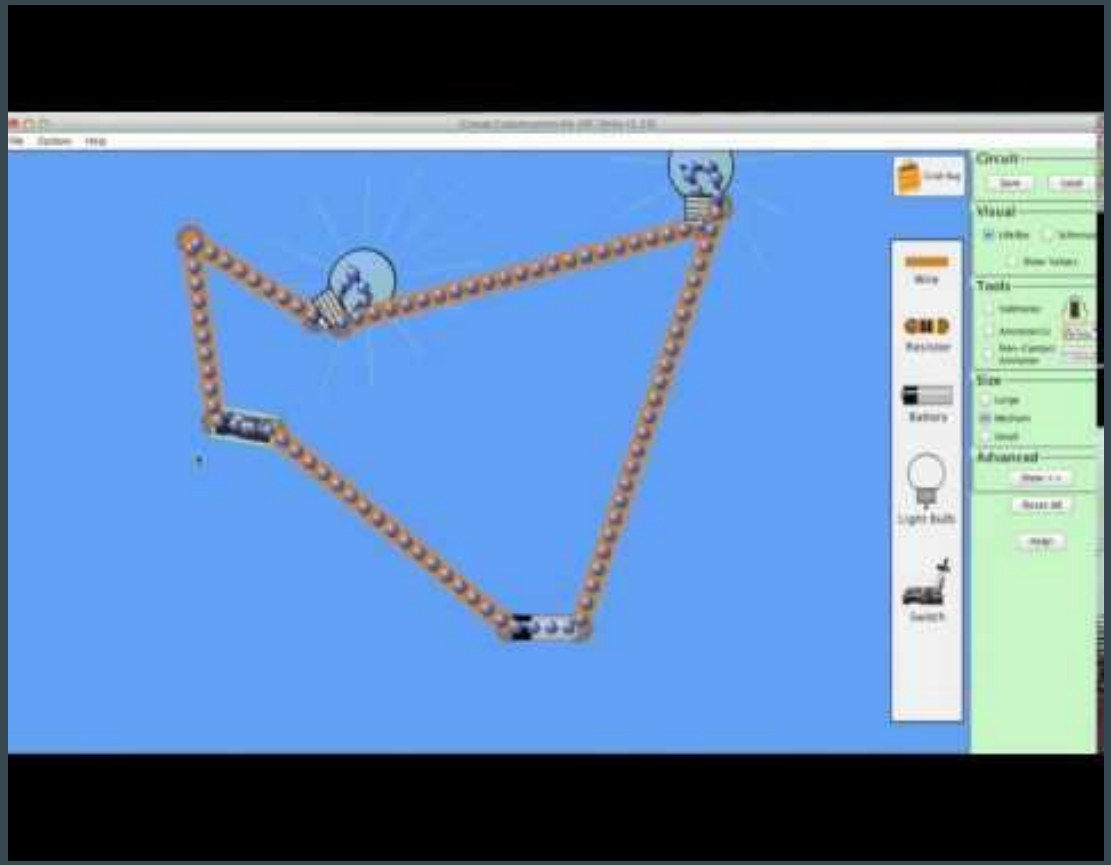

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Current approaches to make sense of student log data

- Knowledge engineering (top-down)
  - Based on expert analysis
  - More challenging as event space grows
- Knowledge discovery (bottom-up)
  - Extract patterns from data via machine learning and statistical approaches
  - Often hard to interpret the detected trends and inform theory (Aleven 2016, Roll 2005)
  - Effective for skills that are easy to label, but less for divergent strategies (Baker 2013, Sao Pedro 2013)
  - The detected models may be overly specific to context and populations (Conati 2015)

- Ideal to combine the two

Goal of Research

- Create a hybrid approach that combines:
  - Data-driven, bottom-up insights
  - Human-initiated, top-down understanding
- Allow others to easily interpret their own log data through exploratory analysis

Goal of Research

Create a visual approach that:

- Highlights potential patterns of related actions (using data)
- Helps its users raise hypotheses about these actions (when combined with their knowledge of theory)
- Allows them to quickly test their hypotheses in an exploratory way by:
  - Grouping actions
  - Visualizing the relationship between behaviors and other student-level factors (such as knowledge level)

tempr

a visualization tool for exploratory analysis of temporal log data

What does tempr allow you to do?

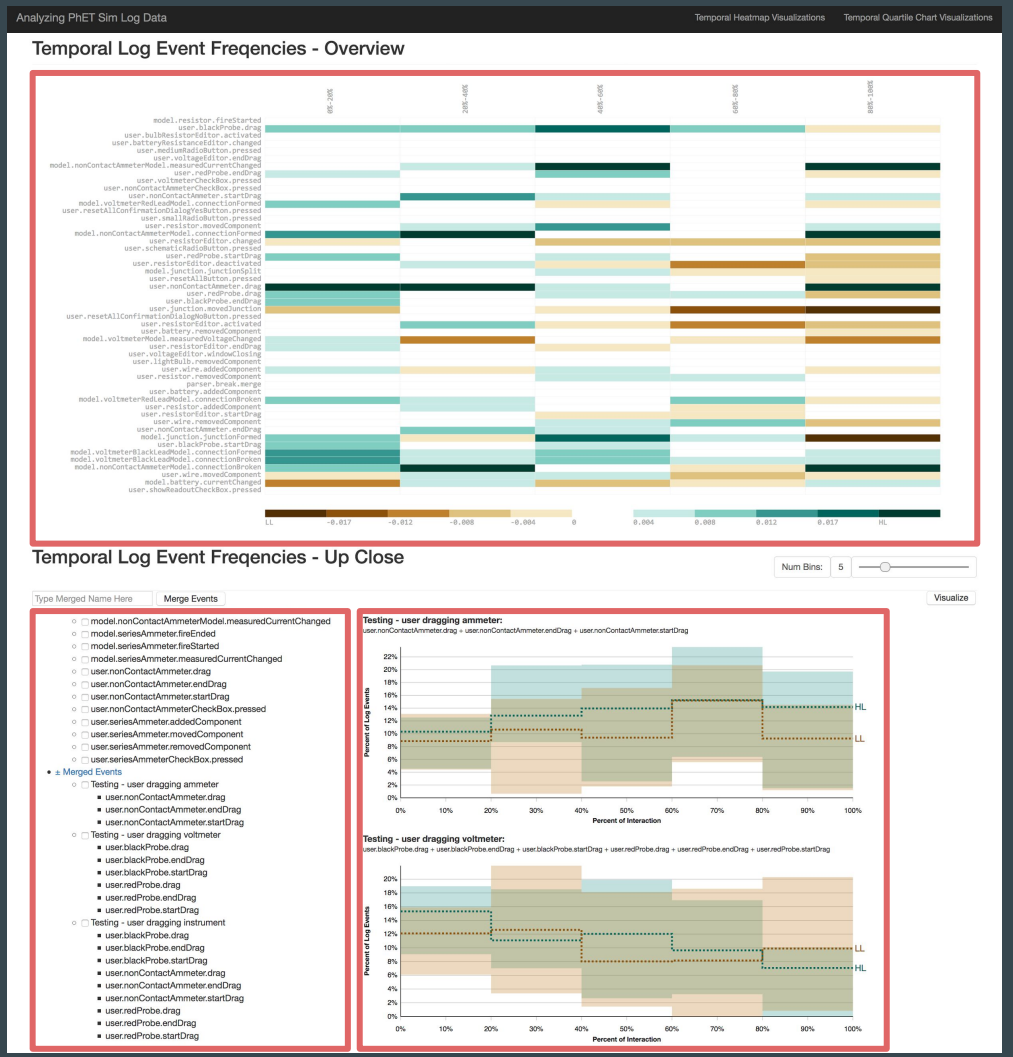
Identify features in your log data that:

- Differentiate groups of learners temporaly
- Abstract beyond surface differences
- Are informative with respect to common learning strategies

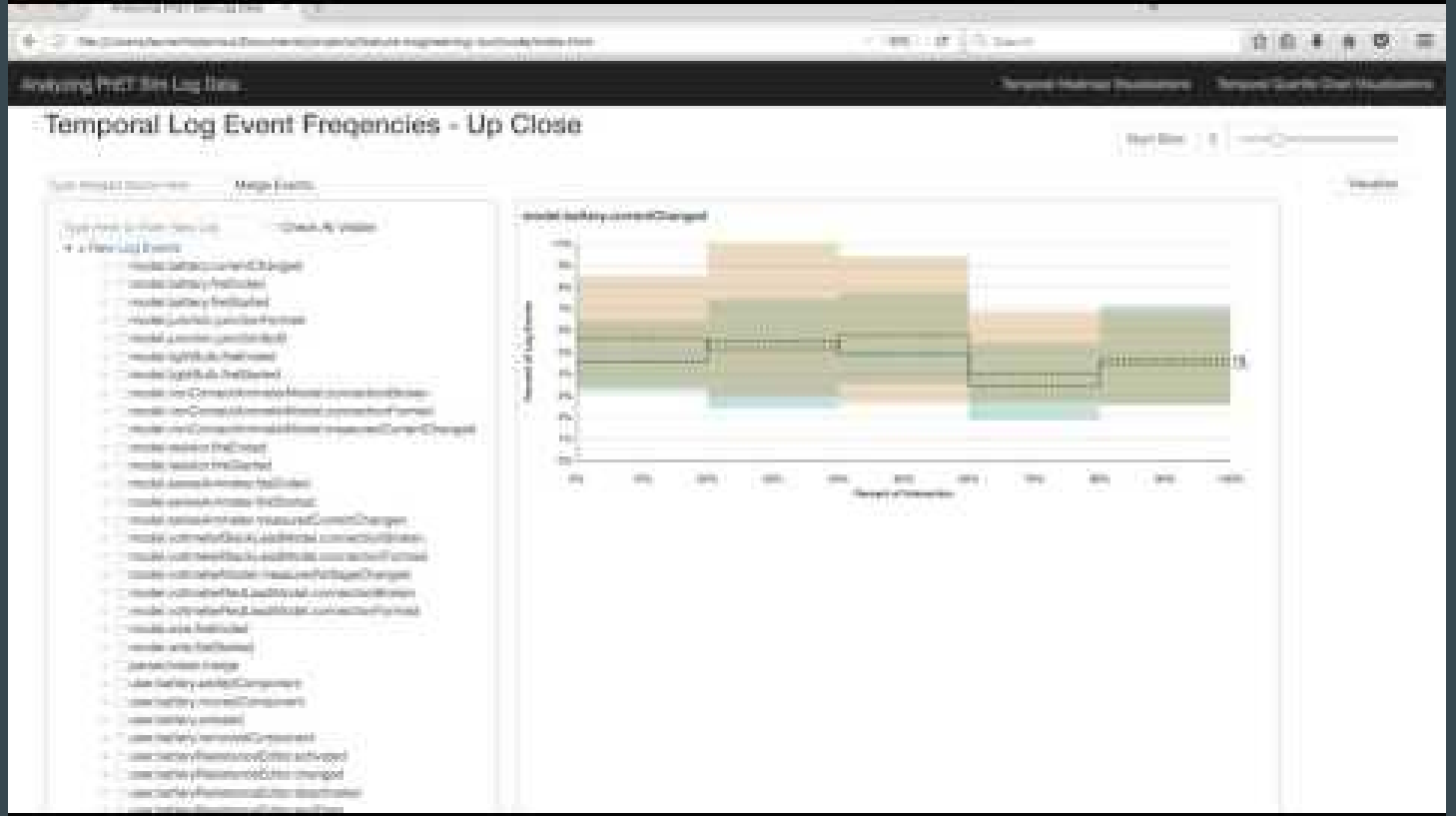
3 main panels of tempr

- Heatmap
- Merging
- Visualization

GitHub bit.ly/tempr_tool



Overview


Analyzing PHET Sim Log Data
Temporal Log Event Frequencies - Up Close

Exploring Log Data with tempr

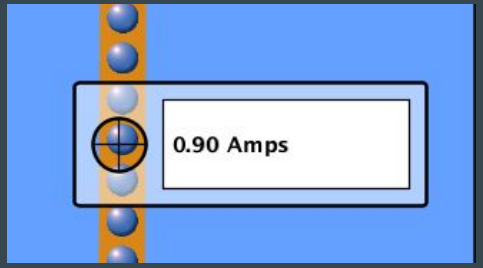
Exploring Log Data with tempr

Data: PhET Circuit Construction Kit log data

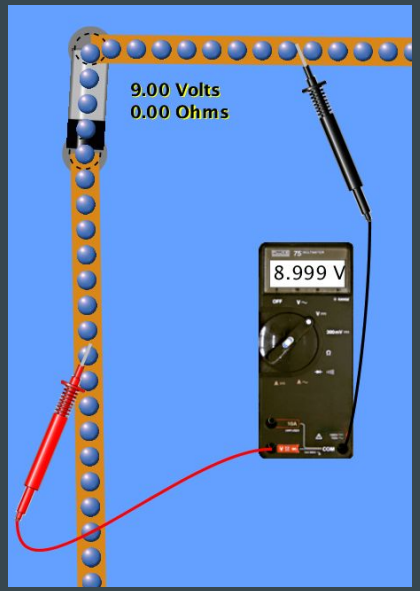
Groups: High Learners and Low Learners

Question: How do students learn by testing circuits?

Ammeter



Voltmeter

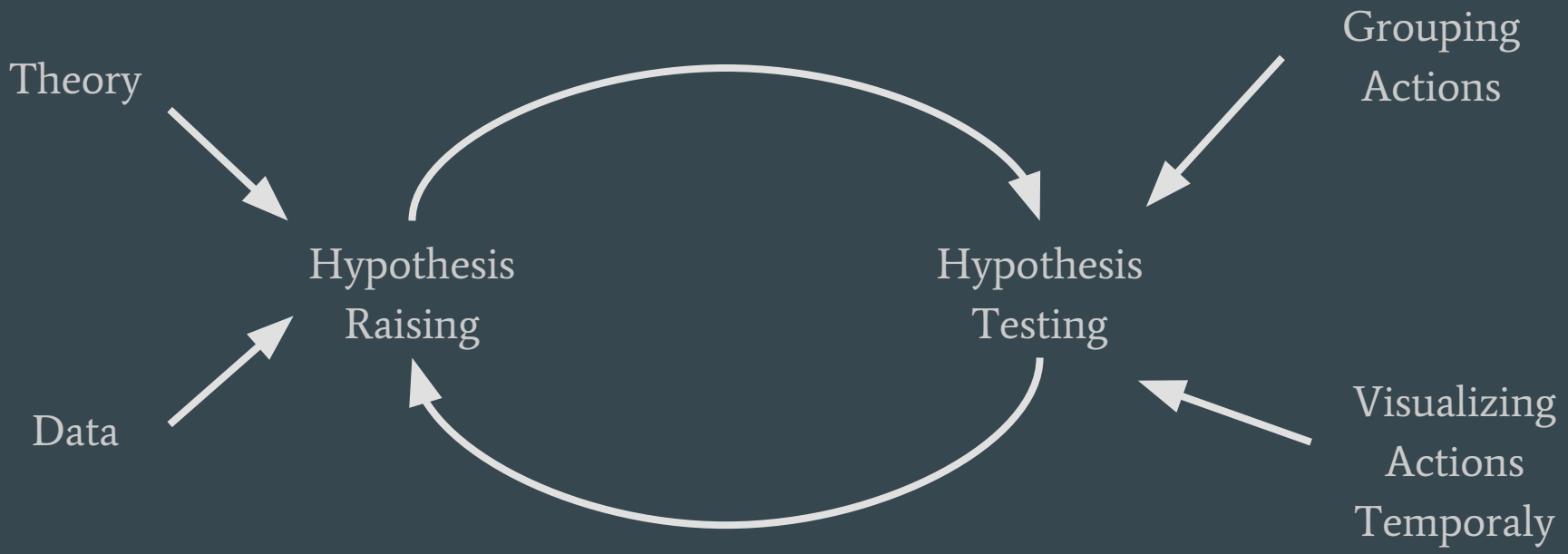


Data Input

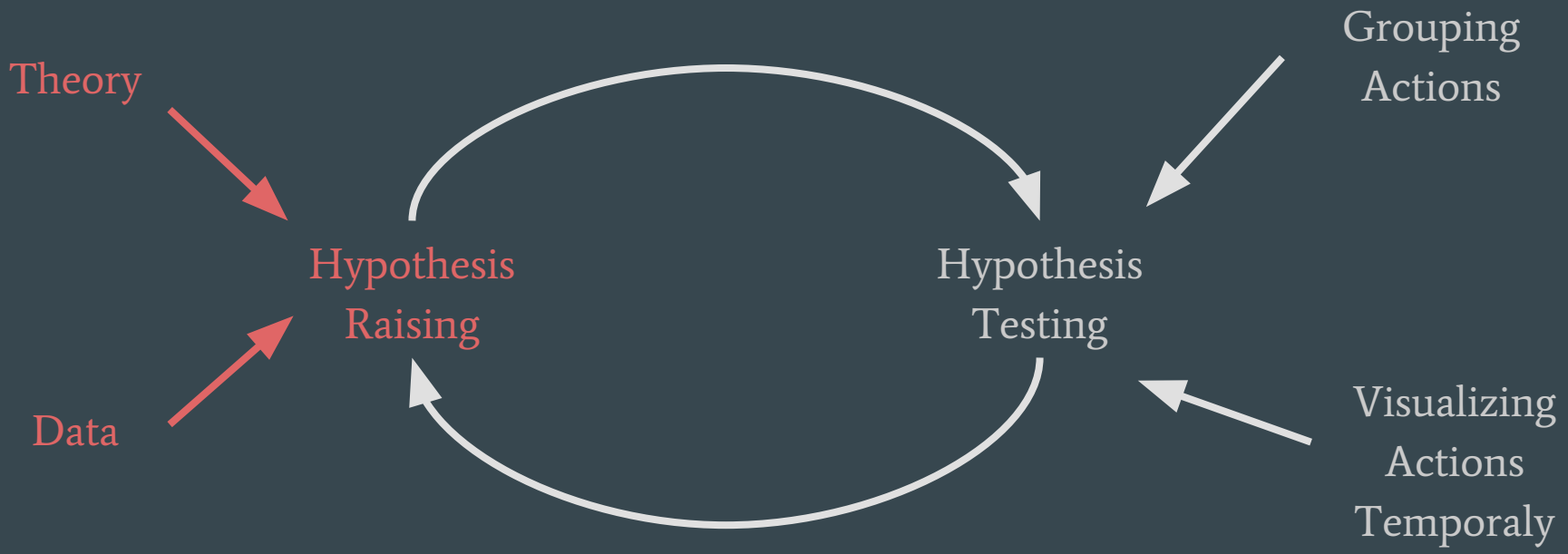
what item

what action

```
========================================
user.wire.addedComponent
user.battery.addedComponent
user.resistor.addedComponent
user.junction.movedJunction
user.battery.movedComponent
…
user.redProbe.drag
user.redProbe.endDrag
user.blackProbe.startDrag
model.voltmeterBlackLeadModel.connectionFormed
user.blackProbe.drag
user.blackProbe.endDrag
model.voltmeterModel.measuredVoltageChanged
========================================
user.wire.addedComponent
user.wire.addedComponent
model.junction.junctionFormed
user.junction.movedJunction
user.resistor.addedComponent
model.junction.junctionFormed
…
```

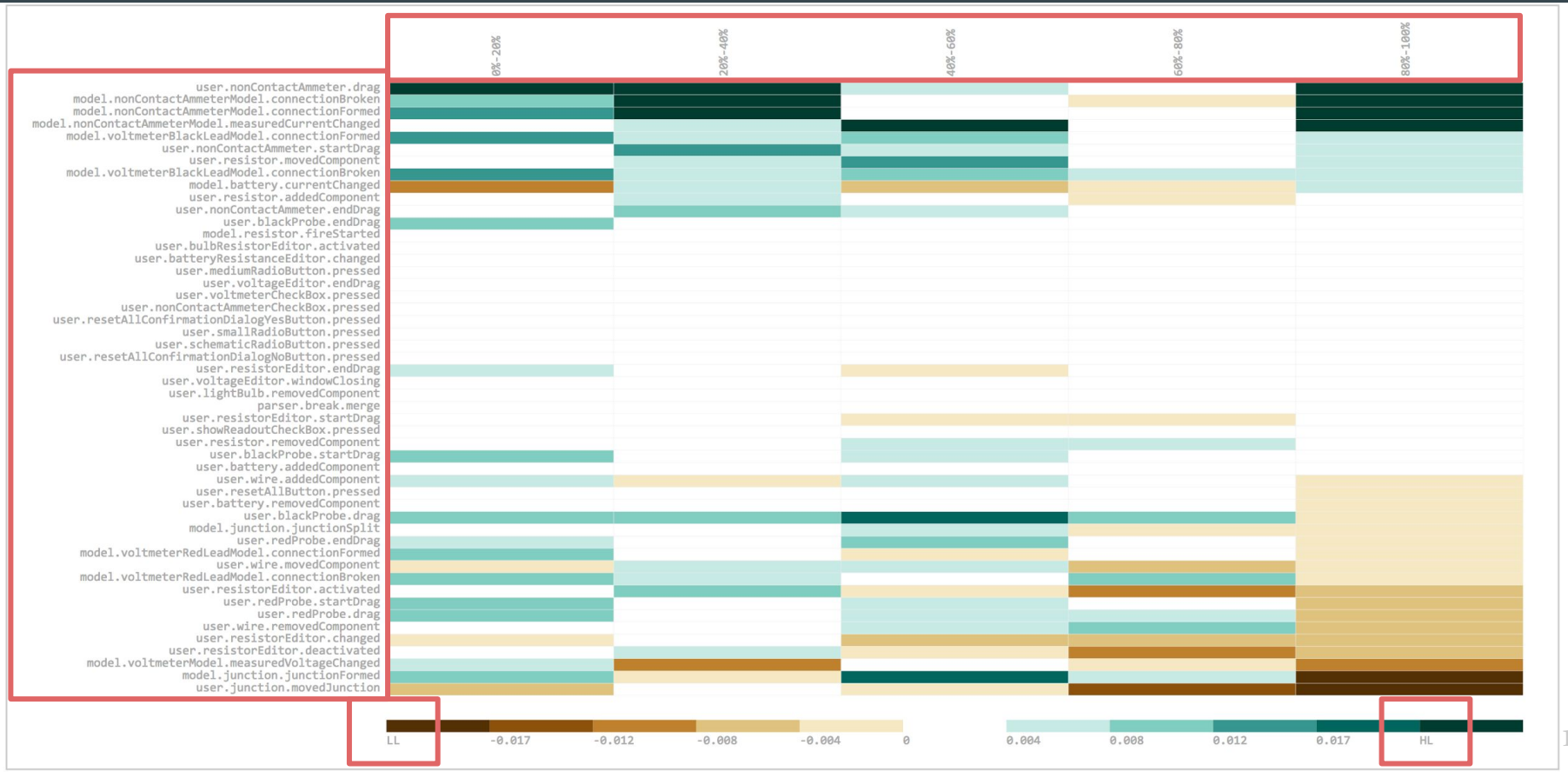

Theory
Data
Hypothesis
Raising
Hypothesis
Testing
Grouping
Actions
Visualizing
Actions
Temporaly

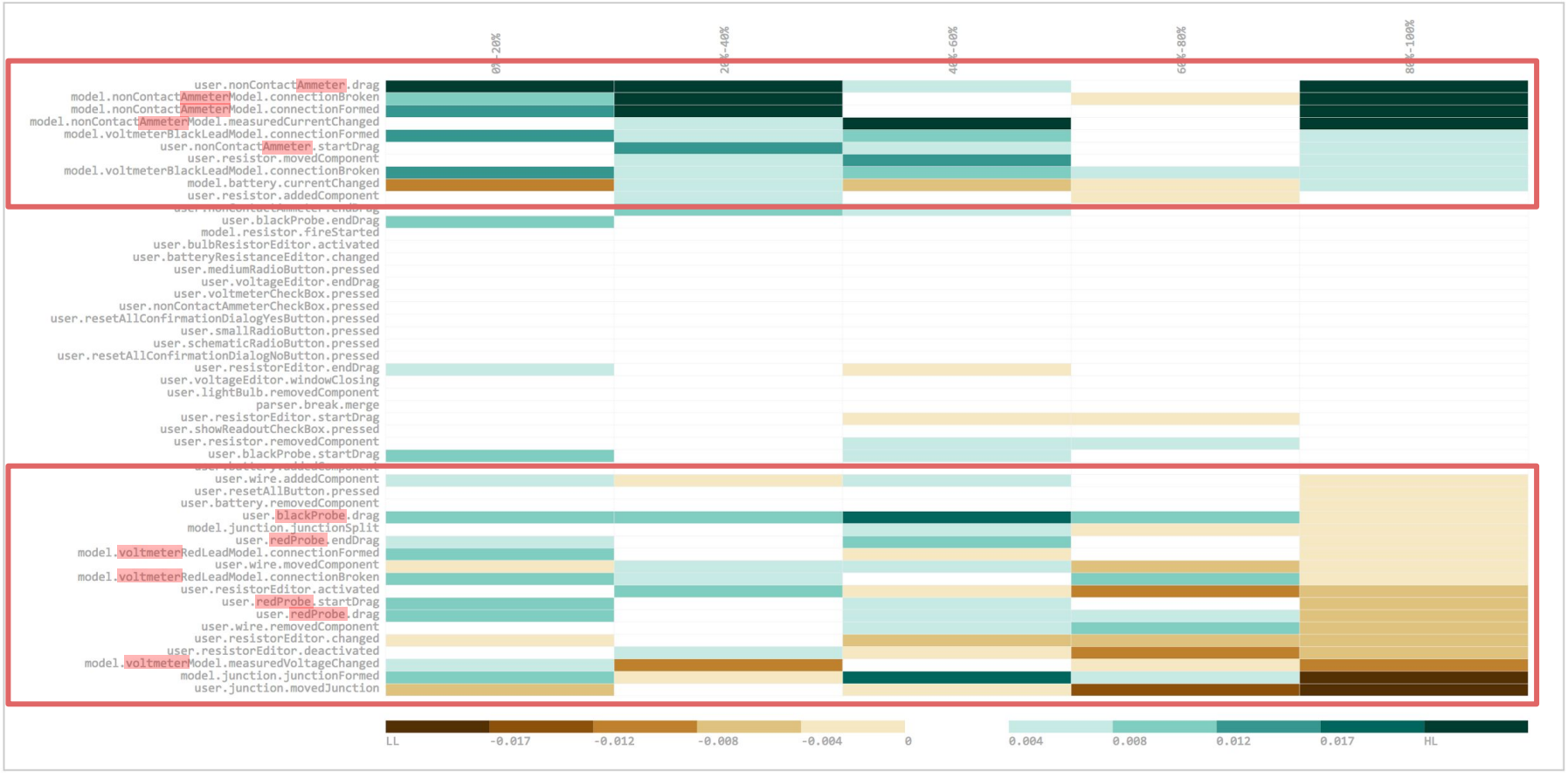
What does tempr allow you to do? - Heatmap Panel



What does tempr allow you to do? - Heatmap Panel

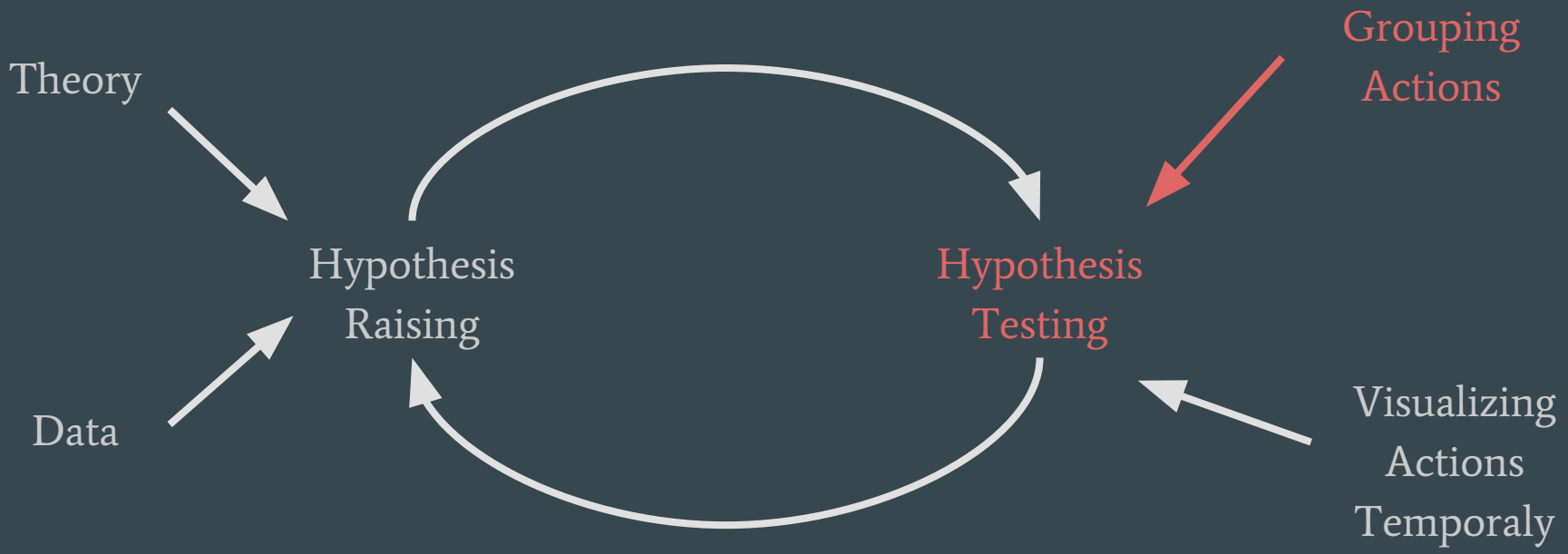
Surface big picture patterns ~ Compare groups of learners





Hypothesis: HL and LL differ in use of ammeter and voltmeter

What does tempr allow you to do? - Merging Panel



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Supports exploratory grouping of related actions

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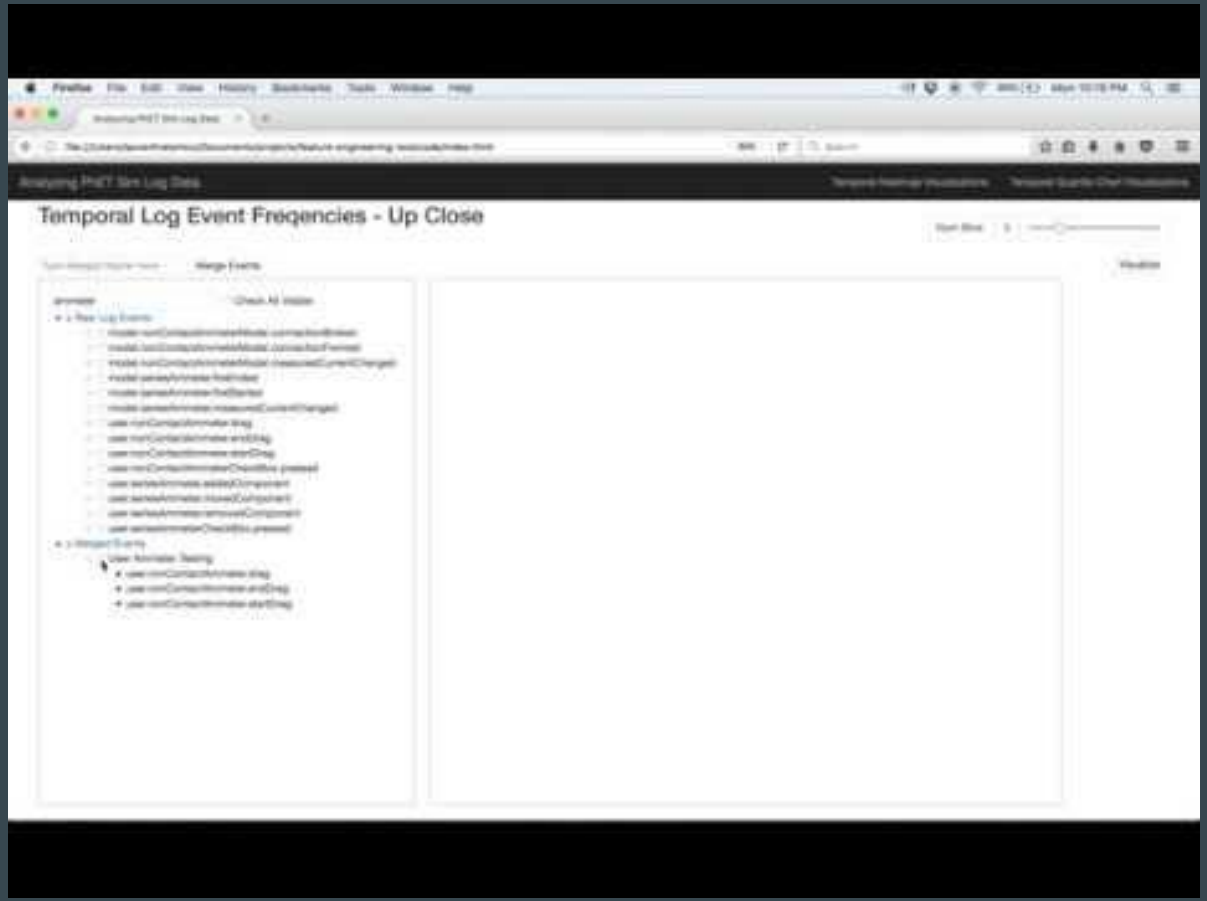
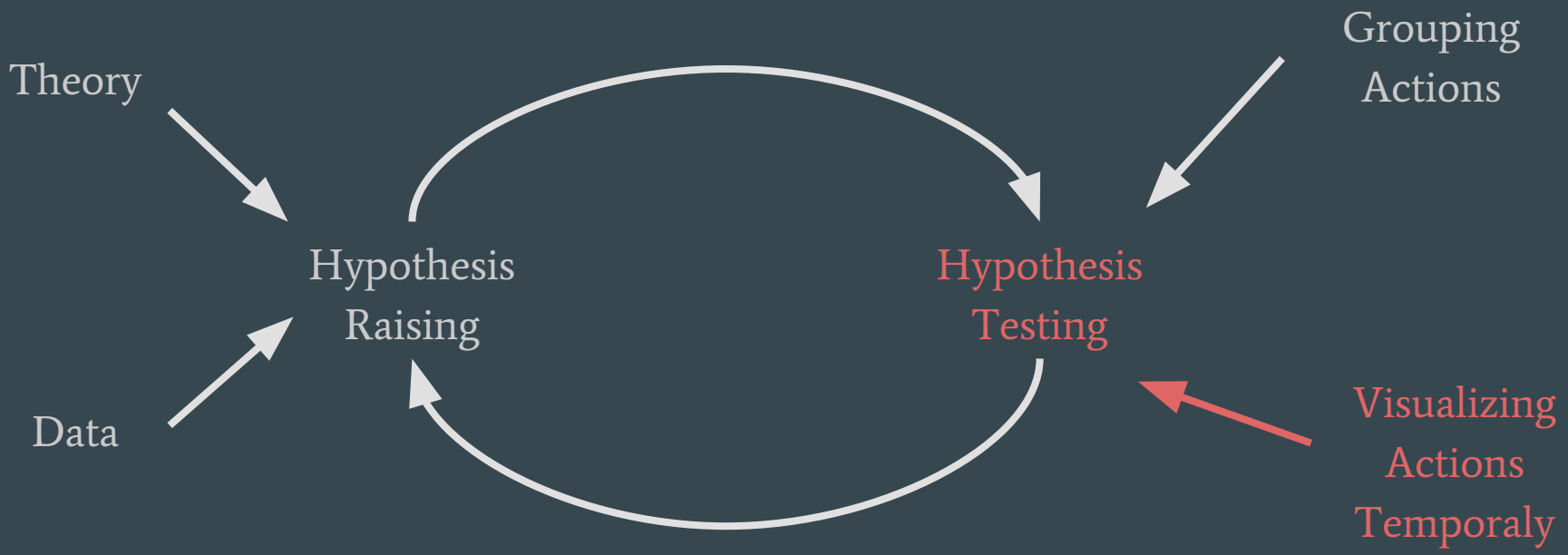


- ± Merged Events
  - ☐ Testing - user dragging ammeter
    - user.nonContactAmmeter.drag
    - user.nonContactAmmeter.endDrag
    - user.nonContactAmmeter.startDrag
  - ☐ Testing - user dragging voltmeter
    - user.blackProbe.drag
    - user.blackProbe.endDrag
    - user.blackProbe.startDrag
    - user.redProbe.drag
    - user.redProbe.endDrag
    - user.redProbe.startDrag

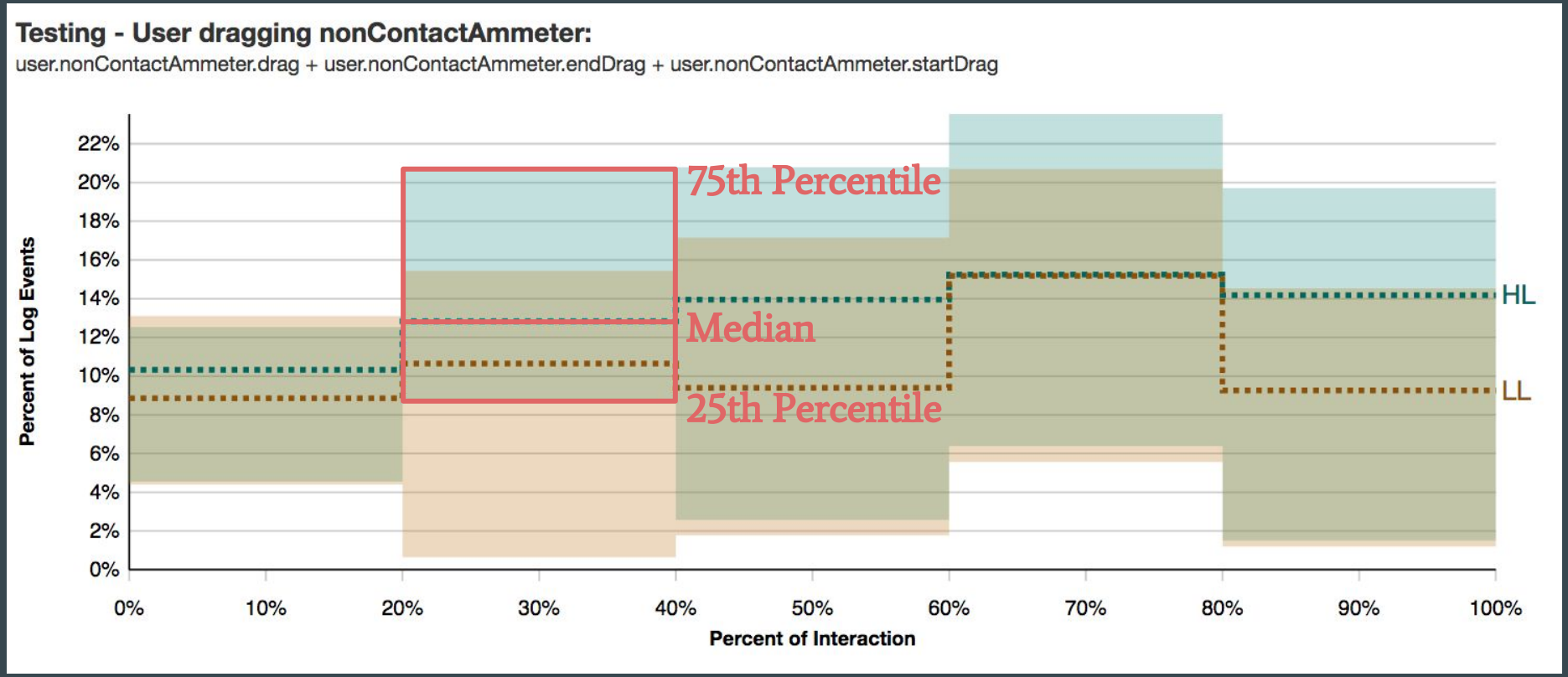
Quickly test hypothesis by merging actions

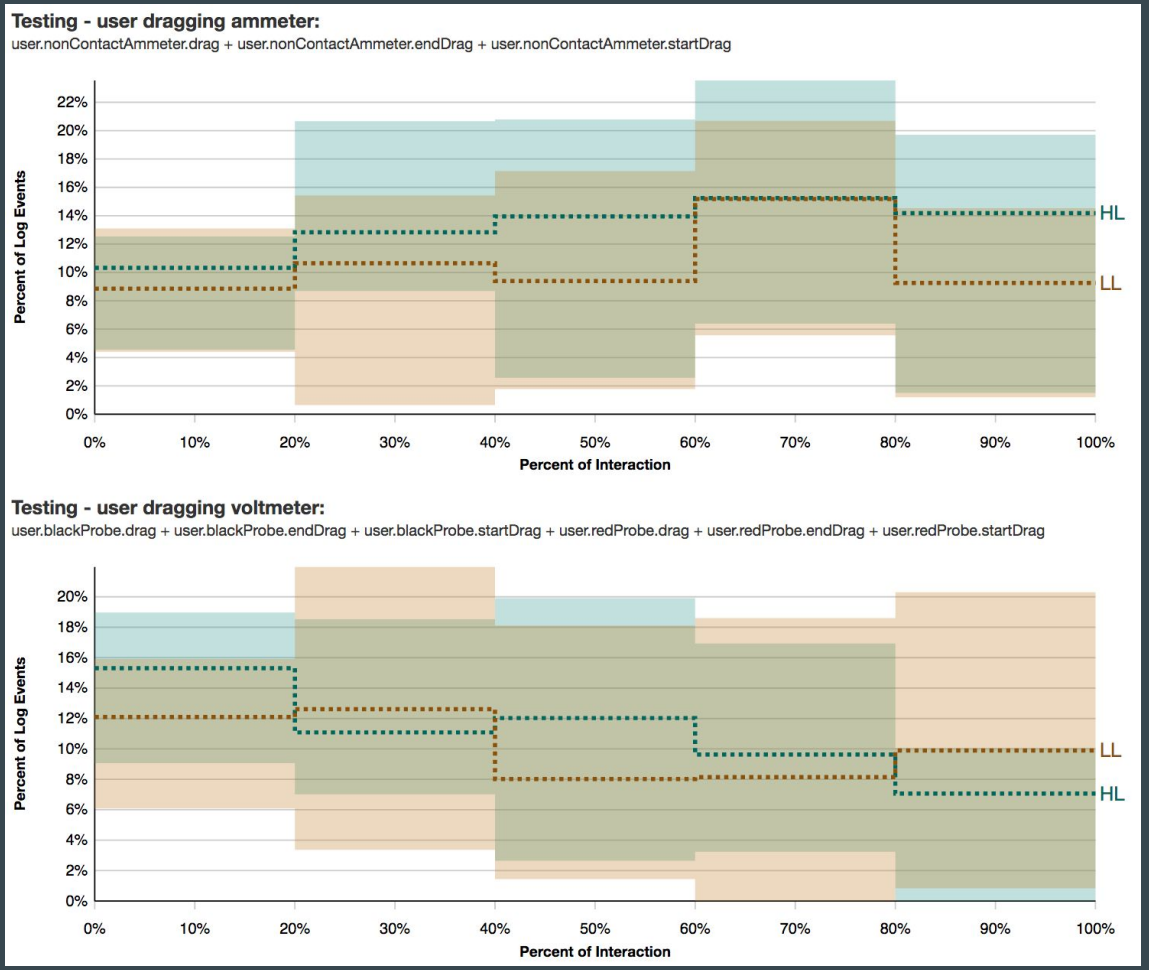
What does tempr allow you to do? - Visualization Panel



What does tempr allow you to do? - Visualization Panel

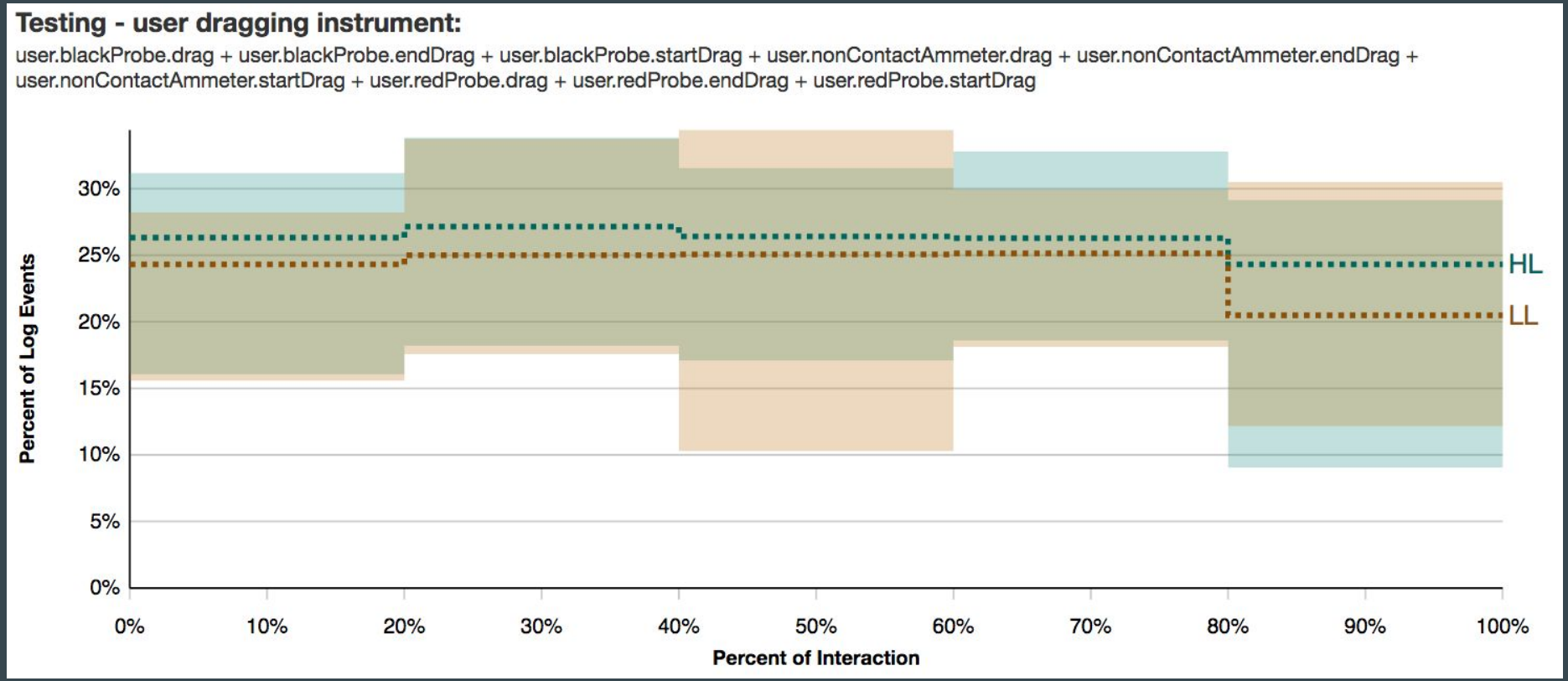
Visualize learning over time - Compare groups of learners - Contrast actions





HL increase use of ammeter over time

HL decrease use of voltmeter over time

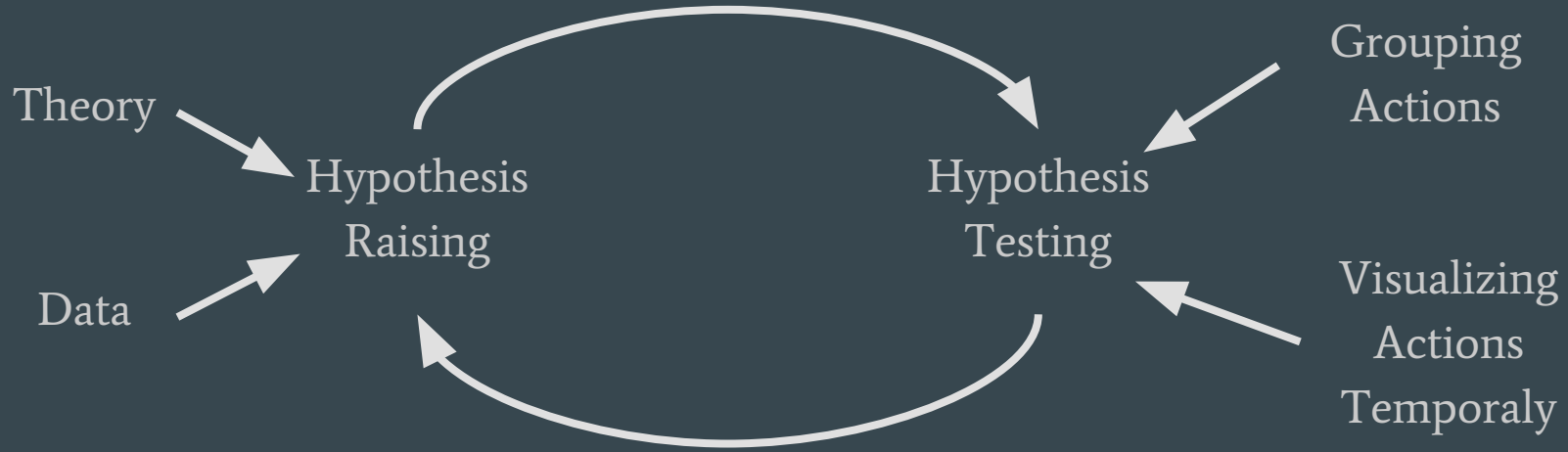


HL test slightly more than LL, fairly constant usage over time

Splitting behaviors into subtypes can reveal important nuances

Conclusion

Tempr aids in temporal analysis of log data by:



Download tempr from GitHub and try it out! **bit.ly/tempr_tool**