Metacognition
What is Metacognition?
We constantly engage in Metacognition

Examples

• You notice you’re having more trouble learning math compared to history
• Someone says drinking orange juice will reduce the time you have a cold but you decide to double-check
• Your assessment of your own knowledge tells you how much studying you should do before an exam
• Any time you think about your study habits or evaluate how good your memory is
Types of Metacognition

Metacognitive Knowledge/Awareness
• Your knowledge about how minds behave (yours and others)

Metacognitive Regulation
• Your ability to modify your behavior
Metacognitive Knowledge/Awareness

• Knowledge about what factors can influence your performance
  • How much sleep you got
  • If you’re sick
  • How much studying you did

• Knowledge about the task
  • Your assessment of how difficult an exam is going to be
Metacognitive Regulation

Planning
• Selecting appropriate strategies and correctly allocating your resources

Monitoring
• Your ability to infer how well you’re doing on the task

Evaluating
• Your ability to assess your performance after the task is over
Sanders, Hangya, & Kepecs (2016)
Metacognitive Bias & Sensitivity

Metacognitive Bias
• Your overall level of confidence

Metacognitive Sensitivity
• Having higher confidence when you’re right and lower confidence when you’re wrong
Metacognitive Bias & Sensitivity

- **High bias** = High confidence
- **Low bias** = Low confidence

- **High sensitivity** = You’re confident when you should be and not confident when you shouldn’t be
- **Low sensitivity** = You’re always the same level of confident
(super short)
Is our sense of certainty calibrated to reality?
Is our sense of certainty calibrated to reality?
Cases where certainty is well calibrated

- **Vision** (Barthelme´ & Mamassian, 2009)
- **Audition** (Sanders, et al., 2016)
- **Numerical discrimination** (Sanders, et al., 2016)
Cases where certainty is overestimated

• Observing disconfirming evidence (Tormala & Petty, 2004; Tormala, et al., 2011)
• Being unskilled (Kruger & Dunning, 1999)
• Hearing another person’s opinions (Yaniv, et al., 2009)
• Learning additional information (Tsai, et al., 2008)
• Recalling a memory’s existence (Loftus, et al., 1989; McDermott & Roediger, 1998)
• When taking stimulants such as Adderall or Ritalin (Smith & Farah, 2011)
Approach

• Participants guessed meaning of a novel word and received feedback
• Reported feelings of certainty during the learning process
Correct, it's Daxxy!

Is this Daxxy?
   Yes ☐
   No ☐

Are you certain that you know what Daxxy means?
   Yes ☐
   No ☐

Next
Methods

• 552 mTurk participants
• Each attempted to guess a single concept over 24 trials
• 10 concepts in total

• Concepts drew from a space of 3 dimensions with binary values
  • Color (Red / Green)
  • Size: (Large / Small)
  • Shape: Square / Triangle
Not Daxxy
Not Daxxy
Daxxy
Daxxy
Daxxy
Daxxy
Daxxy
<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHJ-I_{3[4]}</td>
<td>red</td>
</tr>
<tr>
<td>AND</td>
<td>red $\land$ small</td>
</tr>
<tr>
<td>OR</td>
<td>red $\lor$ small</td>
</tr>
<tr>
<td>XOR</td>
<td>red $\oplus$ small</td>
</tr>
<tr>
<td>SHJ-II_{3[4]}</td>
<td>(red $\land$ small) $\lor$ (green $\land$ large)</td>
</tr>
<tr>
<td>SHJ-III_{3[4]}</td>
<td>(green $\land$ large $\land$ triangle) $\lor$ (green $\land$ large $\land$ square) $\lor$ (green $\land$ small $\land$ triangle) $\lor$ (red $\land$ large $\land$ square)</td>
</tr>
<tr>
<td>SHJ-IV_{3[4]}</td>
<td>(green $\land$ large $\land$ triangle) $\lor$ (green $\land$ large $\land$ square) $\lor$ (green $\land$ small $\land$ triangle) $\lor$ (red $\land$ large $\land$ triangle)</td>
</tr>
<tr>
<td>SHJ-V_{3[4]}</td>
<td>(green $\land$ large $\land$ triangle) $\lor$ (green $\land$ large $\land$ square) $\lor$ (green $\land$ small $\land$ triangle) $\lor$ (red $\land$ small $\land$ square)</td>
</tr>
<tr>
<td>SHJ-VI_{3[4]}</td>
<td>(green $\land$ large $\land$ triangle) $\lor$ (green $\land$ small $\land$ square) $\lor$ (red $\land$ large $\land$ square) $\lor$ (red $\land$ small $\land$ triangle)</td>
</tr>
<tr>
<td>XOR XOR</td>
<td>red $\oplus$ small $\oplus$ square</td>
</tr>
</tbody>
</table>
Predictors of certainty

Behavioral Predictors
• Current Accuracy – *Performance on the current trial*
• Local Accuracy – *Performance on previous N trials*

Model Predictors
• MAP – *The probability of the best hypothesis*
• Domain Entropy – *Uncertainty over which objects belong to the concept*
$R^2 = .50$
$B = .748$
$z = 30.423$
$p < .001$
Conclusion

• Certainty reflects how well you’re doing in the recent past and not how certain you should be.

• Certainty about a latent, abstract concept does not seem to be determined by the same mechanisms that drive learning.

• A large component of certainty could reflect factors that are largely removed from the veridical probabilities that any given hypothesis is correct.