Universal law of Generalization

Cogsci 131

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(Shepard 1980)

Property induction

- **One example:**

  Cows have T9 hormones
  Horses have T9 hormones

  How likely are C   nes?

  How likely are b ones?

- **Anther example:**

  Birds have T9 hormones
  Horses have T9 hormones

  How likely are Chimps to have T9 hormones?

  How likely are butterflies to have T9 hormones?

General phenomena
(Osherson et al. 1990)

- **Factors that strengthen effects:**

  - Premise typicality
    (robins vs penguins)

  - Premise diversity
    (robins+dolphi

  - Conclusion specificity
    (robins+bluejays → birds vs. jays → animals)

  - Premise monotonicity
    (hawks+sparrows+bluejays vs hawks+sparrows)

- **Why might these kinds of effects be seen?**

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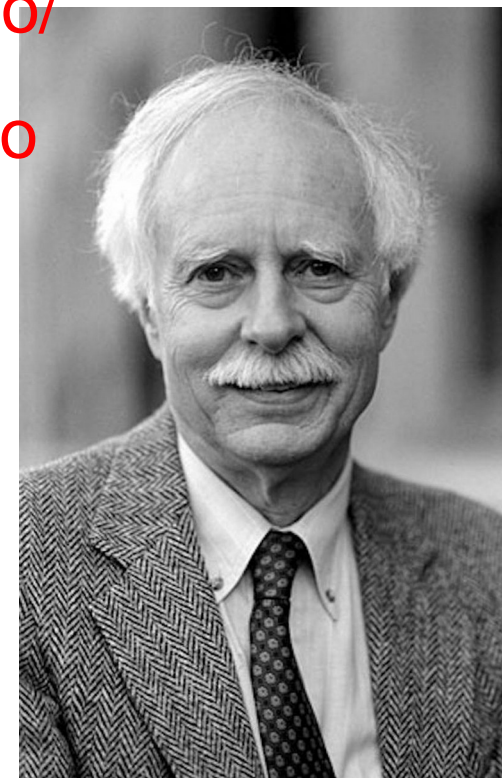
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Similarity and Generalization

- **Similarity is important in part because it determines generalization on new data.**

- **Shepard's Universal Law:** Generalization drops off exponentially in p

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(Shepard 1980)

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(Shepard 1987)

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(Shepard 1987)

"How a cognitive psychologist came to seek universal laws", Shepard (2004)

… [one reason] is my unwillingness to be satisfied with any proposed psychological principle whose sole justification is that it fits all the available empirical evidence—whether behavioral or neurophysiological. *n that that behavioral principle (or that ass*   *hould have the particular form that i*   *ther.* … [I believe] that if, as I fervently hope, psychological   e not merely arbitrary, some may be shown to hav   ccommodations to universal features of the world. If this is so, we might aspire to a science of the mind that, like the physical and mathematical sciences, has universal laws.

What level of analysis is this?

Explaining the universal law

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Explaining the universal law

Single dimension (simple case)

We consider only inte

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Explaining the universal law

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Explaining the universal law

Y-axis:
Probability that y is in the consequential region, **given x is**.

Explaining the universal law

Possible hypotheses (consequential regions) are overlapping intervals of all possible sizes

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Explaining the universal law

Example 1

| Interval includes only the original value of 60 |

Explaining the universal law

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Example 2

Interval
includes 58-60
(size of 3)

Explaining the universal law

Smaller intervals more probable than large intervals **(bar thickness)**

All probabilities sum to 1
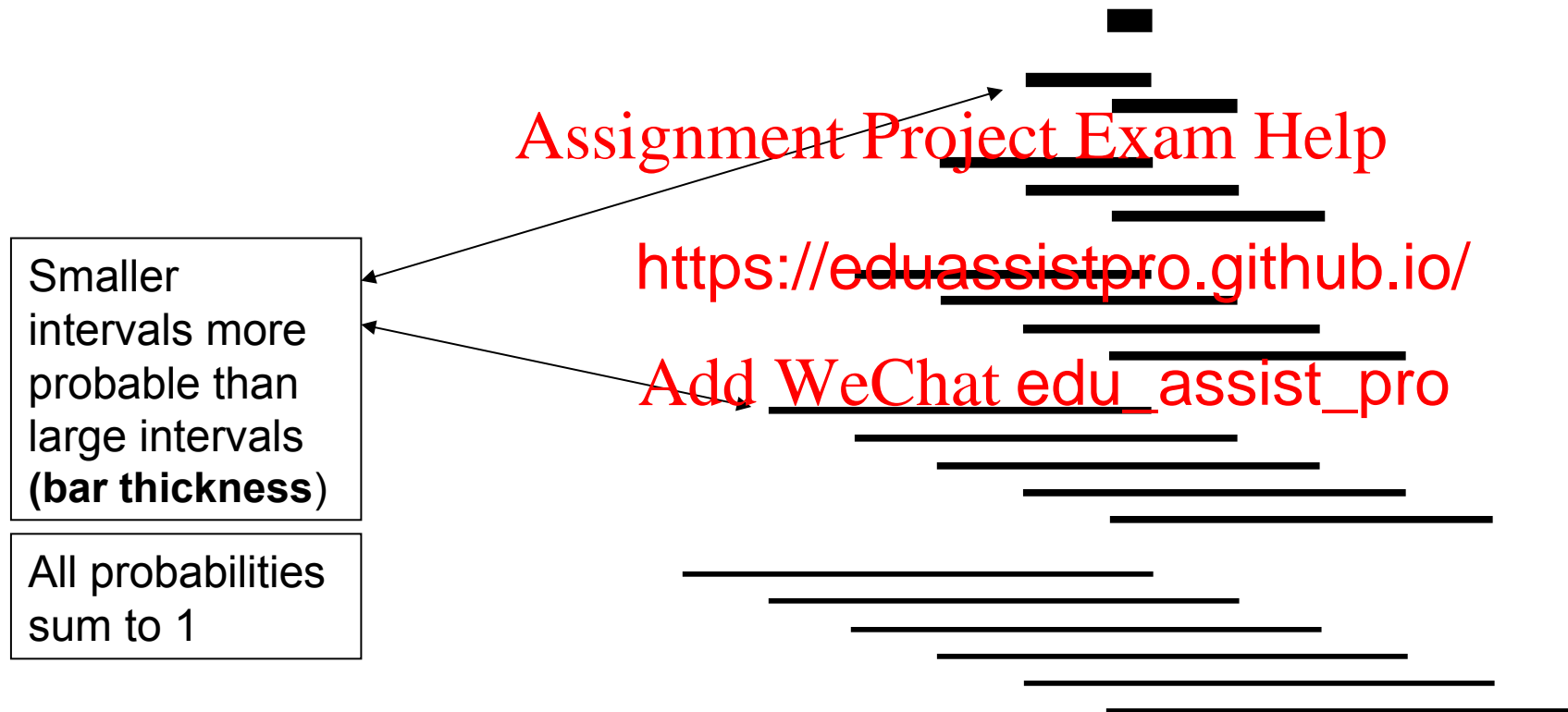
Explaining the universal law

$p(y \in C | x) = 1$

Case 1:

Stimulus **y** also has a value of 60

y is inside all possible intervals that include x

Probability that y is in region is 1.

Explaining the universal law

$p(y{\in}C|x)$
shrinks

Case 2:

Stimulus **y** has a
value of 61

y is inside 16 out
of 21 bars

y is inside 6 less
bars than before

Total probability
of being in the
consequential
region shrinks

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Explaining the universal law

Case 3:

Stimulus **y** has a value of 62

y is inside 5 less bars than before

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Explaining the universal law

Case 4:

Stimulus **y** has a value of 63

y is inside 4 less bars than before

Explaining the universal law

Summary

As y value gets further away from x value, the number of intervals containing it decreases,

BUT, at a decreasing rate **(lost 6,5,4 bars)**.

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Question: What function decreases at a decreasing rate? One answer: $f(x) = e^{-x}$

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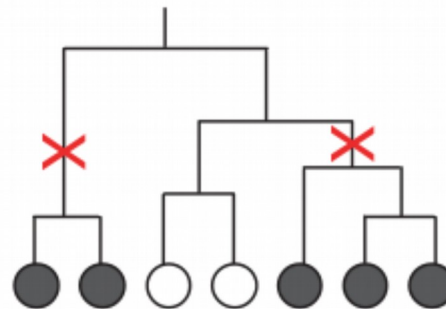Add WeChat edu_assist_pro

Property Induction
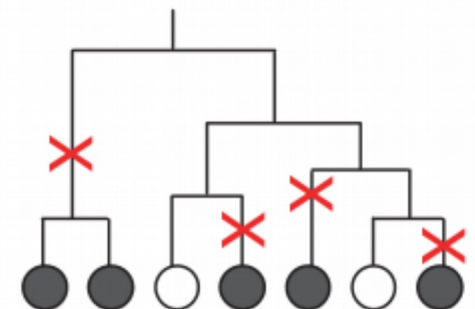## (Kemp & Tenenbaum 2009)
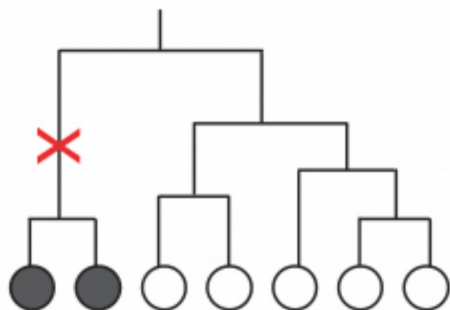
Likely

Less likely

Unlikely

Property Induction
(Kemp & Tenenbaum 2009)

- **Broad observations give evidence for high Xes, because many Xes are unlikely**

- **But high Xes mean that many animals will have it.**

?

Property induction

- **Critically, you need a structure!**

- **And the story is more complex:** what structure is relevant may depend on what the property is!