Implementing and comparing models of estimation bias in "R"

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Introduction

- Theory:
  - Experiments testing spatial estimation have shown systematic bias
  - Two models explaining this phenomenon:
    - Category Adjustment Model (CAM) (Huttenlocher et al., 2000) – preferred model of bias in estimation tasks in current liturature
      - Subjects' memories are not precise
      - They will bias their estimates toward the mean of the category (the center of some spectrum) in order to account for this imprecision
      - Many unknown parameters cause poor predictive ability
    - Cyclical power model of proportional judgment (Hollands & Dyre, 2000) – simpler model suggested as an alternative to the CAM
      - Subjects' bias pattern based on part/whole reasoning
      - Subjects have to estimate the magnitudes of both to estimate proportion
      - Plenty of empirical support; easy to model
- Goals:
  - Implement one- and two-cycle versions of proportion model into the statistical software environment "R"
  - Examine the use of CAM as a predictive model
  - Determine whether a simpler model is just as good at explaining data of estimation bias.
  - Test which model best predicts the data
  - Document how to run and test models

Models

One-cycle version of power model for proportional judgment:

$$y = 2R * \frac{x^\beta}{x^\beta + (2R - x)^\beta}$$

Two-cycle version of power model for proportional judgment:

If x < R:

$$y = R * \frac{x^\beta}{x^\beta + (R - x)^\beta}$$

If x ≥ R:

$$y = 2R * \left(\left(\frac{(x - R)^\beta}{(x - R)^\beta + (2R - x)^\beta} * .5 \right) + .5 \right)$$

R = Center of the category

Fitting the Cyclical Power Model

The following graphs illustrate the results of a spatial estimation task. In this task, children are shown where a toy is buried in a sandbox 30 inches in length. They are then momentarily distracted such that their gaze is broken. Then they are asked to point to the toy. Their estimation is recorded for each of 11 locations in the sandbox. The graphs below show the responses of 2 of the subjects, one which exhibits a pattern of bias best modeled by the one-cycle version of the proportional power model, and another which exhibits a pattern of bias best modeled by two-cycle version of the model.

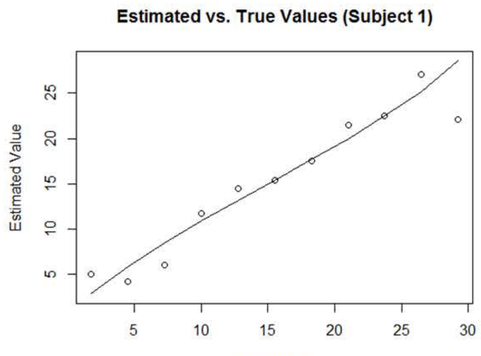

Figure 1. Four year-old subject, one-cycle best fit

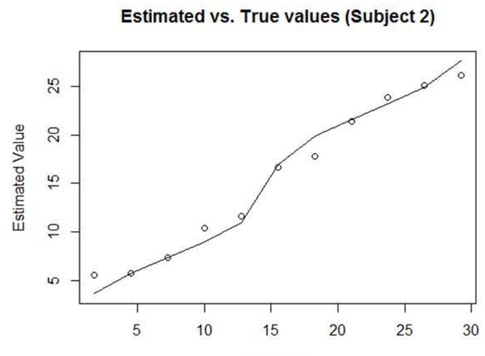

Figure 2. Three year-old subject, two-cycle best fit

	Degrees of Freedom	AIC	BIC
One-cycle Subject 1	2	54.65096	55.44675
Two-cycle Subject 1	2	55.32979	56.12558
One-cycle Subject 2	2	43.84549	43.84549
Two-cycle Subject 2	2	37.47345	38.26924

In model selection, a lower AIC or BIC value suggests a better fitting model. The table above provides statistical evidence that the one-cycle version of the proportional judgment model was best in the first case, but the two-cycle version of the model was best in the second.

Evaluating the Category Adjustment Model

In examining the CAM, we found that its usefulness as a predictive model revolves around quantifying the accuracy of memory. Figure 3 shows how this parameter is vital information in predicting the estimated value in a spatial task. Since memory exactness cannot be quantified, there is no way to make an estimate. The reverse, however, is possible. Given the estimate, one could calculate the inexactness of memory.

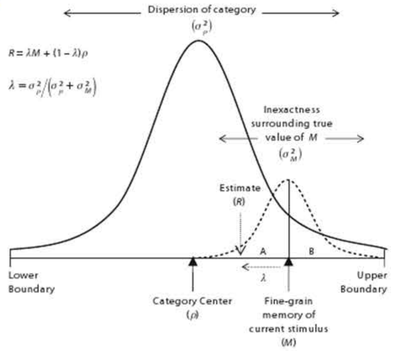

Figure 3. The Category Adjustment Model (CAM) (Duffy et al., 2010)

Conclusions and Future Research

- One- and two-cycle models were implemented and successfully accounted for bias in a spatial education task for preschoolers
  - Suggests that quantitative models of part/whole estimation can explain patterns of estimated bias commonly explained by models of categorical reasoning
- AIC and BIC model selection methods were applied to the models successfully
- Implementation of the Category Adjustment Model was unsuccessful
  - Appears to be qualitative descriptive model for post-hoc analysis only
    - Provides a strong theoretical explanation of the existing bias patterns
    - Very little empirical evidence as to its usefulness as a predictive model
- Documentation completed
  - Different analysts can now use documentation in order to model and graph data in "R"
  - The documentation can now be used to add new models to the existing ones

Literature Cited

Duffy, S., J. Huttenlocher, L. V. Hedges, and L. E. Crawford. "Category Effects on Stimulus Estimation: Shifting and Skewed Frequency Distributions." *Psychonomic Bulletin & Review* 17.2 (2010): 224-30. Print.

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