



# LEGENDARY

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## Advertising Attribution Modeling in the Movie Industry

Victor Lei, Nathan Sanders, and Abigail Dawson

# Contents

- Legendary Entertainment
- Problem
- Our solution



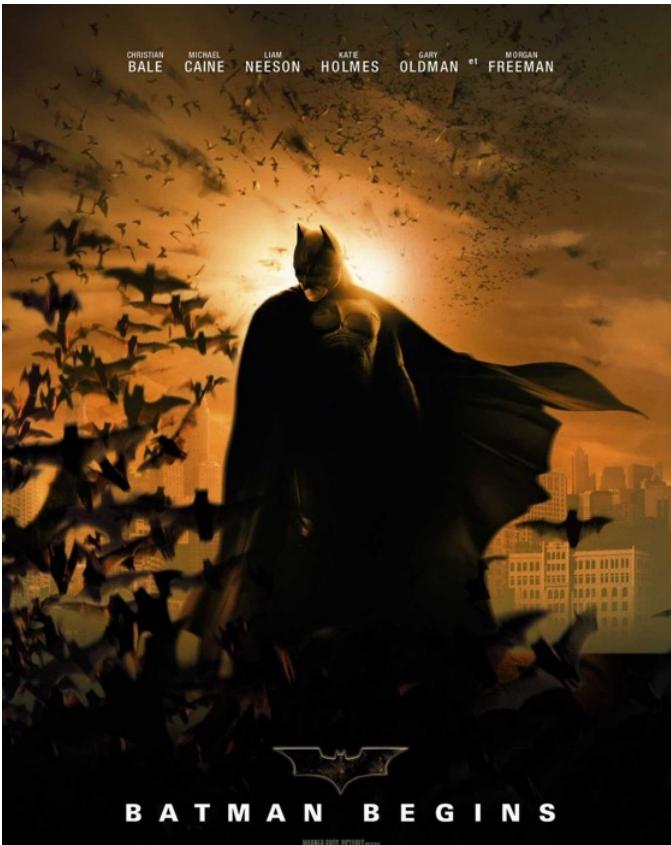
# Legendary Entertainment

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- Entertainment conglomerate with holdings in
  - Film
  - TV
  - Comics
  - Sports
  - Digital media, and more
- \$12B in global box office gross since 2000



# Batman



# Nolan Movies



# Blockbusters



# The Great Wall



# Applied Analytics Scope

- Investment unprecedented in Hollywood

- Top-level department
- 2013: 0 people
- 2016: 80 people



# Legendary Applied Analytics Mandate

**Driving All Strategic Decisions  
with Data and Analytics**

**Inform  
Creative**

**Transform  
Marketing**



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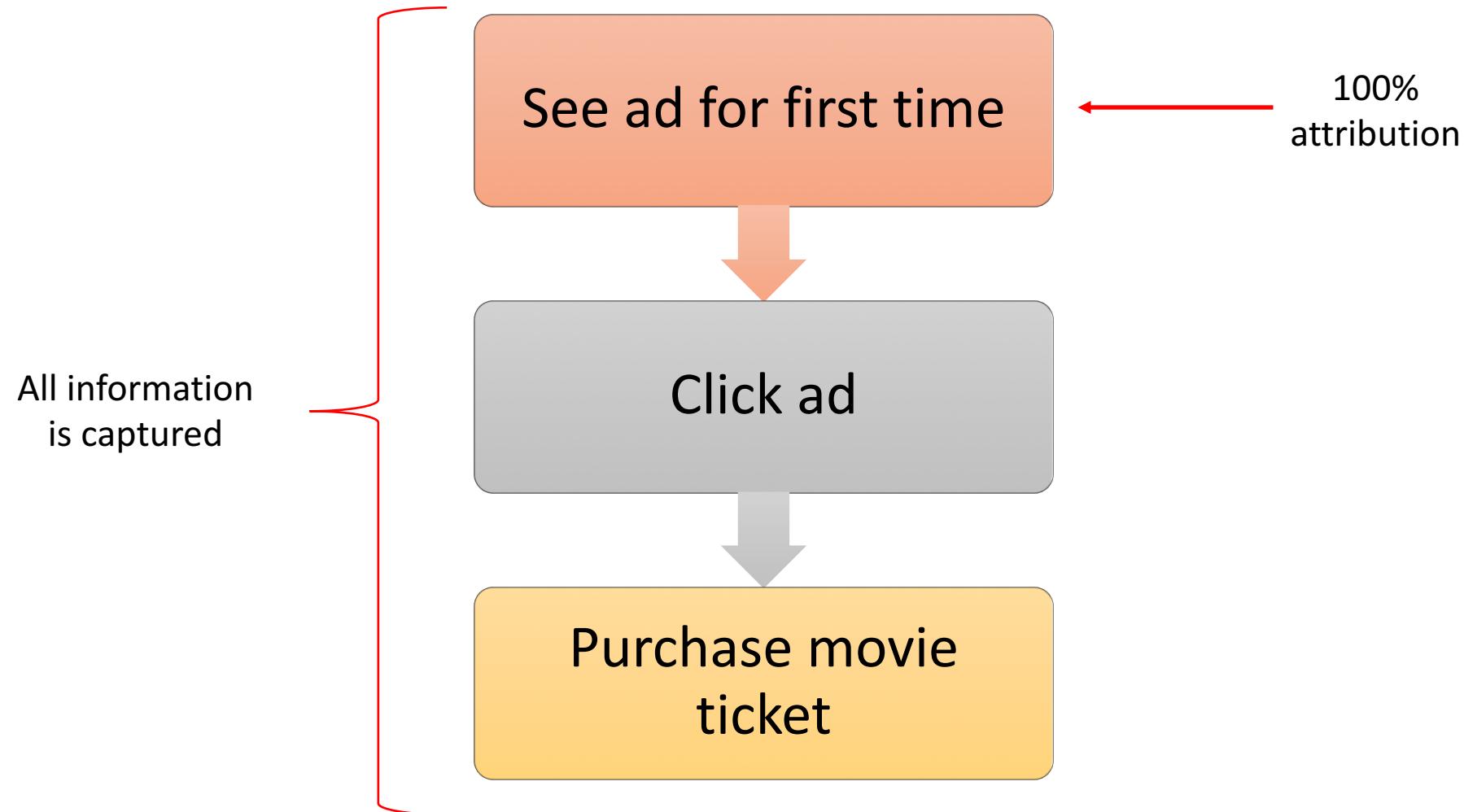
- Legendary Entertainment

- Problem

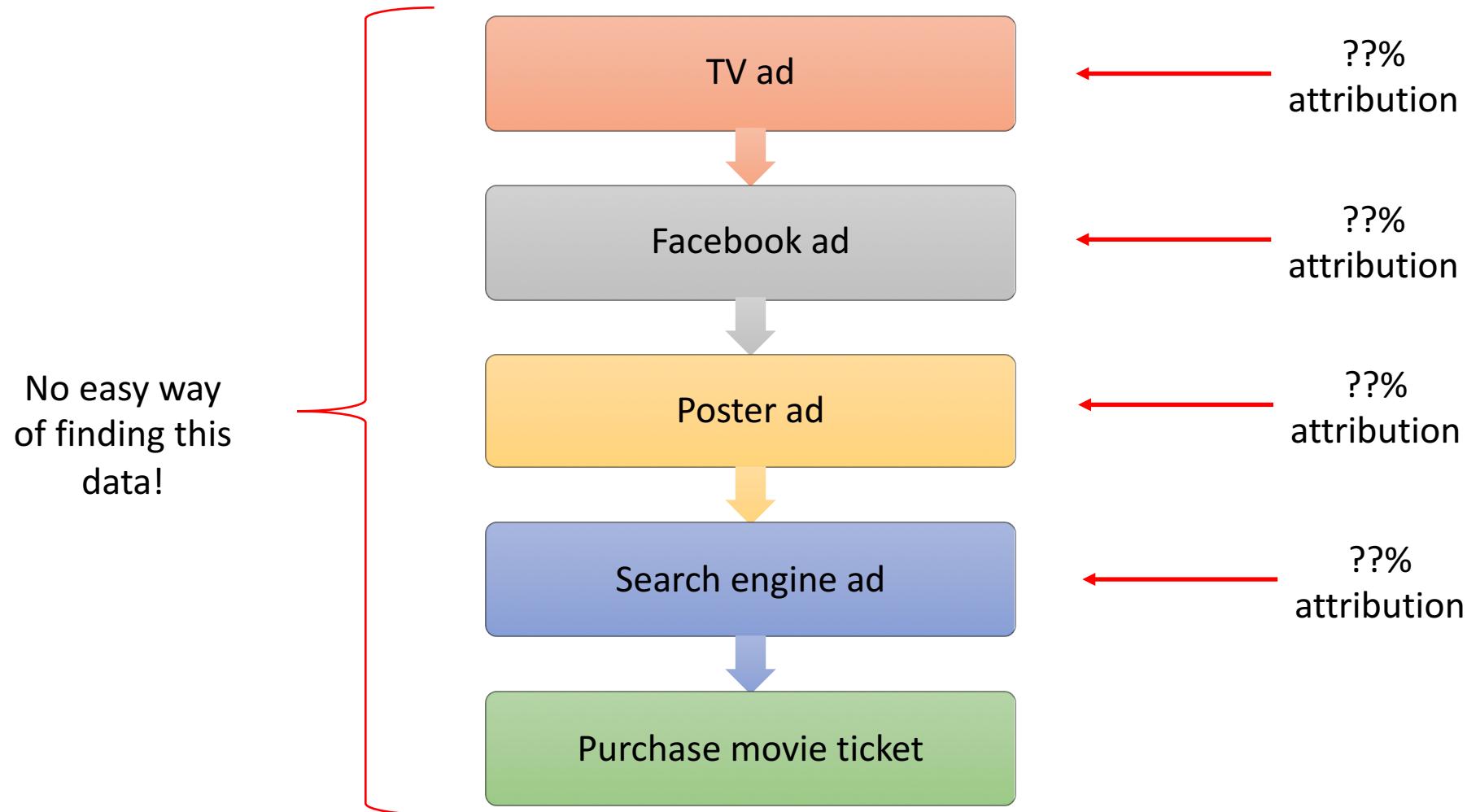
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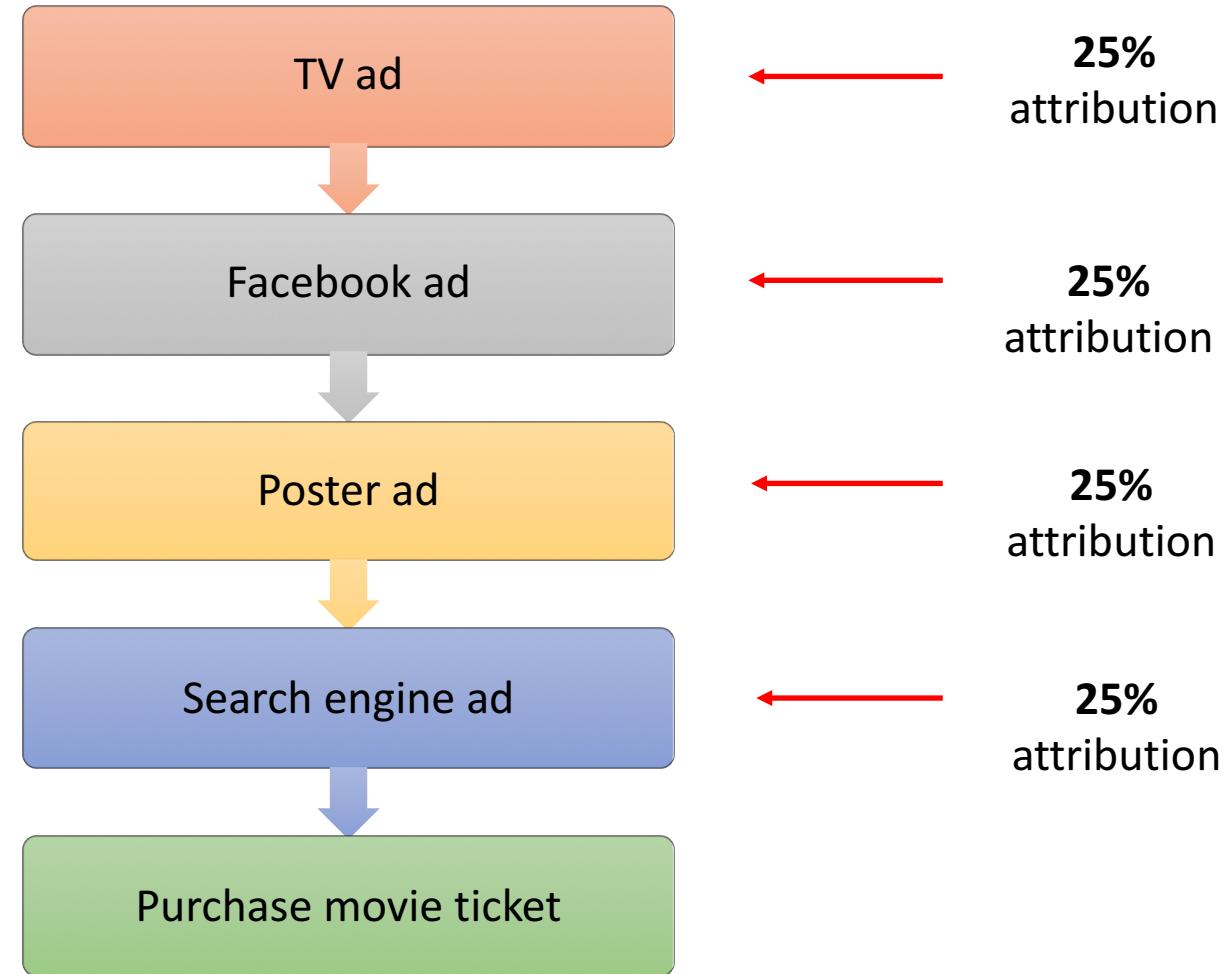
# The Ideal Situation



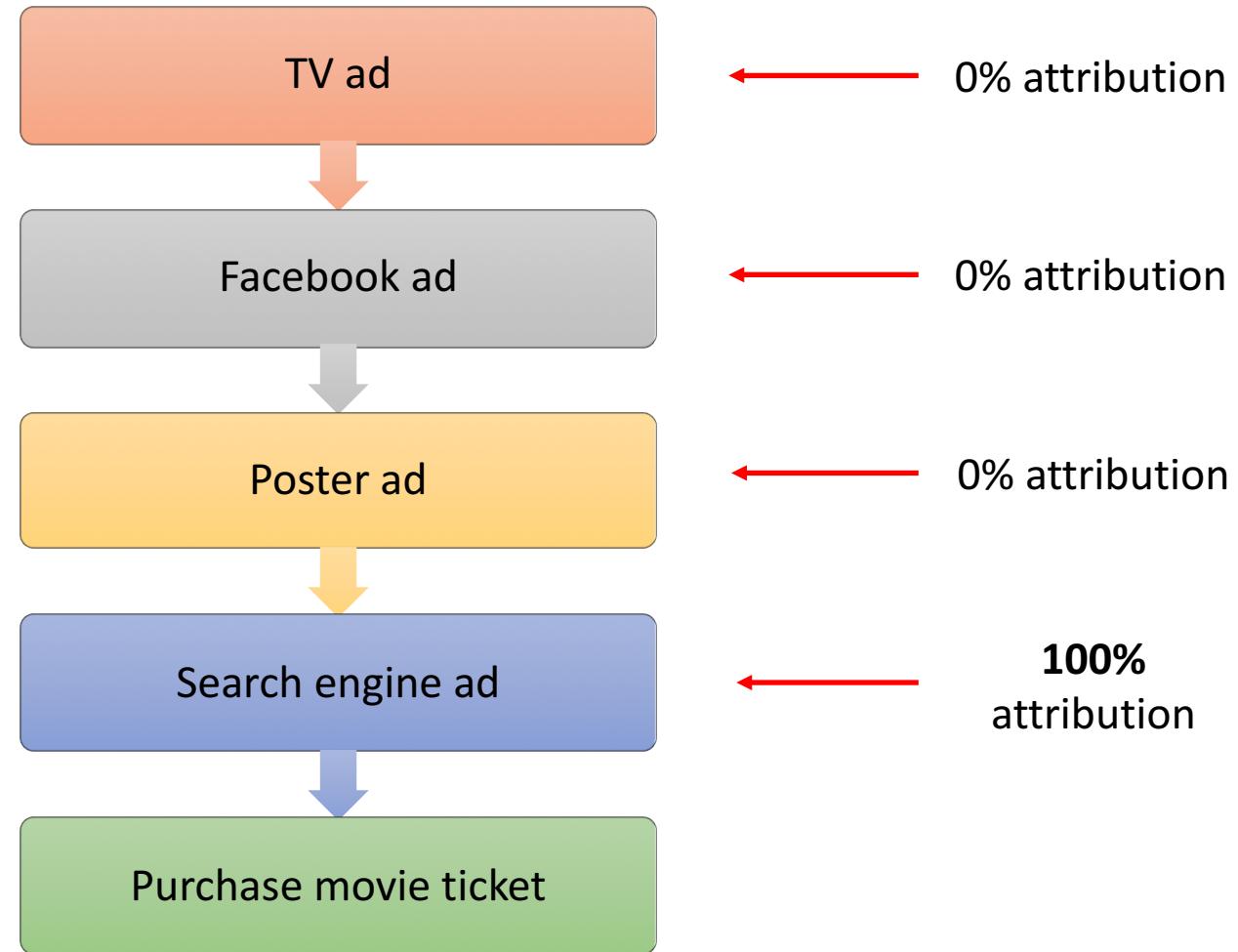
# The Real Situation



# Equal Attribution



# Last Touch Attribution



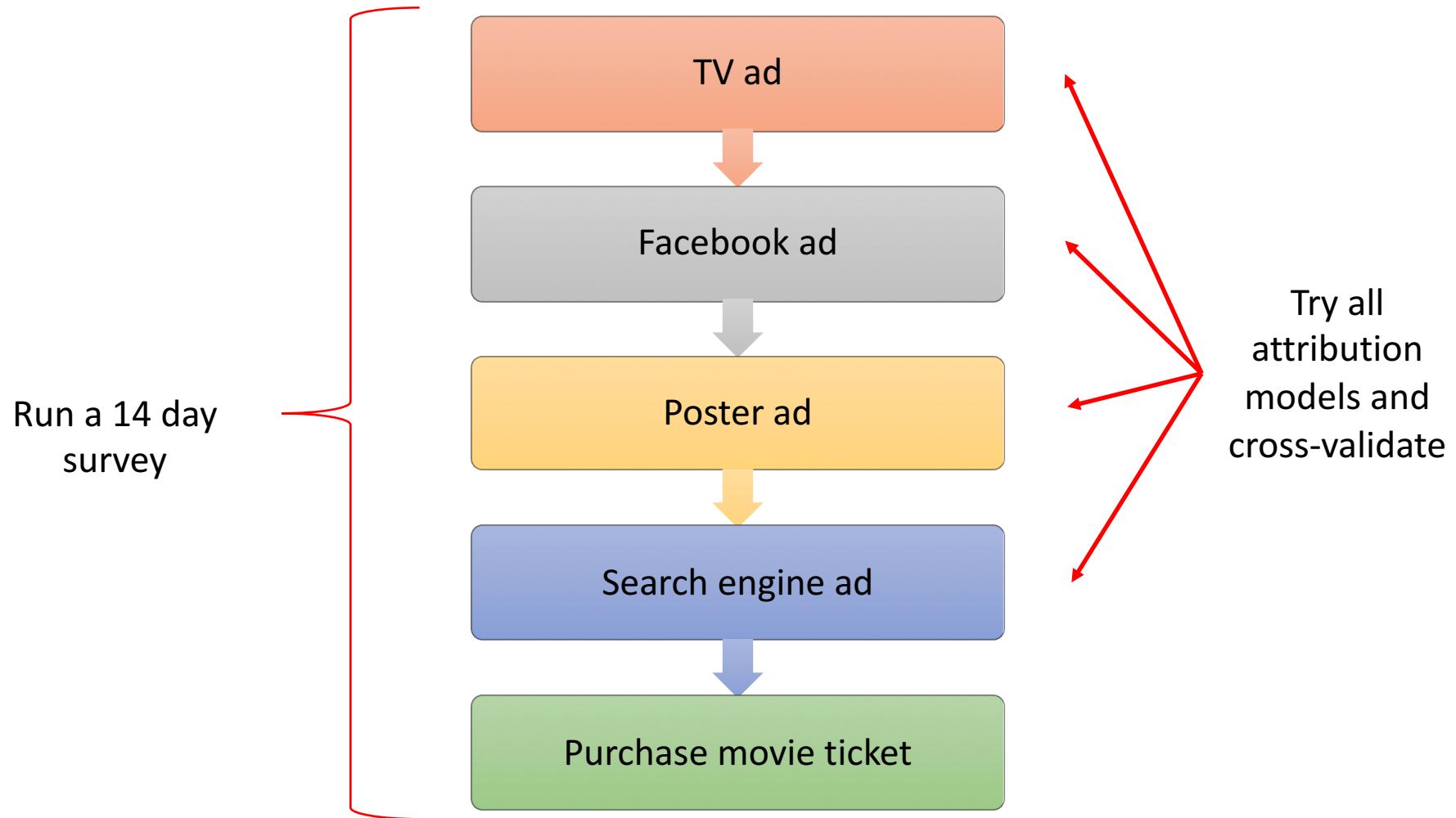
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# Our Solution



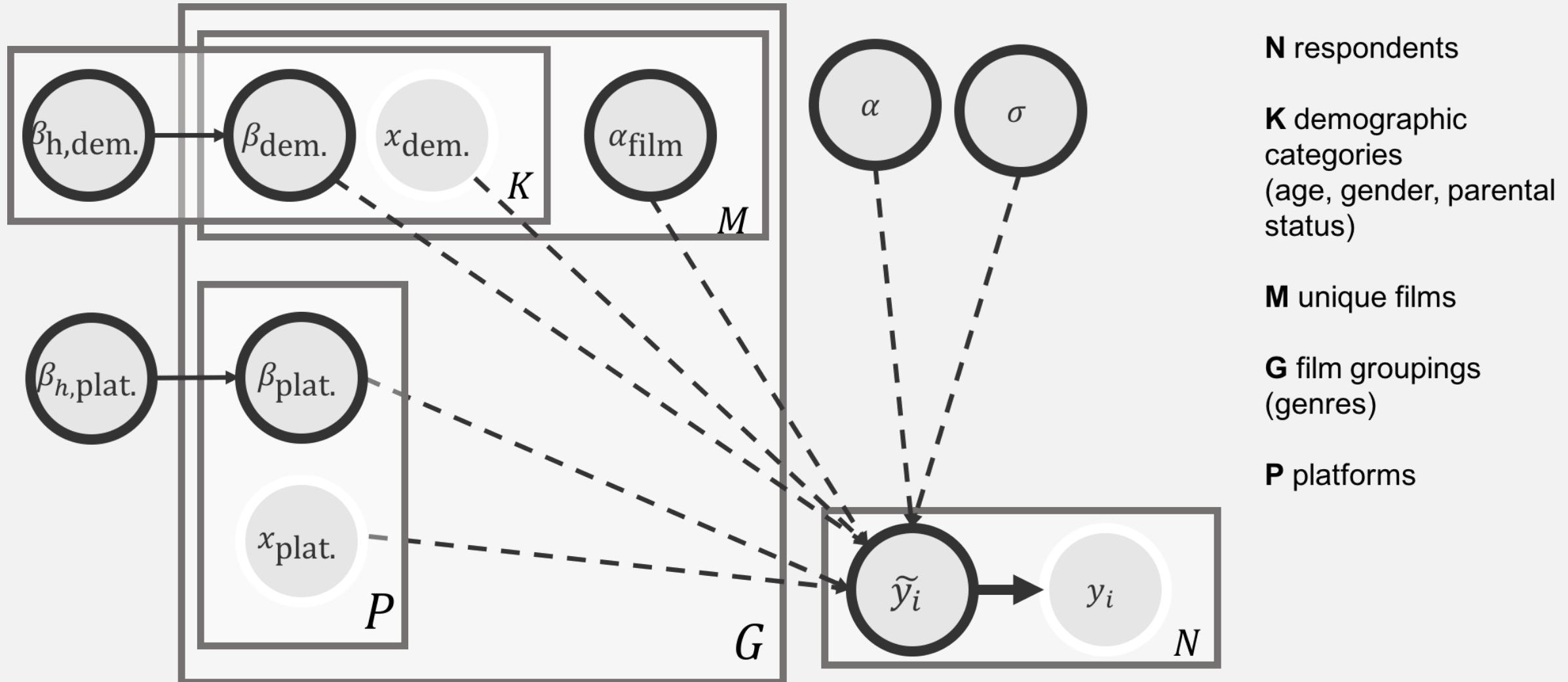
# Survey Data

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- Get demographic data so we can control for this
- Look at both the target movie (e.g. Warcraft), and cohort movies released around the same time
- During target movie release, *everyday* for 14 days, ask about:
  - Ads seen for cohort movies (Twitter, Youtube, TV, Print etc.)
  - Movies they have seen that day
  - How interested they are about each movie
- Follow-up a week or two afterwards and ask:
  - Have people seen any of the cohort movies
  - How interested are they in seeing each cohort movie



# The Partially-Pooled Model



# Hierarchical Logistic Regression Model

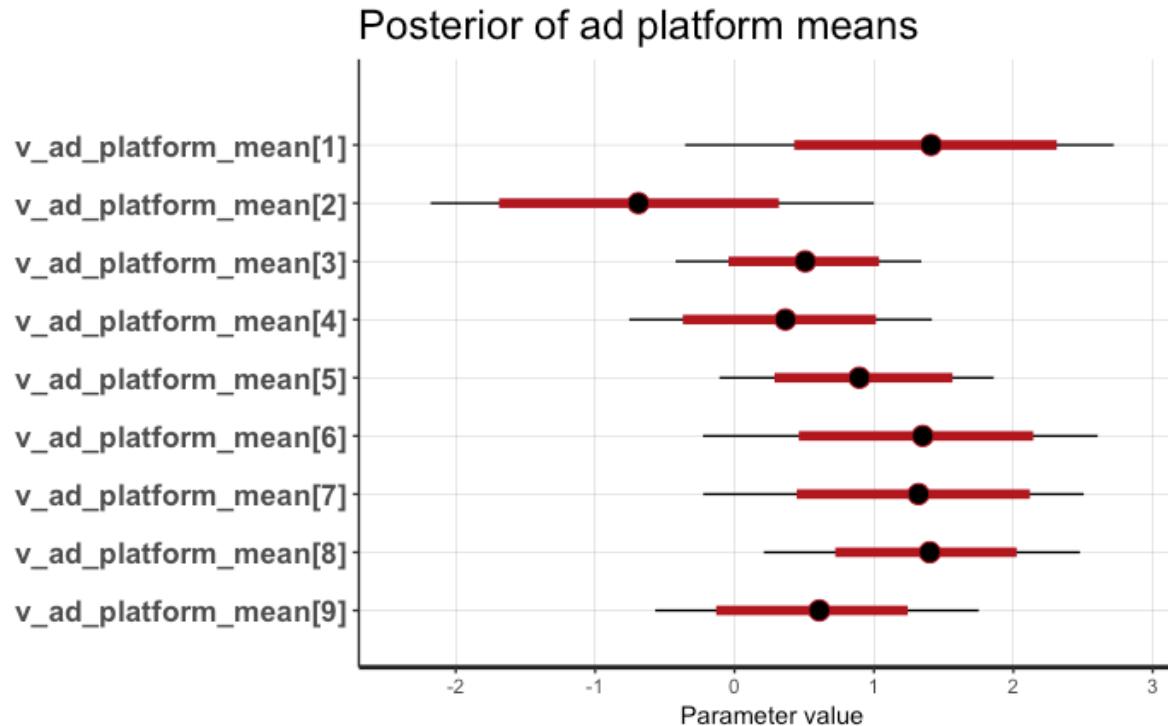
$$\mu = \text{logit}^{-1}(x_{i,\text{age}}\beta_{\omega,\text{age}} + x_{i,\text{gender}}\beta_{\omega,\text{gender}} + x_{i,\text{parent}}\beta_{\omega,\text{parent}} + x_{i,\text{ad}}^T\beta_{\omega,\text{ad}} + \beta_{\omega,0} + \beta_0 + \bar{y})$$
$$y_i \sim \text{Bernoulli}(\mu)$$

$$\left. \begin{array}{l} \beta_{\omega,\text{demo}} = \sigma_{t,\text{demo}}(\sigma_{g,\text{demo}}\beta_{f,\text{demo}} + \beta_{g,\text{demo}}) \\ \beta_{\omega,\text{ad}} = \sigma_{t,\text{ad}}(\mu_{\text{ad}} + (\sigma_{g,\text{ad}}\beta_{f,\text{ad}} + \beta_{g,\text{ad}})) \end{array} \right\} \text{Non-centered parameterization}$$

$$\left. \begin{array}{l} \beta_{g,\text{demo}} \sim \mathcal{N}(0, 1) \\ \sigma_{g,\text{demo}} \sim \text{Cauchy}(0, 1) \mid \sigma_{g,\text{demo}} > 0 \end{array} \right\} \text{Gaussian priors and half-Cauchy hyperpriors}$$

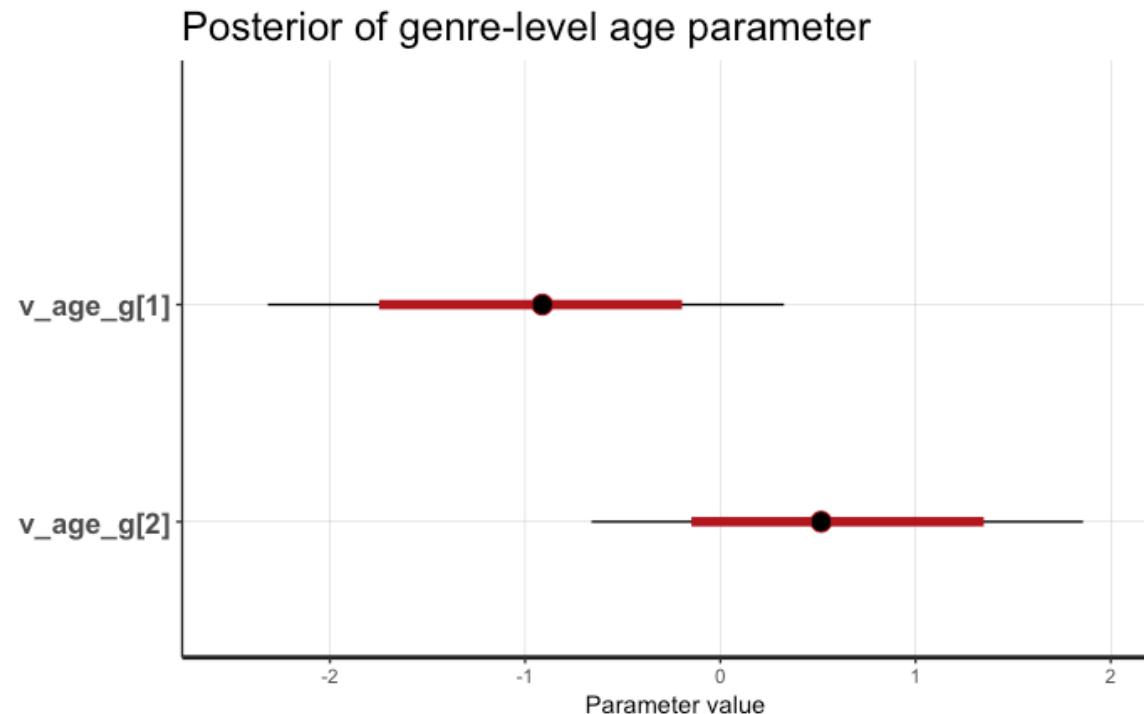
# Advertising Effectiveness

- Platform means allow platform effectiveness comparisons across survey cohort
  - Effectiveness measures also possible across the hierarchy (e.g. specific genres or films)
- Substantially increased significance with the full model and dataset



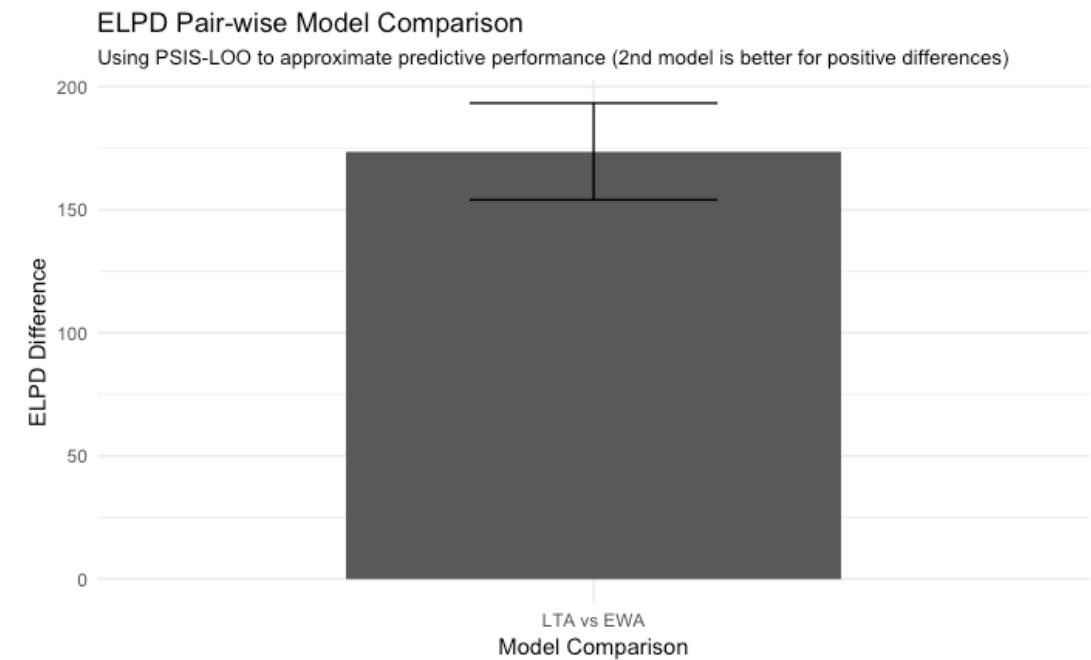
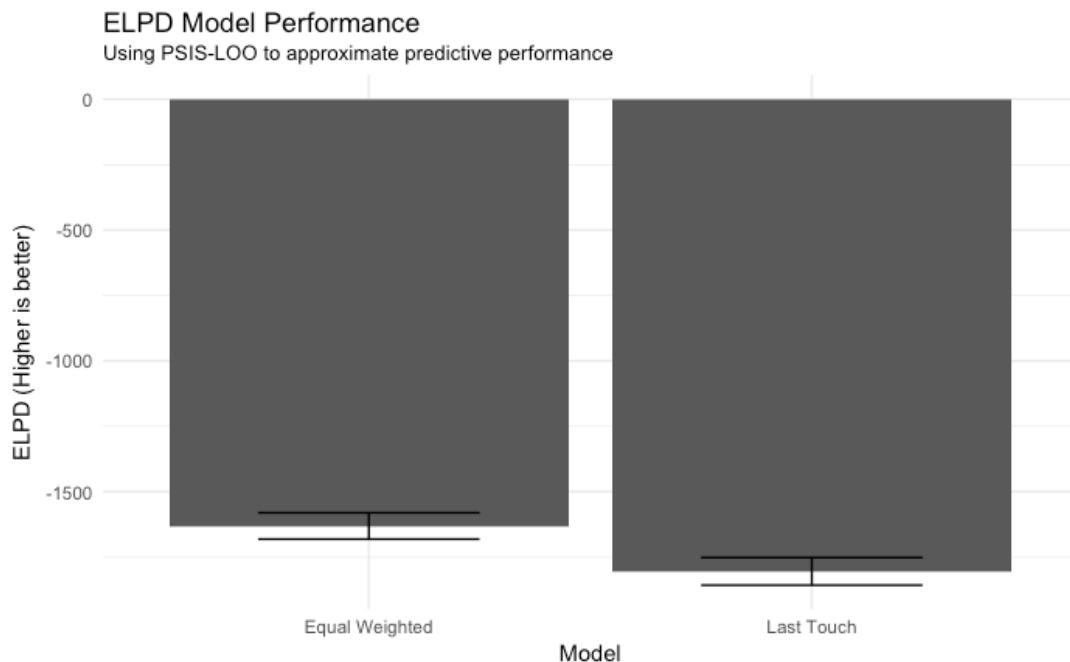
# Analyzing the Hierarchy

- The hierarchical model lends itself easily to analyzing model parameters at different levels of the hierarchy
- For example, how is age associated with different movie genres?



# Leave One Out Cross-Validation (LOO-CV)

- Using LOO-CV to decide between different attribution schemes
  - Computationally infeasible as it requires N model fittings
- Use Pareto-Smoothed Importance Sampling\* to approximate the expected log point-wise predictive density (ELPD) of LOO-CV using a single model fitting



\*Vehtari, A.; Gelman, A.; Gabry, J. *Practical bayesian model evaluation using leave-one-out cross-validation and WAIC*. 2016.

# Conclusion

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- Stan has allowed us to explore applications of Bayesian statistics to important, real-world problems at Legendary Entertainment
  - Robust understanding of associations and uncertainties at all levels of the hierarchy
  - Novel approach to evaluation of attribution schemes using LOO-CV estimation



*Thank you!*  
*Any questions?*

