Assessing the Efficiencies of "Optimal" Discrete Choice Experiments in the Presence of Respondent Fatigue

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Abstract

Unlike operational design-of-experiments implementations where a very select set of trials can be easily completed, marketing choice experiments are easy to "trial," but often difficult to complete. The conjoint challenge is to maximize the amount of quality information any given respondents provide before either their responses become indistinguishable or they quit the survey. Conjoint designers have many variables with which to tailor a marketing choice experiment, including the number of levels within each attribute, the number of attributes in the study, the number of profiles a respondent chooses from and the number of choice tasks given to each respondent. The mathematical basis directing various design considerations will be explored along with accompanying client case studies.

Outline

1. DCE Uses and Application
2. Efficiencies of optimal DCEs with respondent fatigue
3. Trade offs between choice sets, profiles, and surveys
4. Practical implications and future research

The Big Idea

- The theoretical underpinning of DCEs is that the ***choice*** of one option over another is based on the individual ***characteristics*** (attributes) the item possesses.
  - *Lancaster 1966, 1971*

- Using structured choice sets one can conduct utility maximization via a family of analytical models to **PREDICT** future choices.
  - *McFadden's MNL 1974, HMNL, PROBIT…*

DCE Applications

- Designing optimal product/service feature sets
- Establishing/revising pricing
- Determining Brand strength

Fast Food DCE Design Parameters

Five Attributes:

- Occasion @ 4 levels
- Brands Signature Menu Item @ 4 levels
- Speed of Service @ 2 levels
- Proximity @ 2 levels
- Price @ 4 levels

Consumer Fast Food Design

PREFERENCES

On the sixteen screens that follow, you are shown several meal offerings from four restaurants. For each meal that you would consider buying from a restaurant, move the meal from the upper row to the lower row. Select your first choice for a meal from the upper row, highlight it, and use the arrow keys to move it to the lower row. Repeat for all of the meals you would consider buying---your second choice, third choice, and/or fourth choice. You may order selected meals in the bottom row by using the left and right arrow keys under that row. When making choices, assume that you are eating on a normal or regular day, rather than eating on the day of a special event or occasion. When you are finished selecting meals that you would consider buying from restaurants and ordering them from most preferred to least preferred, continue to the next screen.

Occasion. This is the time of day for which you are choosing a meal: breakfast, lunch, dinner, snack.

Signature Menu Item. Various restaurants' signature menu items will be presented for each meal occasion. One of those signature menu items will be a White Castle menu item.

Speed of Service. Menu items will be presented with different responsiveness after you arrive at a restaurant.

Restaurant Proximity. Here you will be presented with various travel times to get to the restaurant.

Price of Meal. This is the price of the meal per person.

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Consumer Fast Food Choices

CHOICE 2 OF 20

Here you are shown several meal offerings from full-service and quick-service restaurants. For each meal that you would consider buying from a restaurant, move the meal from the upper row to the lower row. Select your first choice for a meal from the upper row, highlight it, and use the arrow keys to move it to the lower row. Repeat for all of the meals you would consider buying -- your second choice, third choice, and/or fourth choice. When making choices, assume that each restaurant is in the same location, an easy commute from where you live or work. Also assume that you are eating on a normal or regular day, rather than eating on the day of a special event or occasion. When you are finished selecting meals that you would consider buying from restaurants, continue to the next screen.

Offering	Proposal 1	Proposal 2	Proposal 3	Proposal 4
Eating Occasion	Lunch	Lunch	Lunch	Lunch
Restaurant Offering	Quiznos Turkey Ranch & Swis Sub	Firehouse Hook & Ladder Sub (Turkey & Ham)	*NO RESPONSE*	Subway Cold Cut Combo Sub
Speed of Service	Served within 10 minutes	Served within 20 minutes	Served within 20 minutes	Served within 10 minutes
Restaurant Proximity	15 minutes	15 minutes	30 minutes	30 minutes
Price per Person	$5.99	$7.99	$9.99	$11.99

Fast Food DCE Fatigue

Designs done to accommodate client demands for competitive tradeoff analysis resulted in excessive abandonment with existing methods.

	20 Screens	16 Screens	8 Screens
Completes	1512	1808	355
Incompletes	1713	1534	152
Responses	3225	3342	507
Finish Rate	47%	54%	70%

Notation

- C: # of choice sets per survey
- P: # of profiles per choice set
- A: # attributes per profile
- l_a: level of attribute a (e.g., levels = [2,2,2,3])

Multinomial Logit

- Respondent utility

$$U_{ncp} = \mathbf{f}'(\mathbf{x}_{cp})\boldsymbol{\beta} + \varepsilon_{ncp}$$

  - ε : I.I.D, Extreme Value Distribution
  - ε_j - ε_i: logistic distribution

- Then: MNL (McFadden,1974)

$$p_{cp} = \frac{e^{\mathbf{f}'(\mathbf{x}_{cp})\beta}}{\sum_{j=1}^{P} e^{\mathbf{f}'(\mathbf{x}_{cj})\beta}}$$

Multinomial Logit

- Information matrix:

$$\mathbf{I}(d,\beta) = N\sum_{c=1}^{C}\mathbf{X}_c'(\mathbf{P}_c - \mathbf{p}_c\mathbf{p}_c')\mathbf{X}_c$$

where

$$\mathbf{p}_c = (p_{1c},\ldots,p_{Pc})'$$

$\mathbf{P}_c$ = Diag($\mathbf{p}_c$)

Heteroskedastic MNL

- Reality: Utility error variance is not constant: People get tired!
- So:

$$U_{ncp} = \mathbf{f}'(\mathbf{x}_{cp})\beta + \sigma_c \varepsilon_{ncp}$$
$$\lambda_c = 1/\sigma_c,\ c = 1, \ldots, C$$

- Result: HMNL

$$p_{cp\lambda} = \frac{e^{\lambda_c \mathbf{f}'(\mathbf{x}_{cp})\beta}}{\sum_{j=1}^{P} e^{\lambda_c \mathbf{f}'(\mathbf{x}_{cj})\beta}}$$

Cumulative Cognitive Burden (CCB)

- Respondent fatigue results from…
  - Complexity of choices (Louviere et al., 2008)
  - Total number of choices (DeShazo and Fermo, 2002)
  - Total time spent (Haaijer et al., 2000)
- Implications as CCB increases…
  - Respondents drop out
  - Respondents answer without careful discrimination
    - "Choice inconsistency"
    - Var(ε) increases
    - Estimates of β become less precise

Fatigue effect and λ_c

- Fatigue is related to the CCB
- CCB after respondent completes c sets:

$$CCB(c) = w(c-1)P\sum_{a=1}^{A} l_a$$

$$\lambda_c = e^{-CCB(c)} = e^{-w(c-1)P\sum_{a=1}^{A} l_a}$$

- Next, we consider methods for determining w (hence λ_c)

Finding λ_c

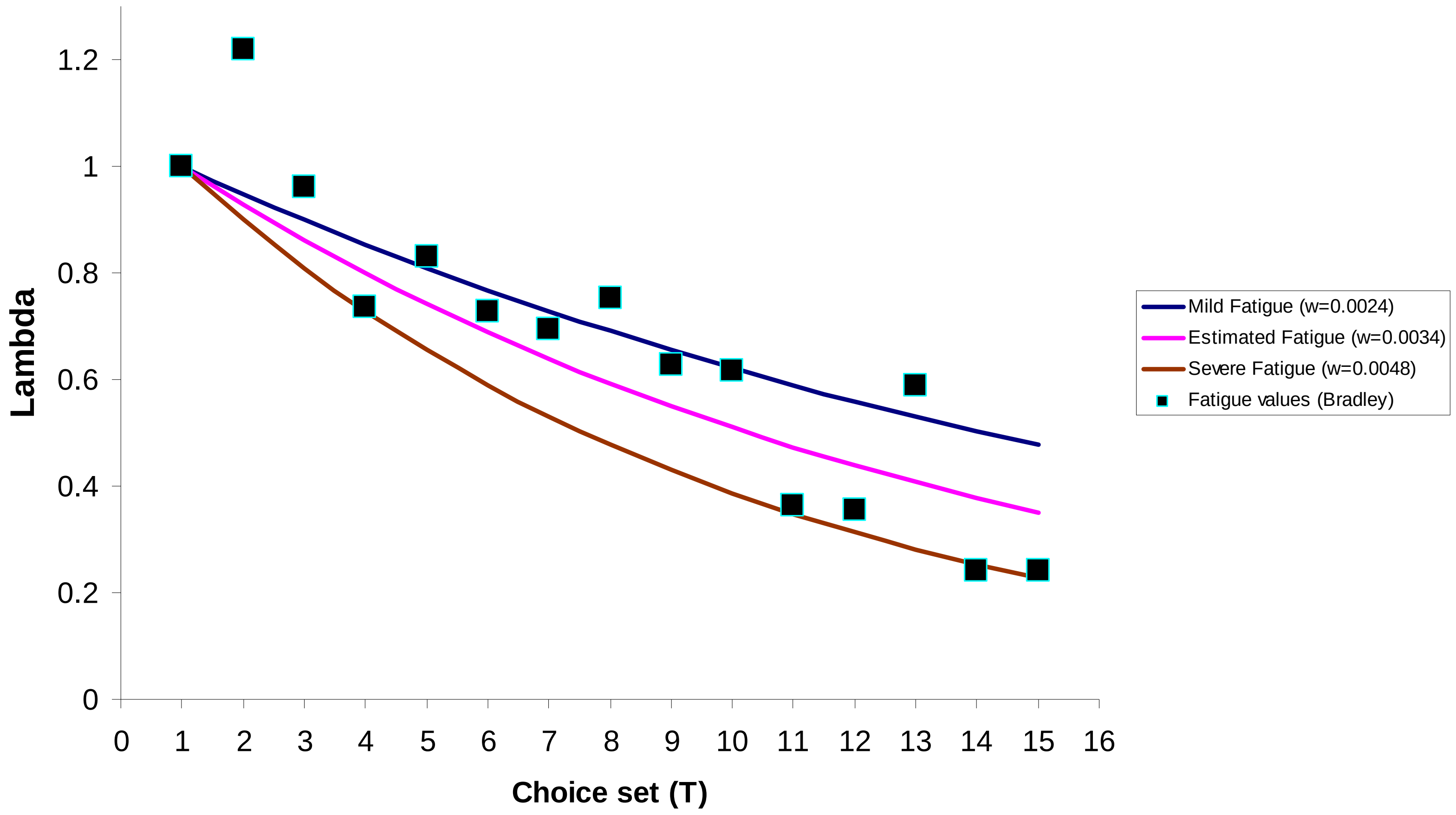
- In one study, λ_1=1 (no fatigue) and λ_{14}= .3782 (estimated by HMNL)
- $SDIF_C$ (standard deviation inflation factor)

$$SDIF_C = \frac{\sigma_C}{\sigma_1} = \frac{1}{\lambda_C} = 2.64 \quad \text{for which } w = .0037$$

- In general,

$\sigma_C = 2\sigma_1 \Leftrightarrow$ "mild" fatigue (w = .0024)
$\sigma_C = 4\sigma_1 \Leftrightarrow$ "severe" fatigued (w = .0048)

Fatigue curves



Research questions

1. For current designs, what is the loss of efficiency resulting from the fatigue effect?
2. What is the trade-off between the number of choice sets (C), # of profiles/choice set (P), and the attribute levels?
3. What is the tradeoff between the number of surveys and the number of choice sets per survey?

Relative efficiency criterion

- Information matrix for HMNL:

$$\mathbf{I}(d, \beta, \boldsymbol{\lambda}) = \sum_{c=1}^{C} (\lambda_c \mathbf{X}_c)' (\mathbf{P}_{c\lambda} - \mathbf{p}_{c\lambda}\mathbf{p}'_{c\lambda})(\lambda_c \mathbf{X}_c).$$

- Relative efficiency of two designs

$$e(d_1, d_2, \beta, \boldsymbol{\lambda}_1, \boldsymbol{\lambda}_2) = \left(\frac{|I(d_1, \beta, \boldsymbol{\lambda}_1)|}{|I(d_2, \beta, \boldsymbol{\lambda}_2)|} \right)^{1/k}$$

Expected Relative Efficiency

- Use prior distribution: β ~ $\mathrm{N}(\boldsymbol{\beta}_0, \Sigma_0)$

$$\boldsymbol{\beta}_0 = [0, \ldots, 0]' \text{ and } \Sigma_0 = \mathbf{I}_{k \times k}$$

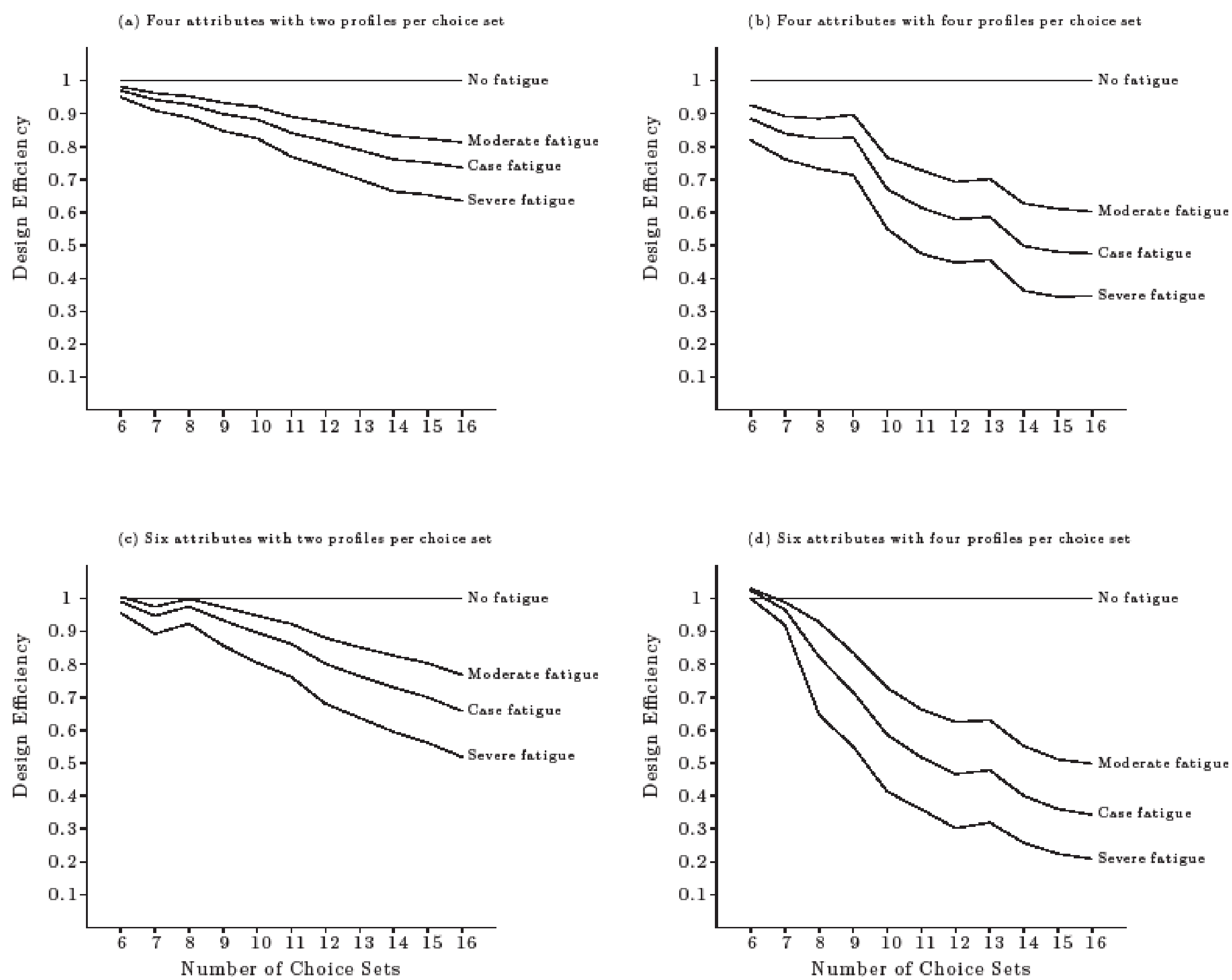
Then:

$$E[e(d_1, d_2, \beta, \lambda_1, \lambda_2)] = \int_{\mathbb{R}^p} e(d_1, d_2, \beta, \lambda_1, \lambda_2) f(\boldsymbol{\beta}) d\boldsymbol{\beta}$$

Efficiency loss due to fatigue

- We constructed a series of D-optimal designs (from JMP)
  - P=2 or 4 (profiles/choice set)
  - A=4 or 6 two-level attributes
  - C=6, 7, 8, …, 16
- For each optimal design, compute relative efficiency of the actual results where respondent fatigue is present to the assumed result with no fatigue

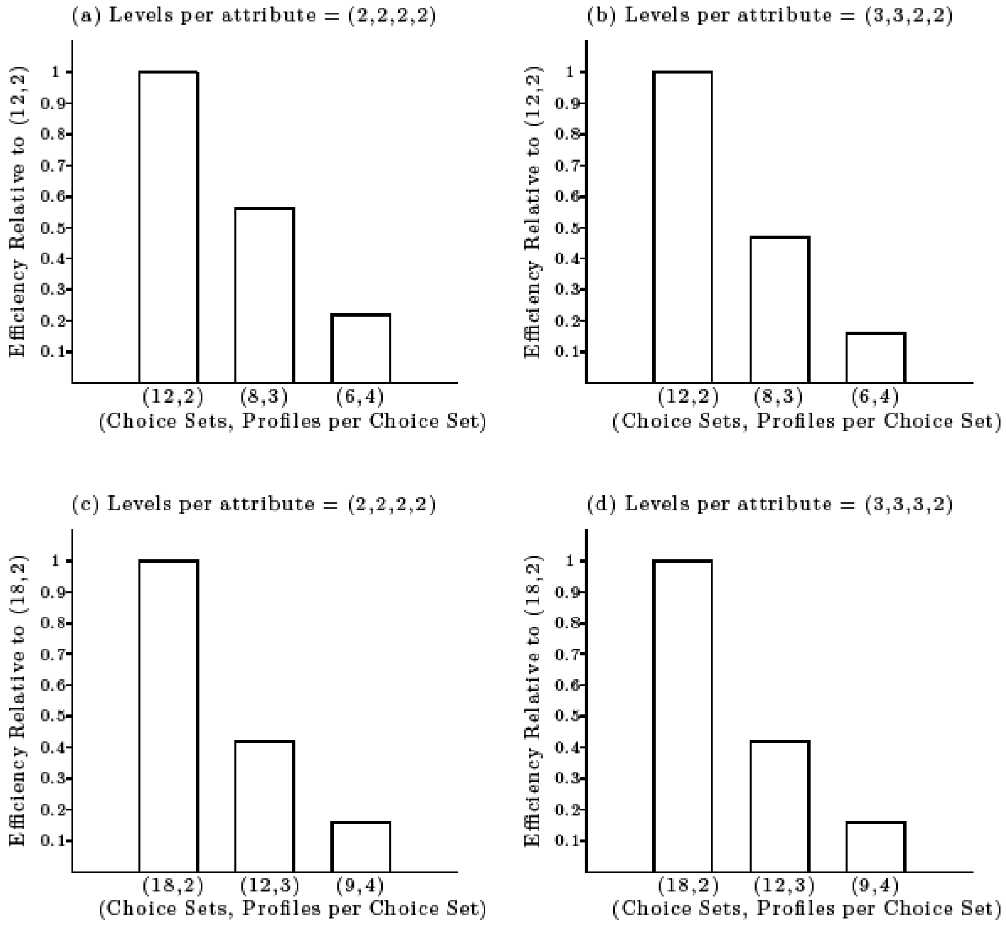
Efficiency loss plots



Trade-off between C and P

- Question: Which design provides more information?
  - Larger C and smaller P?
  - Smaller C and larger P?
- Consider examples where CP = constant
  - (C,P)=(12,2),(8,3),(6,4), and levels=[2,2,2,2]
  - (C,P)=(12,2),(8,3),(6,4), and levels=[3,3,2,2]
  - (C,P)=(18,2),(12,3),(9,4), and levels=[2,2,2,2]
  - (C,P)=(18,2),(12,3),(9,4), and levels=[3,3,2,2]

Comparison of designs assuming no fatigue



Results Imply:

- Never use more than 2 profiles per choice set if no fatigue

- When respondents are fatigued, comparisons are essentially unchanged

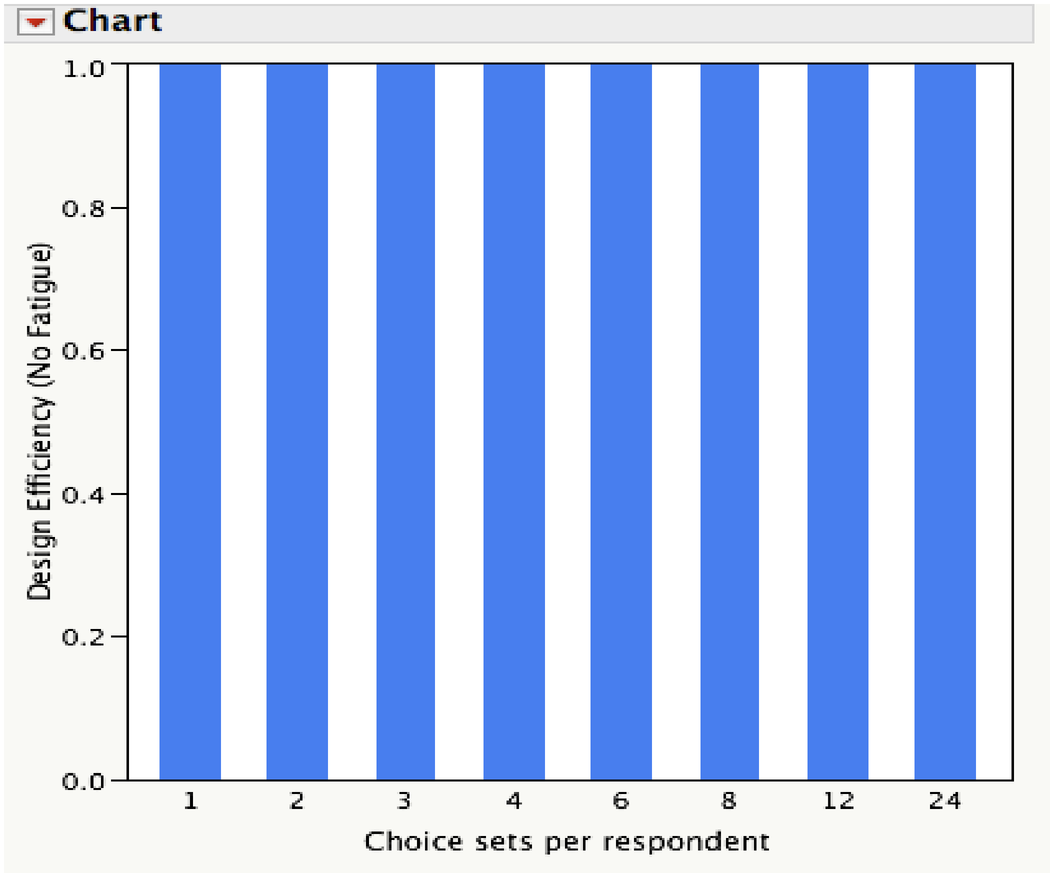
- Bottom line: 2 profiles per choice set always!

Tradeoff Between Number of Respondents and Survey Length

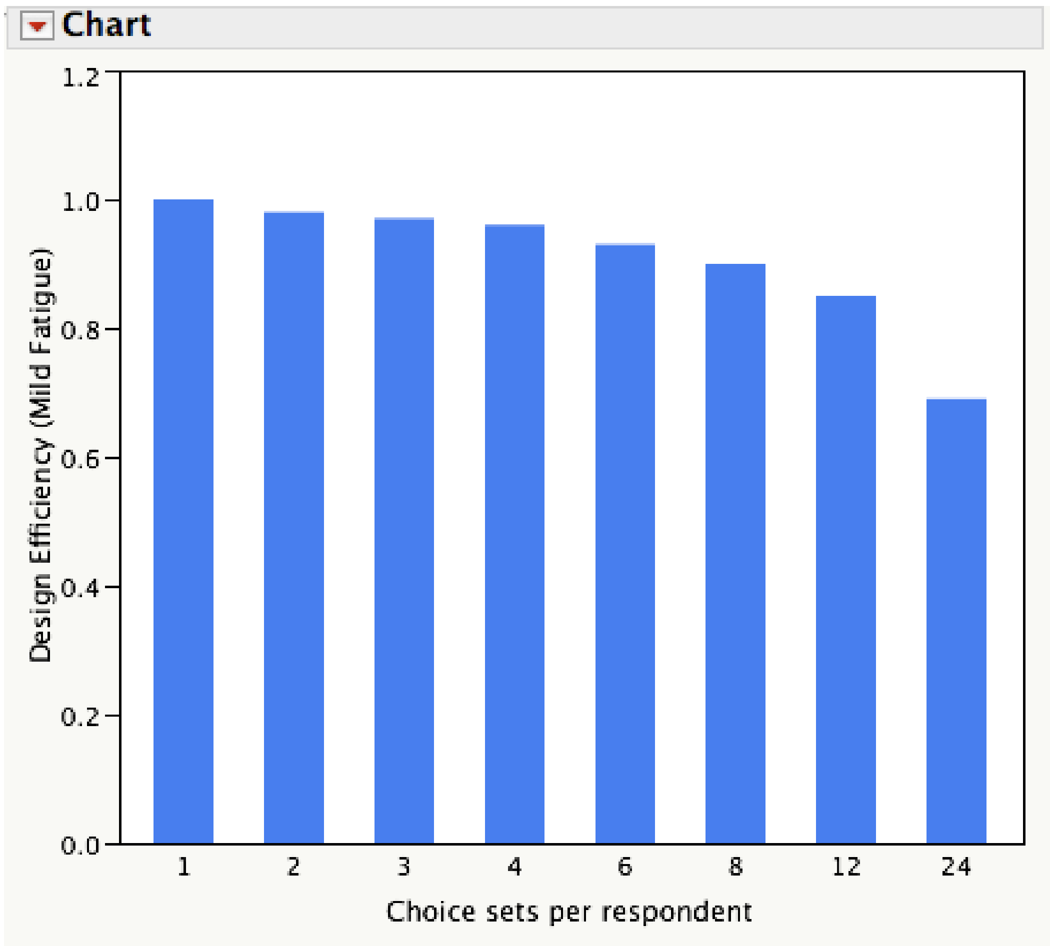
- Rob asked: If I have “unlimited” access to respondents, am I better off using fewer respondents with larger surveys (i.e., more choice sets) for each?

- Or more respondents using fewer choice sets per respondent?

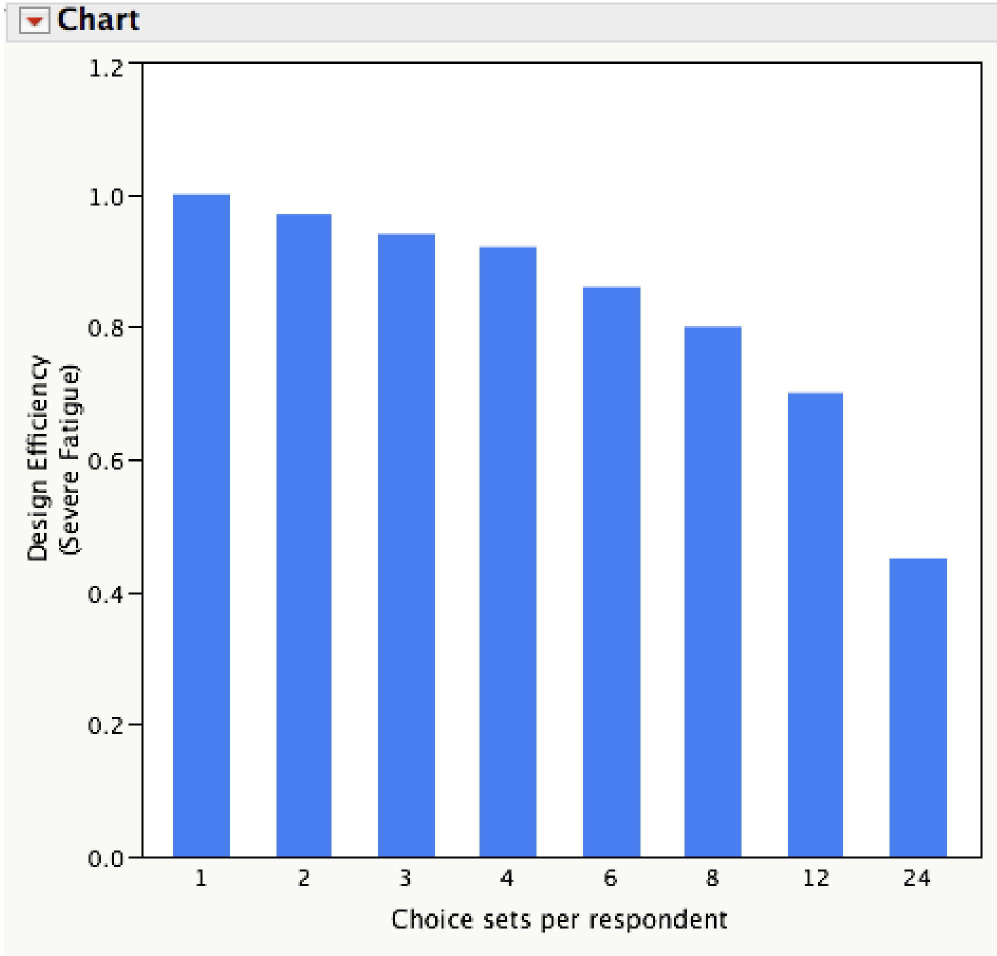
Answer 1: No Fatigue



Answer 2: Mild Fatigue



Answer 3: Severe Fatigue



Answer:

More respondents, fewer choice sets per respondent

Future research

- Optimal designs using the proposed model with fatigue effects
  - Optimal heteroscedastic design
  - Use the quadrature scheme proposed by Gotwalt, Jones, and Steinberg (2009)
- Rank-order conjoint experiments
  - Rank-order experiments add more information (Vermeulen, Goos, Vandebroek, 2008)
  - But they also increase fatigue!
  - Research ongoing
- Mixed logit designs for fatigue

Conclusions

- Fatigue leads to choice inconsistency and decreased efficiency, decreased completion rates.
- Two profiles per choice set: stick with binary choices
- Robust strategy is one binary choice per respondent