An Associative Network Model for Advertising: A Hierarchical Bayesian Approach

Presented by: Sandeep C. Rao

Overview

- Advertising and background
- Marketing data
- Associative Network
- Proposed model
- Preliminary simulation & estimation procedure
- Assumptions
- Work in Progress
- Conclusions

Advertising

- Marketing communicators spend millions on advertising, trying to influence consumers' brand-related beliefs and attitudes.
- Consumers' minds however, are black boxes.
- Innumerable models have been proposed that focus on different aspects of advertising effectiveness like cognition, feelings, product usage experience etc.
- Difficult to come up with one unified theory for advertising effectiveness.

Models in Advertising

- Elaboration Likelihood Model (ELM): ***Petty & Cacioppo***
  - Individuals may form their attitudes in two ways (centrally or peripherally).
  - Under central processing, advertising messages are processed through counter-arguing and support arguing. Under peripheral processing individuals rely on cues such as celebrity status of the product endorser.
- Integrated Information Response model (IIRM): ***Smith & Swinyard***
  - Concept of “low order beliefs” -> “high order beliefs”.
- Conglomeration of advertising studies: ***Vakratsas & Ambler***
  - Look at a plethora of models in advertising.
  - Summarize different consumer advertising processing models.

Marketing Data

Typical marketing data collected includes:

- Motivating Conditions
- Brand Attributes
- Brand Beliefs
- Consideration Sets

Motivating Conditions for Tooth brushing

Solving Immediate Problems

a1: My teeth stain easily.

a2: I wake up with a bad taste/feeling in my mouth.

a3: I am concerned about the condition of my gums

a4: I am predisposed to having sensitive teeth.

a5: I am concerned about tartar and plaque build-up on my teeth.

a6: I am concerned about bad breath.

a7: My teeth are dull/not white enough.

a8: I am predisposed to having cavities.

a9: I have trouble getting my kids to brush.

a10: I am concerned about germs and mouth infections.

Preventing Potential Problems:

b1: I would feel I'm letting myself down if I didn't brush regularly.

b2: I believe that people expect me to brush regularly

Enjoying Sensory Pleasure:

e1: I like the tingle I feel in my mouth after I brush.

e2: I enjoy the fresh taste I get from brushing.

e3: I love to see my teeth gleaming like pearls.

e4: Bubbling action adds to the sensory pleasure of brushing.

Displeasure in Use:

f1: Toothpastes are too strong tasting.

f2: Toothpastes scratch the enamel on my teeth.

f3: Toothpastes irritate my mouth.

f4: Toothpastes cost too much.

f5: Toothpastes contain artificial ingredients.

f6: Toothpaste packaging can be harmful to the environment.

Example Question

Person BJ	Person AW	Person MC	Person JD
Stains, bad taste/feel in my mouth and gums aren't a problem for me	My teeth stain easily.	I wake up with a bad taste/ feeling in my mouth.	I am concerned about the condition of my gums
Sensitive teeth, tartar, plaque and bad breath aren't a problem for me.	I am predisposed to having sensitive teeth.	I am concerned about tartar and plaque build-up on my teeth.	I am concerned about bad breath.
Regularly brushing my teeth doesn't figure in my self image, or the impression I want to create.	I would feel I'm letting myself down if I didn't brush regularly.	I believe that people expect me to brush regularly.	I believe that people expect me to brush regularly.

Toothpaste Attributes/Benefits

Medical Benefits:
A1: Helps prevent cavities.
A2: Helps remove tartar and plaque.
A3: Helps promote healthy gums.
A4: Helps fight germs and infections in your mouth.

Taste:
B1: Mild tasting.
B2: Fresh tasting.
B3: Gives your mouth a tingle.
B4: A taste kid's love.
B5: Great bubbling action.

Abrasiveness:
C1: Doesn't irritate my mouth.
C2: For sensitive teeth.

Resulting Appearance:
D1: Helps clean teeth.
D2: Helps remove stains.
D3: Whitens your teeth.

Resulting Breath:
E1: Fights bad breath.
E2: Freshens breath for 12 hours.
E3: Helps take away morning mouth.

Price:
F1: Regular price*.
F2: 20% less.

Ingredients:
G1: 80% natural /20% artificial ingredients*.
G2: 100% natural ingredients.

Interests:
I1: An interesting way to clean your teeth
I2: Provides a change of pace

Social:
J1: Shows others you care about your teeth
J2: Helps you feel good about yourself for bushing regularly

Brand Beliefs **

	AQUAFRESH	COLGATE	CREST	MENTADENT
1. Helps prevent cavities.	____	____	____	____
2. Delivers protection in hard to reach places.	____	____	____	____
3. Helps remove tartar and plaque	____	____	____	____
4. Helps promote healthy gums.	____	____	____	____
5. Penetrates to strengthen your teeth against cavities	____	____	____	____
6. Helps fight germs and infections in your mouth.	____	____	____	____
7. Mild tasting.	____	____	____	____
8. Fresh tasting.	____	____	____	____
9. Gives your mouth a tingle.	____	____	____	____
10. A taste kids love.	____	____	____	____

Consideration set **

When I buy toothpaste: *(Please mark only one box)*

- o I usually buy the same toothpaste brand
- o I usually buy one of the same two or three brands
- o I keep trying different brands
- o I buy toothpaste without noting what the brand is

When I buy toothpaste: *(Please mark only one box)*

- o I usually buy a nationally advertised brand
- o I usually buy a store brand
- o I sometimes buy a nationally advertised brand, sometimes a store brand

When I buy toothpaste for myself, I:

- o Buy a particular brand
- o Do not buy a particular brand

(*If Yes*) Which brand? *(Please mark only one box)*

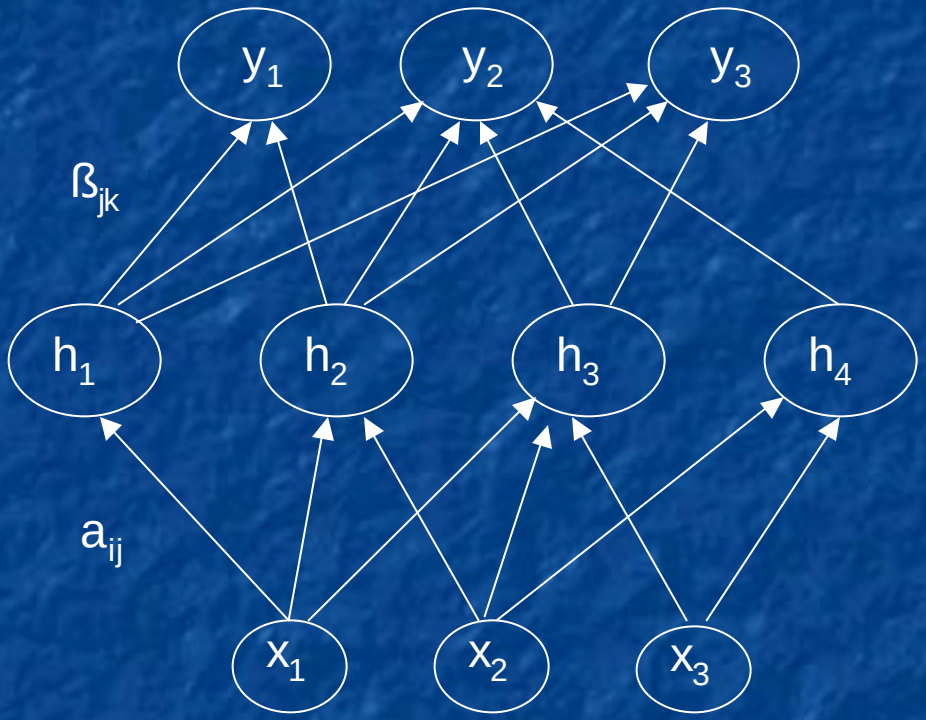
- o Aquafresh
- o Colgate
- o Crest
- o Mentadent
- o Other brand (please specify)_____

** Source: Survery conducted by Yankelovich partners

Associative Networks

- Intended to represent abstract models of the brain
- Numerous computational units that are highly interconnected, called nodes and represent biological neurons.
- Similar to MLP Feedforward networks with single hidden layer.

Associative Net Framework



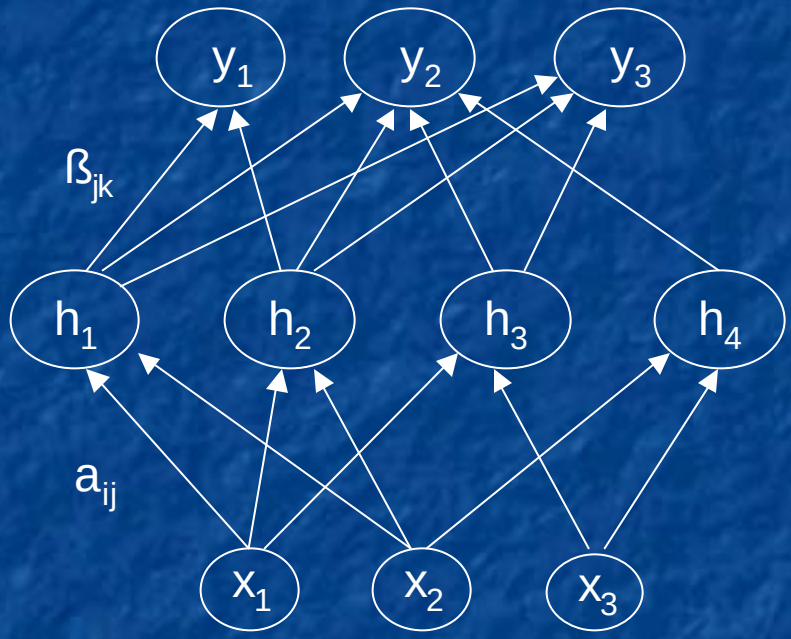
Output nodes
(consideration sets)

Intermediate nodes
(brand attributes)

Input nodes
(motivating conditions)

Associative Net Framework (Contd...)

- x ➔ Motivating conditions
- α ➔ Attribute efficacy
- h ➔ Attributes
- β ➔ Brand belief
- y ➔ Consideration set
- θ ➔ Threshold



Hierarchical Model

$$x_T = 1 \text{ if } e_i \geq q_{x,y}$$

$$x_T = 0 \text{ if } e_i < q_{x,y}$$

$$h_j = 1 \text{ if } \sum_i x_i a_{ij} \geq q_h$$

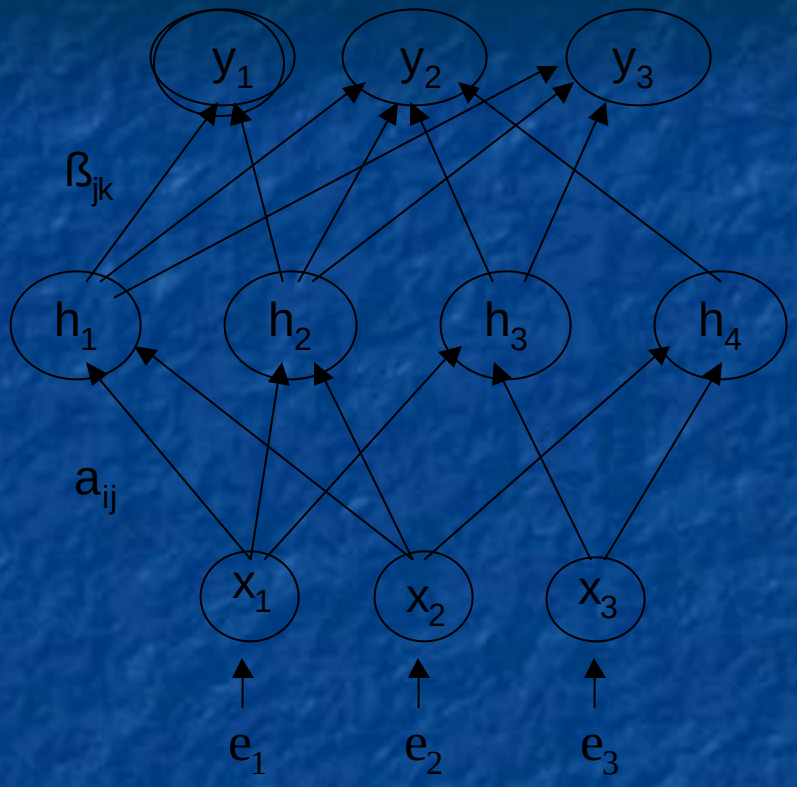
$$h_j = 0 \text{ if } \sum_i x_i a_{ij} < q_h$$

$$y_k = 1 \text{ if } \sum_j h_j b_{jk} \geq q_{x,y}$$

$$y_k = 0 \text{ if } \sum_j h_j b_{jk} < q_{x,y}$$

$$x_O = 1 \text{ if } e_i \geq q_{x,y} - d$$

$$x_O = 0 \text{ if } e_i < q_{x,y} - d$$



$$q_h = g_0 + g * (IS)$$

Hierarchical Model

$$[y \mid q_{x,y}, b, h]$$
$$[h \mid q_h, x_T, a]$$
$$[q_h \mid g_0, g, IS]$$
$$[x_T \mid e, q_{x,y}]$$
$$[x_O \mid e, d, q_{x,y}]$$
$$[e]$$

Hierarchy

Likelihood

$$[y \mid q_{x,y}, b, g, IS, g_0, x_T, e, a][x_O \mid e, d, q_{x,y}]$$

Conditional Independence

$$[y \mid q_{x,y}, b, g, IS, g_0, x_T, a][x_T \mid e, q_{x,y}][x_O \mid e, d, q_{x,y}][e][q_{x,y}][q_0][g][d][a][b]$$

Preliminary Assumptions

We assume that we know:

y → consideration set (data)
α → Attribute efficacy
β → Brand belief (data)

} Network structure known (initially)

We assume the same threshold (θ) for two layers in the network

Some of these assumptions will be relaxed (discussed in future work).

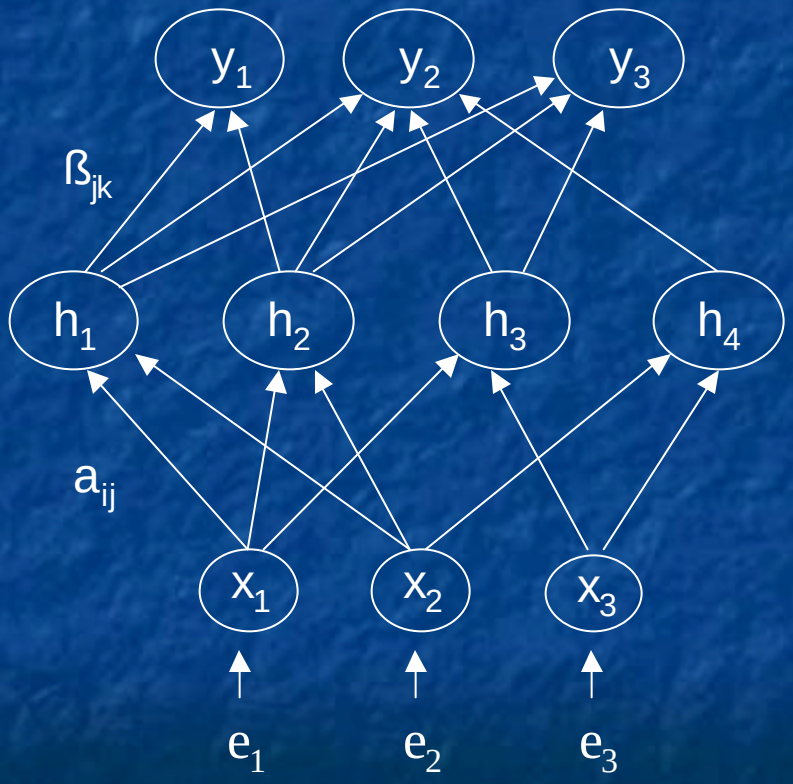
Simulation

Data is simulated based on the network shown:

With $a = \begin{pmatrix} 0.33 & 0.33 & 0.33 & 0 \\ 0.33 & 0.33 & 0 & 0.33 \\ 0 & 0 & 0.5 & 0.5 \end{pmatrix}$

$ß = \begin{pmatrix} 0.33 & 0.33 & 0.33 \\ 0.33 & 0.33 & 0.33 \\ 0 & 0.5 & 0.5 \\ 0 & 1 & 0 \end{pmatrix}$

? = 0.3



Draw e_{it}'s ~ i.i.d. N(0,1)

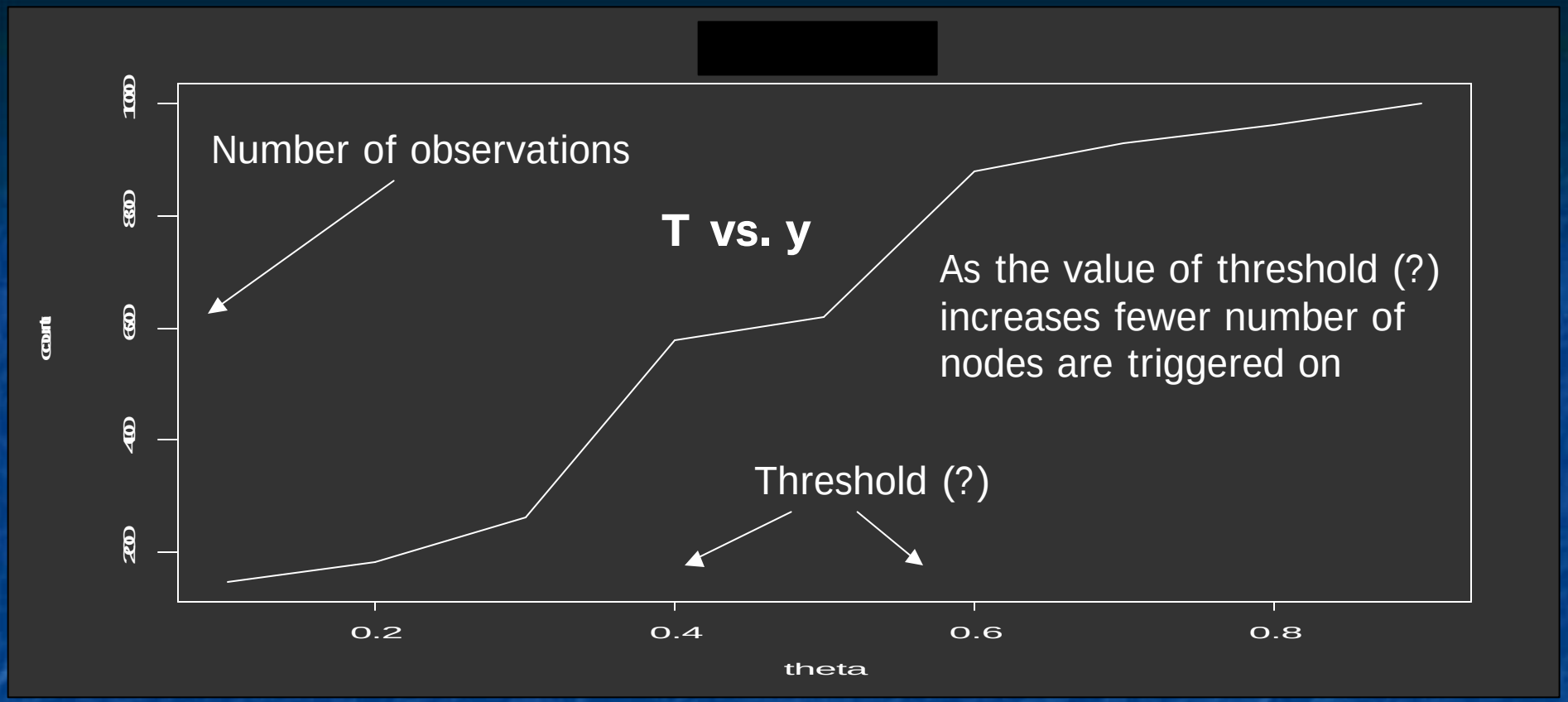
Compute the y's.

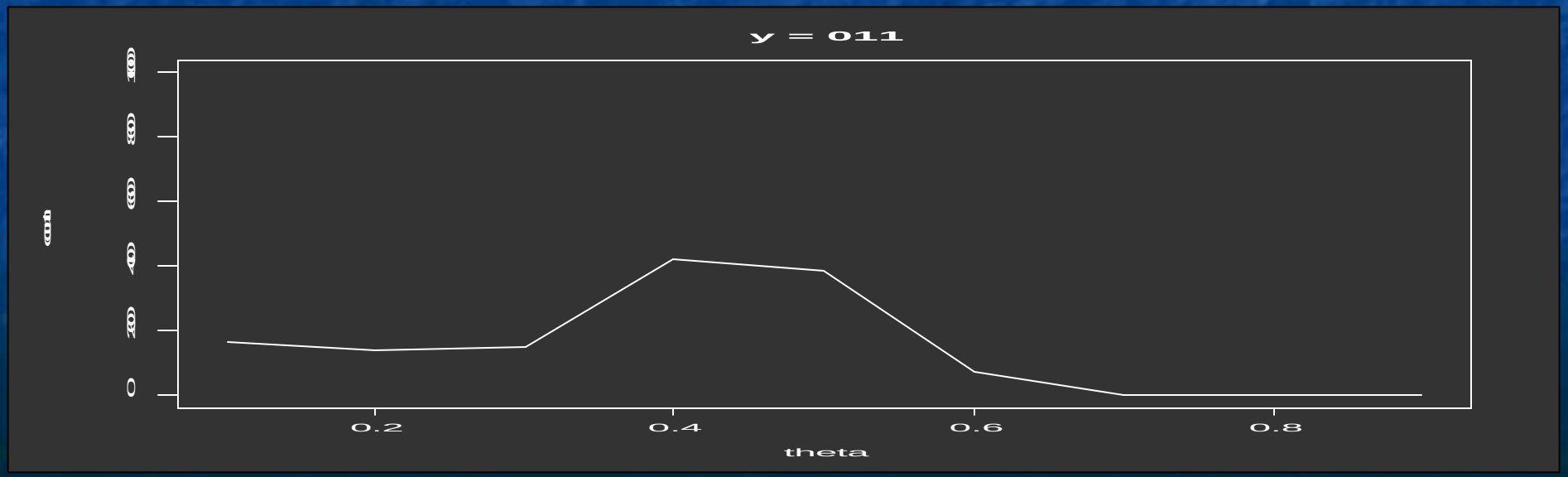
Subset of the simulated data

e_1	e_2	e_3	y_1	y_2	y_3
0.31	-0.35	0.52	1	1	1
-1.2	-0.89	0.91	0	1	1
0.14	-1.14	0.01	1	1	1
-1.16	0.63	0.23	1	1	1
-0.89	0.35	-0.65	1	1	0
1.17	-0.31	-0.98	1	1	1
-0.38	-0.95	1.13	0	1	1
0.5	1.21	-0.62	1	1	1
0.54	1.22	-1.2	1	1	1
1.14	1.1	1.07	1	1	1
-1.58	1.08	0.56	1	1	1
0.71	-0.21	-0.58	1	1	1
0.15	-1.15	-2.95	1	1	1
0.99	-0.28	-1.58	1	1	1
-1.09	-0.09	-0.78	0	0	0
-0.71	-0.11	0.78	0	1	1
-0.01	-0.69	0.07	0	0	0
0.45	-0.81	1.42	1	1	1
-1.39	0.62	-1.43	1	1	0
0.95	-1.65	-0.26	1	1	1

t

i


Number of observations
T vs. y
As the value of threshold (?) increases fewer number of nodes are triggered on
Threshold (?)
cnt
20
40
60
80
100
0.2
0.4
0.6
0.8
theta

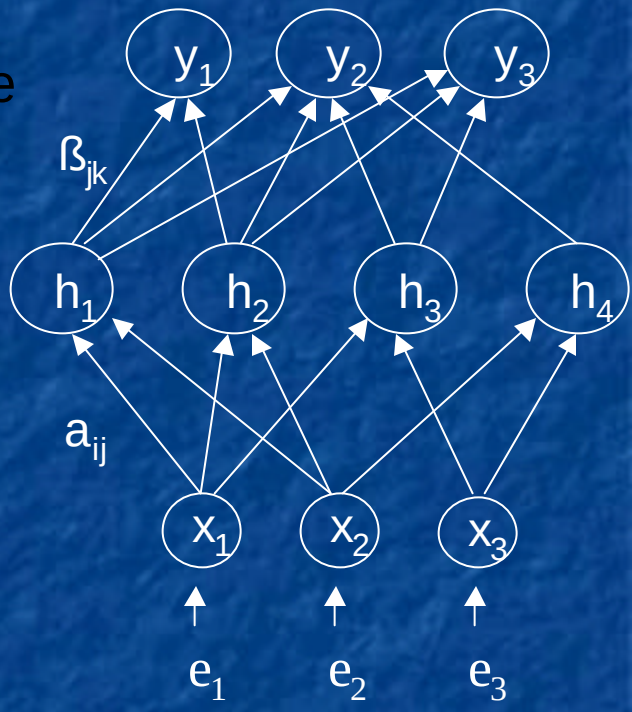

y = 011
cnt
0
20
40
60
80
100
0.2
0.4
0.6
0.8
theta

Preliminary Estimation Procedure

- Step 1: $[e_1 \mid e_2, e_3, q, y]$
  - if $e_1 >$? => $x_T = 1$, if $e_1 <$? => $x_T = 0$
  - Let $x_T = 1$, compute the y's (y_{out}) and compare y_{out} to y_{obs}
  - if $x_T = 1$ and $y_{out} = y_{obs}$ => $e_1 >$?

    if $x_T = 0$ => $e_1 <$?

    else $x_T = 1$ or 0 => e_1 ~ Normal dist. with truncation at ?-d (depending on X_O)
- Step 2: $[e_2 \mid e_1, e_3, q, y]$
  - Draw e_1 from the feasible region
  - Repeat step 1 to obtain feasible region for e_2
- Step 3: $[e_3 \mid e_1, e_2, q, y]$



Estimation Procedure Contd...

$$p(e_1 \mid e_2, e_3, q, y) = \sum_{x_1} p(e_1 \mid e_2, e_3, q, x_1, y)\, p(x_1 \mid e_2, e_3, q, y)$$

$p(x_1 \mid e_2, e_3, q, y) \rightarrow I[x_1 \mid e_2, e_3, q, y]$

- Step 4: $[q \mid e_1, e_2, e_3, y]$

$$q^{(n)} = q^{(o)} + eps$$

Random walk Metropolis-Hastings

$$eps \sim N(0, 0.01)$$

$$[q] \sim Unif[-5, 5]$$

1 or 0, if matches the output accept new ? else reject

$$a = \min\left(\frac{\prod_i [y_i \mid q^{(n)}, e_i][q^{(n)}]}{\prod_i [y_i \mid q^{(o)}, e_i][q^{(o)}]}, 1\right)$$

Denominator evaluates to 1

- Repeat steps 1 through 4

Work in progress

- Estimating the α's & ?'s.
- Assume different θ's for different layers of the network.
- Find out the admissible values for starting off the Markov chain.
- Impose more constraints, consistent with theory, on θ's.

Conclusion

- An attempt to use an associative net framework to explain how advertising works.
- Advertising can impact the attribute weights in a simple regression equation by linking needs to attributes that are responsive.
- Advertising can change the network structure.
- Tries to understand the impact of advertising from this new perspective