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@ ITM 2010 Tempe

Vive la Difference: Heterogeneous Travelers and Behavioral Mixing Models

Free Lanes $0.00

Toll Lanes $1.95

Free Lanes $0.00

Toll Lanes $9.55

Neighborhood
A

Neighborhood
B

Atlanta Regional Commission and the City of Atlanta


38
GEARY
Ocean Beach


BART


FiOS TV
IS
HERE.

Mixture Models

$U = V + \varepsilon$

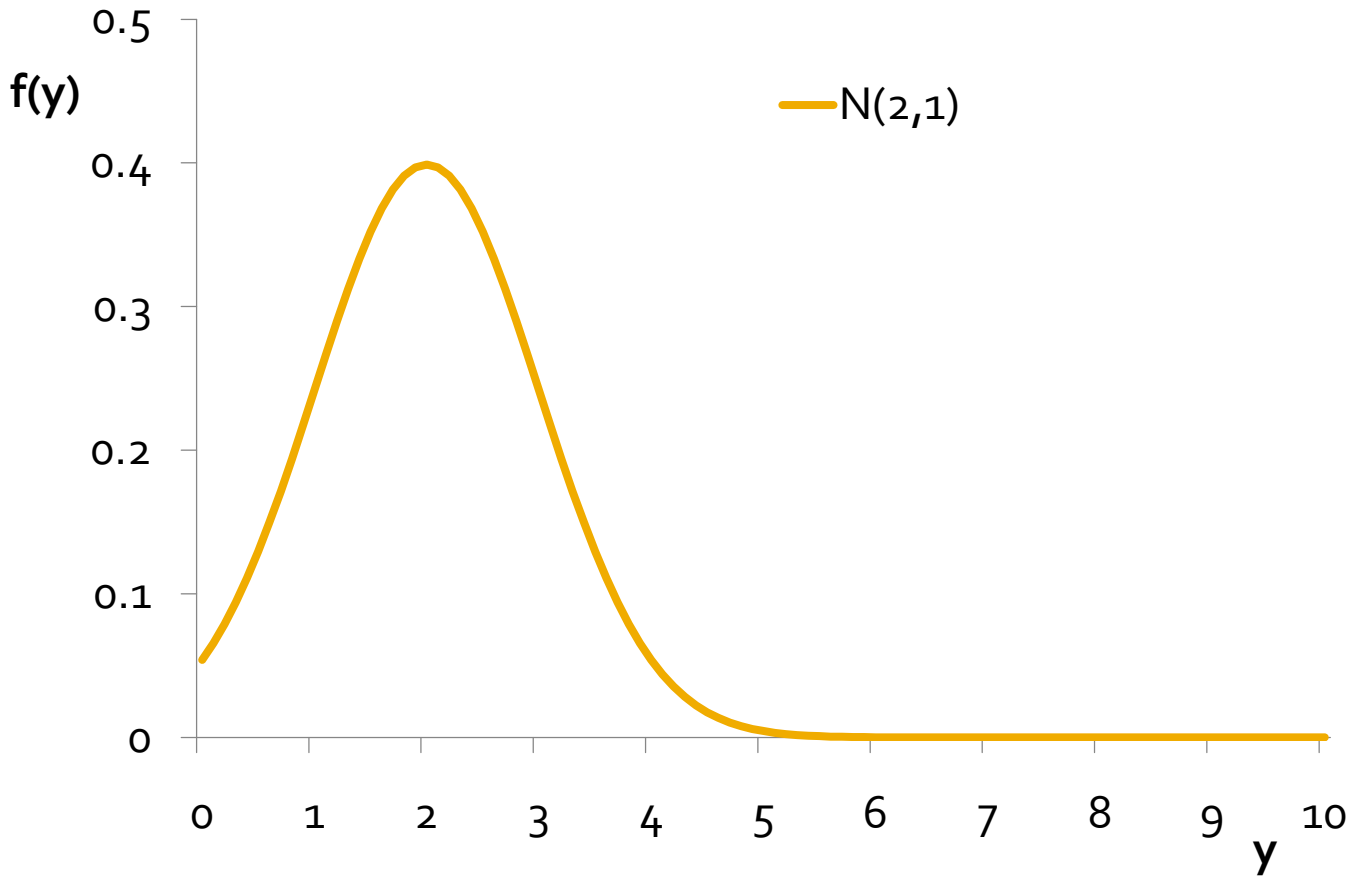
Logit

→ Nested Logit

→ Generalized Extreme Value

→ Logit Mixture

What is a mixture?



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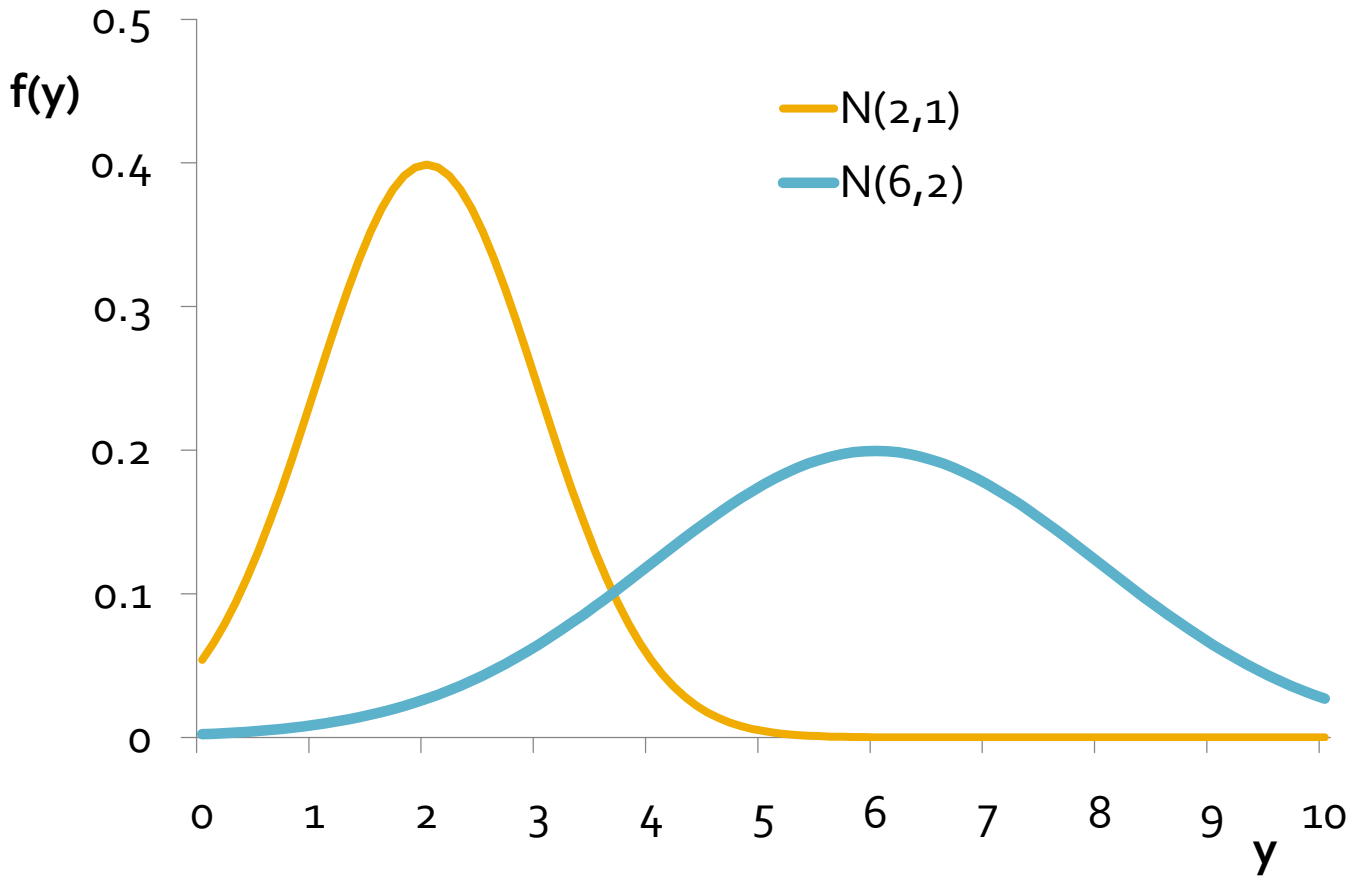

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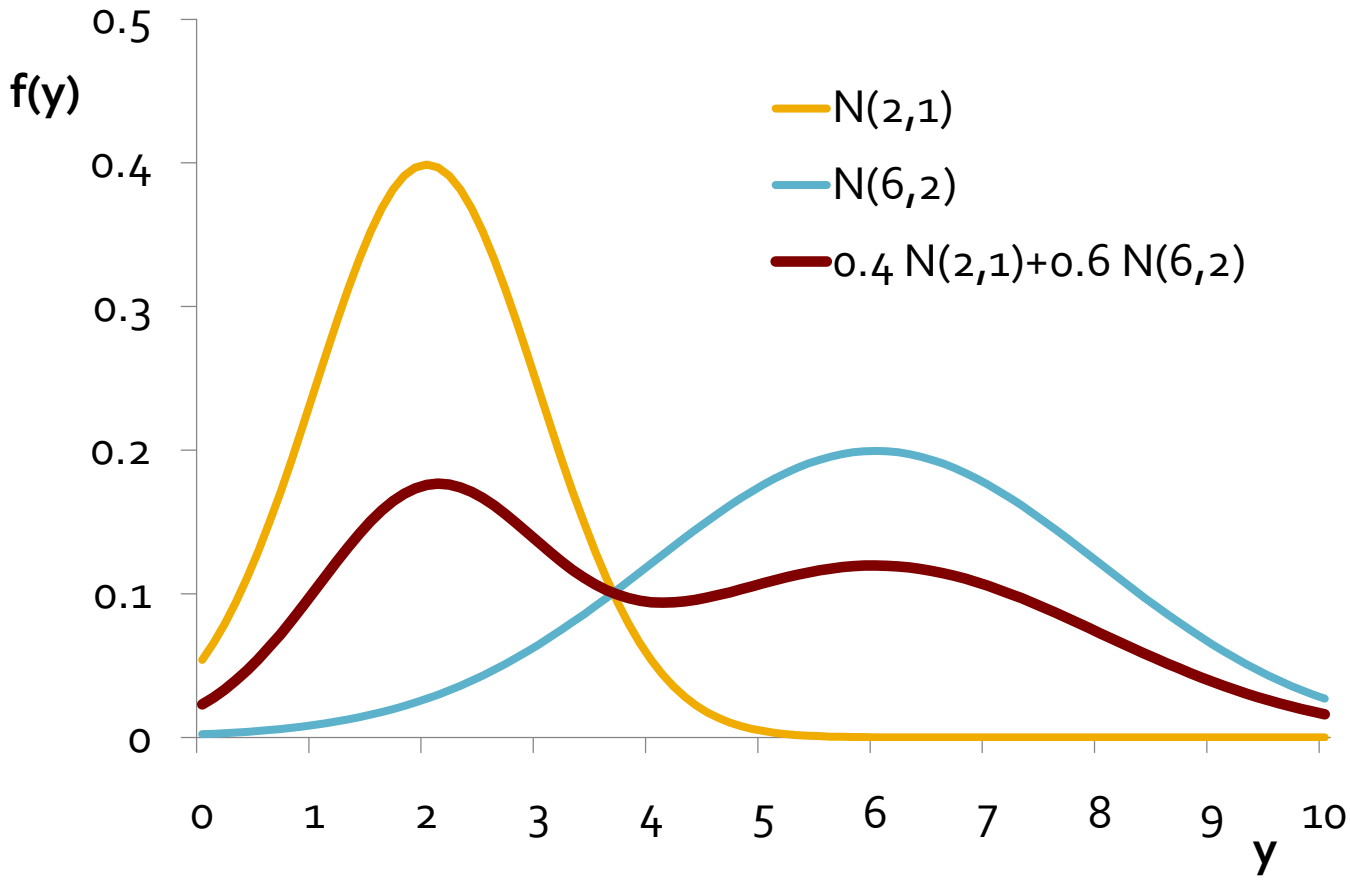
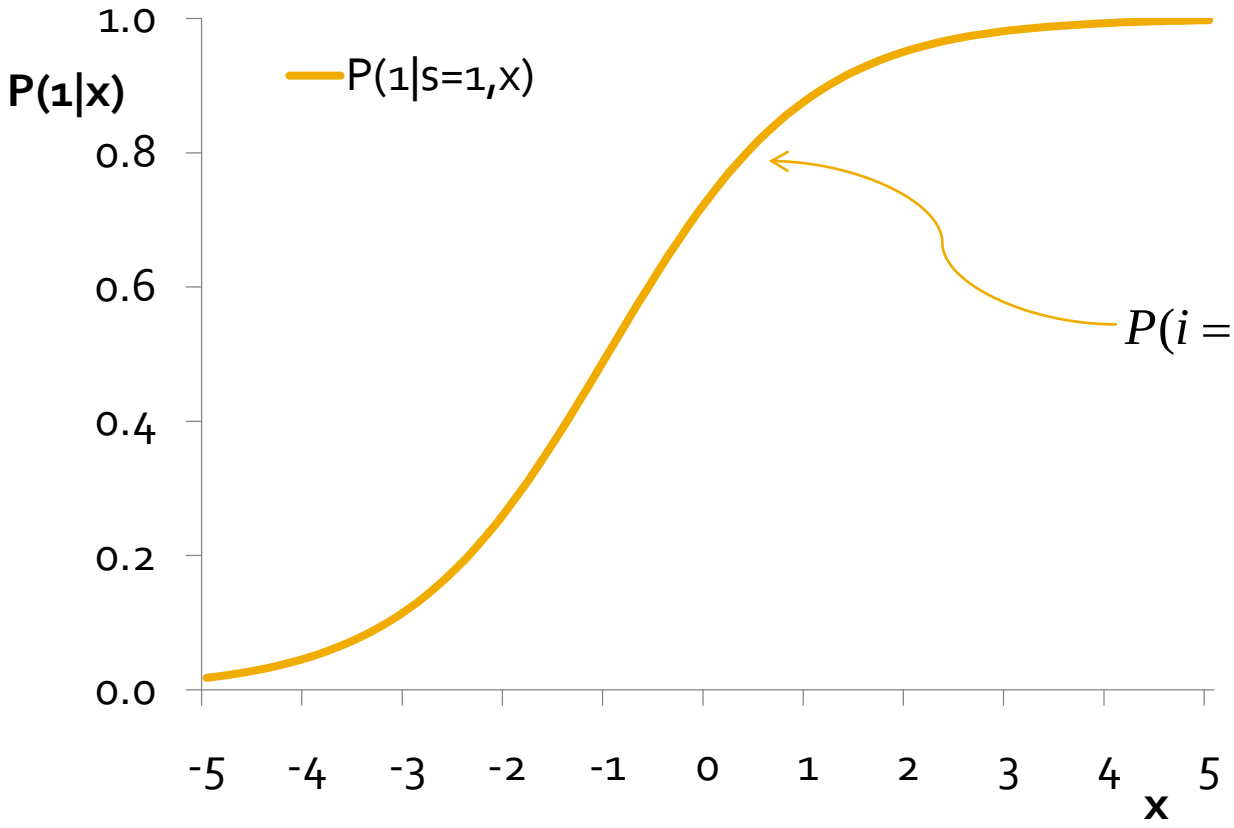


Why Mixtures?

- General motivation
  - generate flexible distributional forms
- For discrete choice
  - Correlation across alternatives
  - Alternative specific variances
  - Taste heterogeneity

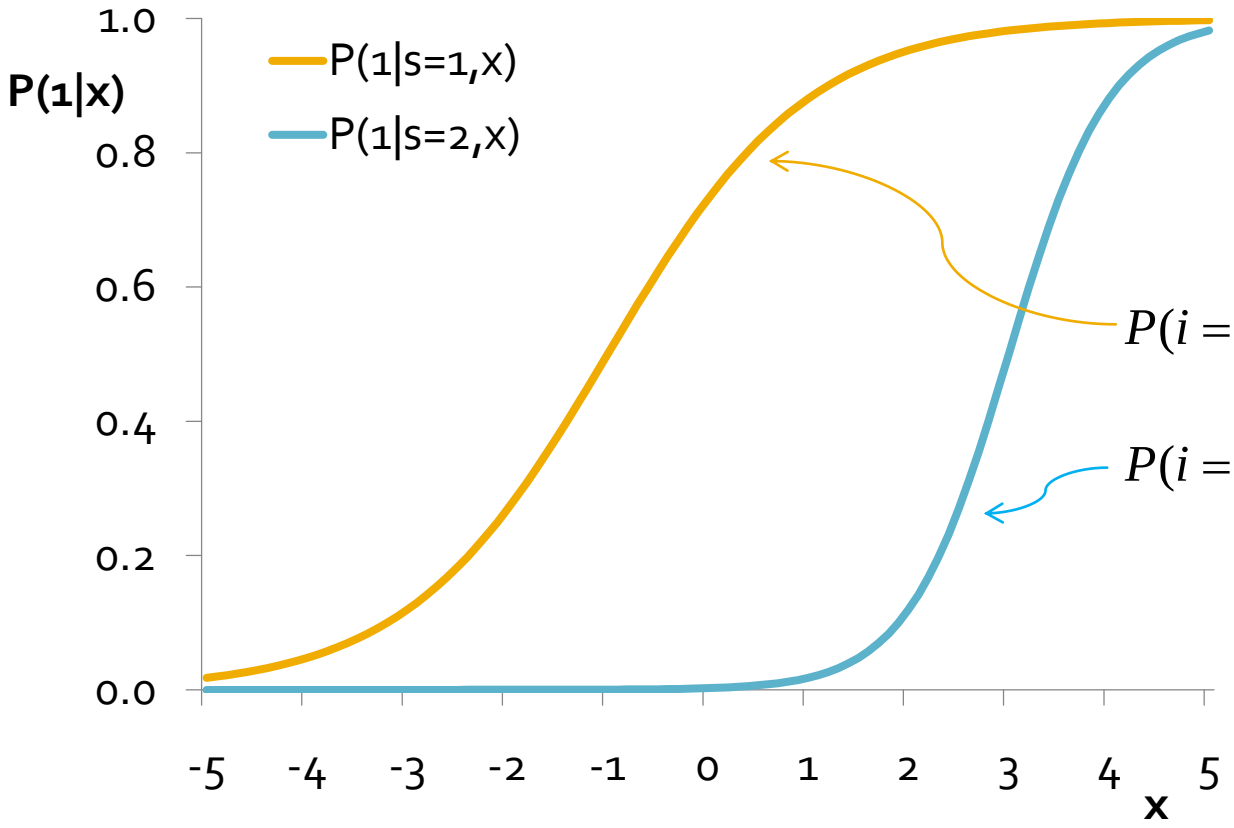
  etc.

Mixing discrete choice models



$$P(i=1 \mid s=1, x) = \frac{1}{1+e^{-(1+x)}}$$

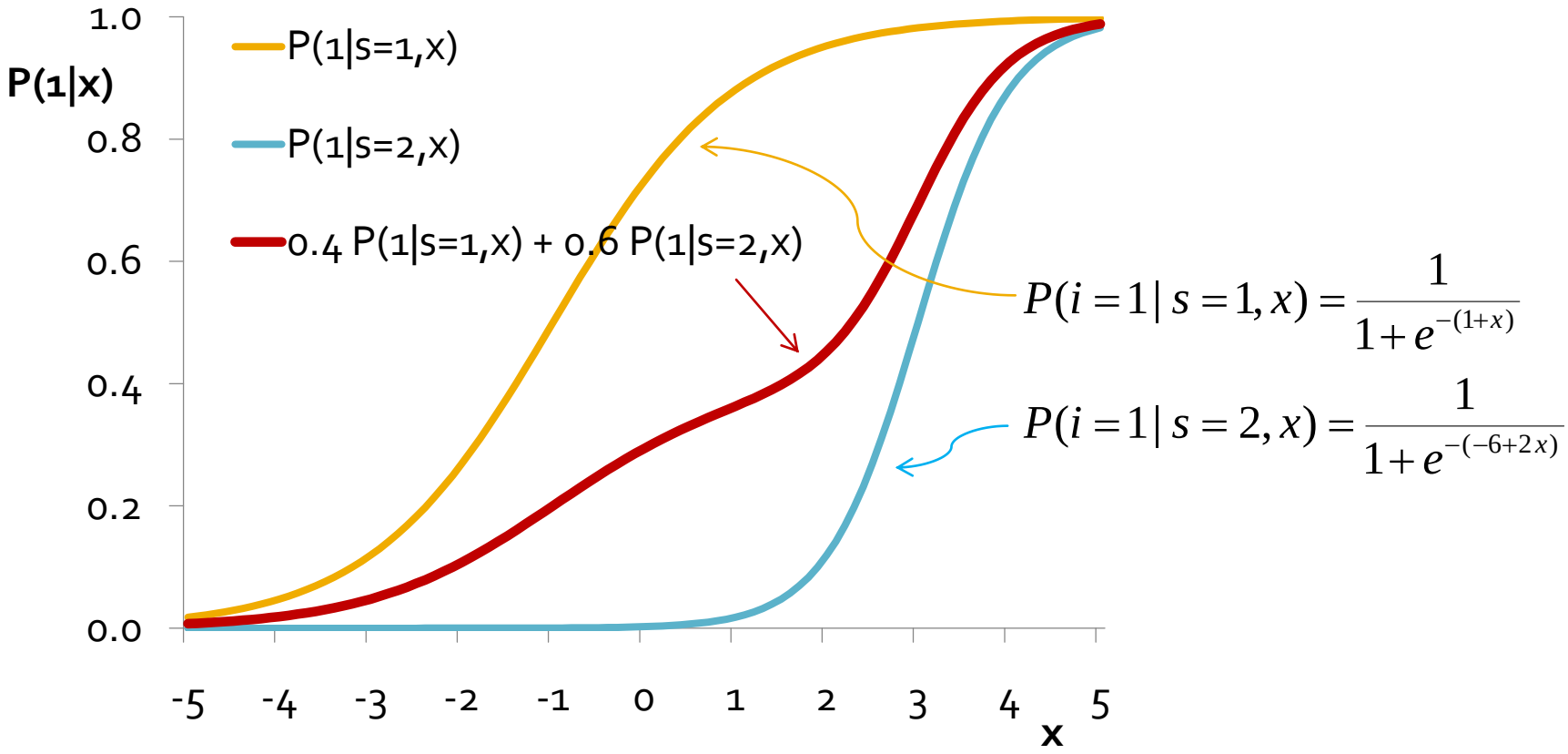
Mixing discrete choice models



$$P(i=1 \mid s=1, x) = \frac{1}{1+e^{-(1+x)}}$$

$$P(i=1 \mid s=2, x) = \frac{1}{1+e^{-(-6+2x)}}$$

Mixing discrete choice models



Point: Mixing enables flexible distributional forms

Probability Mixture Models

- Discrete Probability Mixture

$$\text{Probability}(i \mid \gamma) = \sum_{s=1}^{S} \gamma_s P(i \mid \theta_s)$$

$$0 \le \gamma_s \le 1, \quad \sum_{s=1}^{S} \gamma_s = 1$$

- Continuous Probability Mixture

$$\text{Probability}(i \mid \gamma) = \int_{\theta} P(i \mid \theta) f(\theta \mid \gamma) d\theta$$

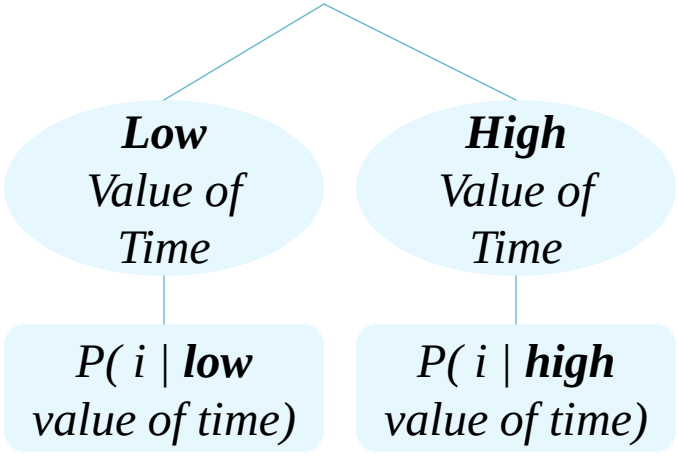
$$\int_{\theta} f(\theta \mid \gamma) d\theta = 1$$

Probability Mixture Models
Example: Value of Time

- Discrete Probability Mixture

$$\text{Probability}(i \mid \gamma) = \sum_{s=1}^{S} \gamma_s P(i \mid \theta_s)$$

$$0 \le \gamma_s \le 1, \quad \sum_{s=1}^{S} \gamma_s = 1$$



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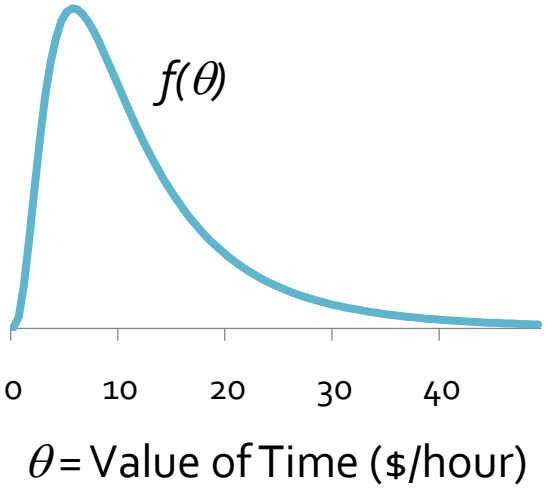
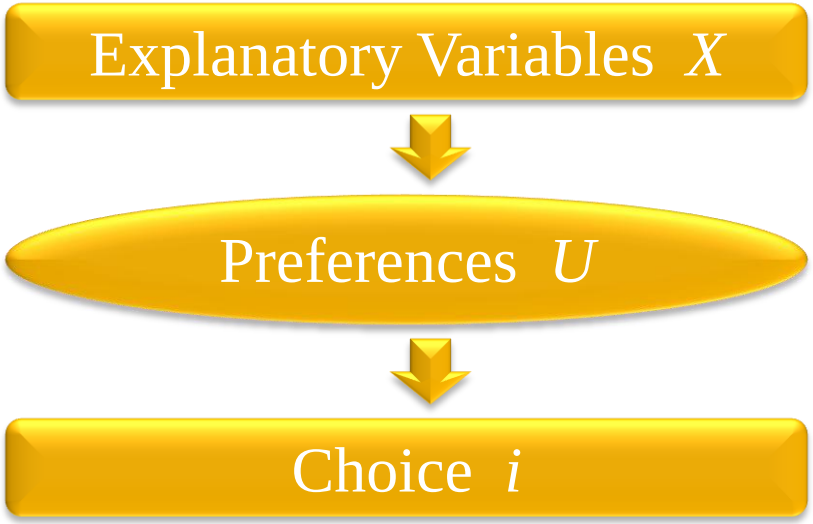


Mixtures in Choice Models



$$\text{Probability}(i \mid \gamma) = \int_{\theta} P(i \mid \theta) f(\theta \mid \gamma) d\theta$$

- Sophisticated models of the covariance
  - Random parameters, error components
  - Flexible substitution patterns (alternatives, space, time)
- Increases model fit

Issues

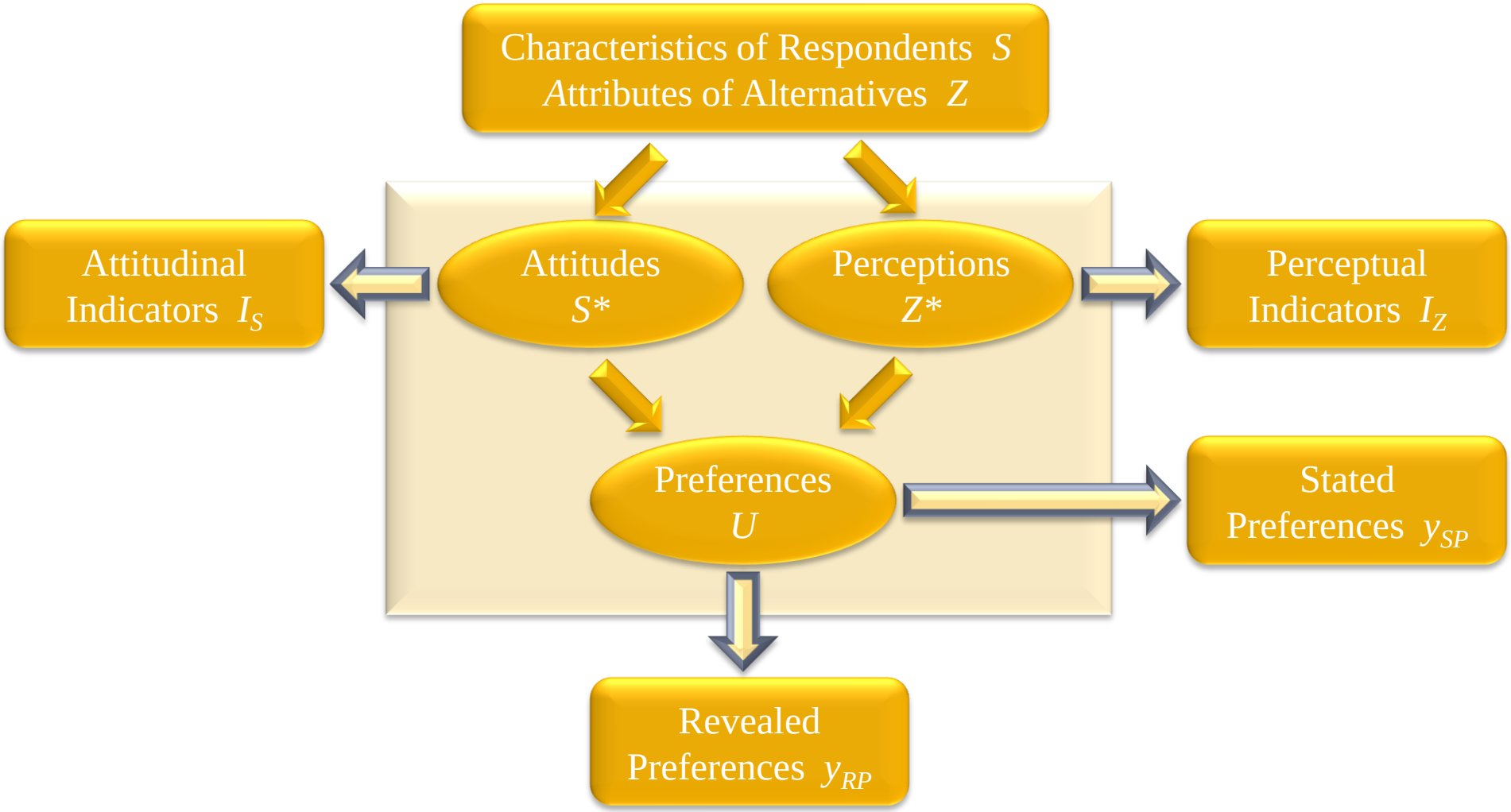
- Computation

$$\text{Probability}(i \mid \gamma) = \int_{\theta} P(i \mid \theta) f\left(\theta \mid \gamma\right) d\theta$$

  - No closed form
  - Simulation & increased computational power
- Identification
- Black box
- Explosion of difficult to interpret parameters
- Temporal stability
- Policy implications

Behavioral Mixing

Behavioral Mixing



Behavioral Mixing

- Provide behavioral rational to mixtures
  - Model covariance structure via explicit latent variable constructs as the method to capture the source of behavioral heterogeneity.
  - Treat the mixing distribution as an additional model – a mixing distribution of behavioral factors based on a-priori considerations that have meaning and its estimation results can be interpreted.

Example

- Two models combined
  1. Choice model = *f(latent variables)*
  2. Latent variables models
- Choice = f(*environmental consciousness* **"EC"**)
  - Need model of ***EC***
    - Assumptions of distribution and corresponding unknown parameters (e.g., mean and variance)
    - Explain these parameters in terms of covariates
    - This model of ***EC*** then becomes the mixing distribution over which the choice probability is mixed.

Indicators of Environmental Consciousness

- We should raise the price of gasoline to reduce congestion and air pollution.
- I would rather drive an electric or other clean-fuel vehicle than give up driving.
- Stricter vehicle smog control laws should be introduced and enforced.
- We should provide incentives to people who use electric or other clean-fuel vehicles
- Environmental protection is good for California's economy.
- People and jobs are more important than the environment.
- Whoever causes environmental damage should repair the damage.
- Environmentalism hurts minority and small businesses.
- Vehicle emissions increase the need for health care.
- Environmental protection costs too much.

Discrete Behavioral Mixtures

Latent Class Choice Model

$$\text{Probability}(i) = \sum_{s=1}^{S} P(i|s)\,Q(s)$$

Class-specific Choice Model
probability of choosing *i* conditional on belonging to class *s*

Class Membership Model
probability of belonging to class *s*

- Behavioral
  - Latent classes have distinct behavioral meanings
    - Choice sets; Decision protocols; Tastes; Model structures
  - Membership in classes explained by covariates.
- Particularly accessible

Residential Choices

Lifestyle & Residential Location

- Hypothesis
  - Lifestyle preferences exist (e.g., suburb vs. urban)
  - Lifestyle differences lead to differences in considerations, criterion, and preferences for residential location choices
- Infer "lifestyle" preferences from choice behavior using latent class choice model
  - Latent classes = lifestyle
  - Choice model = location decisions

	(Alternative 1)	(Alternative 2)	(Alternative 3)	(Alternative 4)	(Alt. 5)
	Buy Single Family	Buy Multi-Family	Rent Single Family	Rent Multi-Family	
Type of Dwelling :	*single house*	*apartment*	*duplex / row house*	*condominium*	
Residence Size :	*< 1,000 sq. ft.*	*500-1,000 sq. ft.*	*1,500 - 2,000 sq. ft.*	*< 500 sq. ft.*	Move
Lot Size :	*< 5,000 sq. ft.*	*n/a*	*5,000 - 7,500 sq. ft.*	*n/a*	out
Parking :	*street parking only*	*street parking only*	*driveway, no garage*	*reserved, uncovered*	of the
Price or Monthly Rents :	*< $75K*	*$50K - $100K*	*> $1,200*	*$300 - $600*	Metro
Community Type :	*mixed use*	*mixed use*	*rural*	*urban*	Area
Housing Mix :	*mostly single family*	*mostly multi-family*	*mostly multi-family*	*mostly multi-family*	
Age of Development :	*10-15 years*	*0-5 years*	*10-15 years*	*0 - 5 years*	
Mix of Residential Ownership :	*mostly own*	*mostly own*	*mostly rent*	*mostly own*	
Shops/Services/Entertainment :	*community square*	*basic shops*	*community square*	*basic, specialty shops*	
Local Parks :	*none*	*yes*	*none*	*none*	
Bicycle Paths :	*none*	*yes*	*yes*	*yes*	
School Quality :	*very good*	*very good*	*fair*	*fair*	
Neighborhood Safety :	*average*	*average*	*average*	*average*	
Shopping Prices Relative to Avg :	*20% more*	*20% more*	*same*	*10% more*	
Walking Time to Shops :	*20-30 minutes*	*20-30 minutes*	*< 10 minutes*	*10 - 20 minutes*	
Bus Fare, Travel Time to Shops :	*$1.00, 15-20 minutes*	*$1.00, > 20 minutes*	*$0.50, 5 - 10 minutes*	*$0.50, < 5 minutes*	
Travel Time to Work by Auto :	*> 20 minutes*	*15-20 minutes*	*15 - 20 minutes*	*< 10 minutes*	
Travel Time to Work by Transit :	*> 45 minutes*	*30-45 minutes*	*30 - 45 minutes*	*15 - 30 minutes*	

Residential Location Choice Model with Latent Lifestyle Segmentation

~ Class 1 ~

suburban, school, auto
affluent, more established families

~ Class 2 ~

transit, school
less affluent, younger families

~ Class 3 ~

high density, urban activity
older, non-family, professionals

Latent Class Choice Model Estimation

- Estimate simultaneously
  - Class-membership model
    - E.g., for residential location model
      1 logit model
  - Class-specific choice models
    - E.g., for residential location model
      3 logit models, 1 for each latent class
- Number of classes determined either a priori or statistically

$$\text{Prob}(i) = \sum_{s=1}^{S} P(i \mid s) Q(s)$$

$Q(s)$

$s = 1, 2, 3$

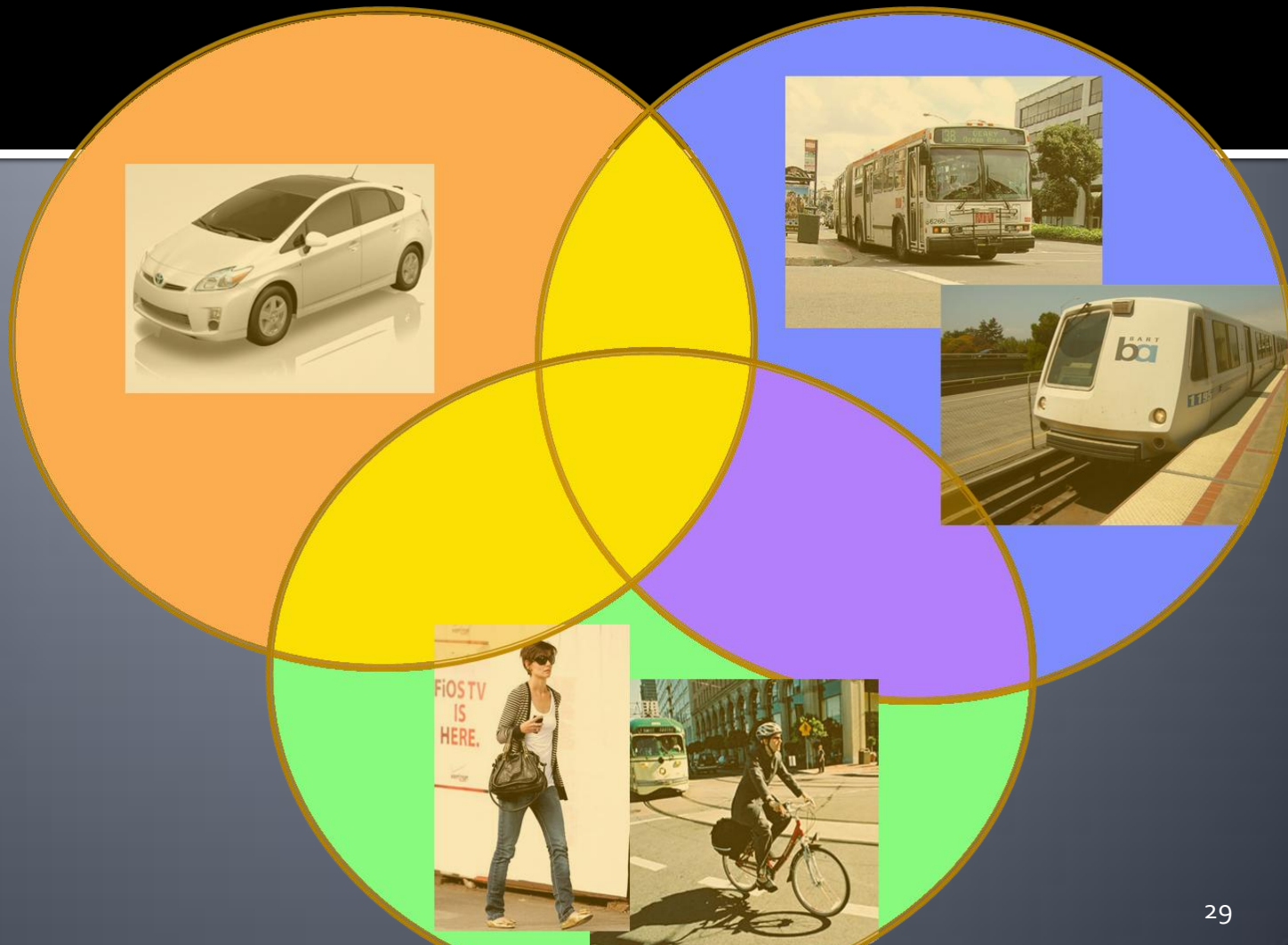
$P(i \mid s = 1)$

$P(i \mid s = 2)$

$P(i \mid s = 3)$

$i = 1, \ldots, 5$

Mobility Styles



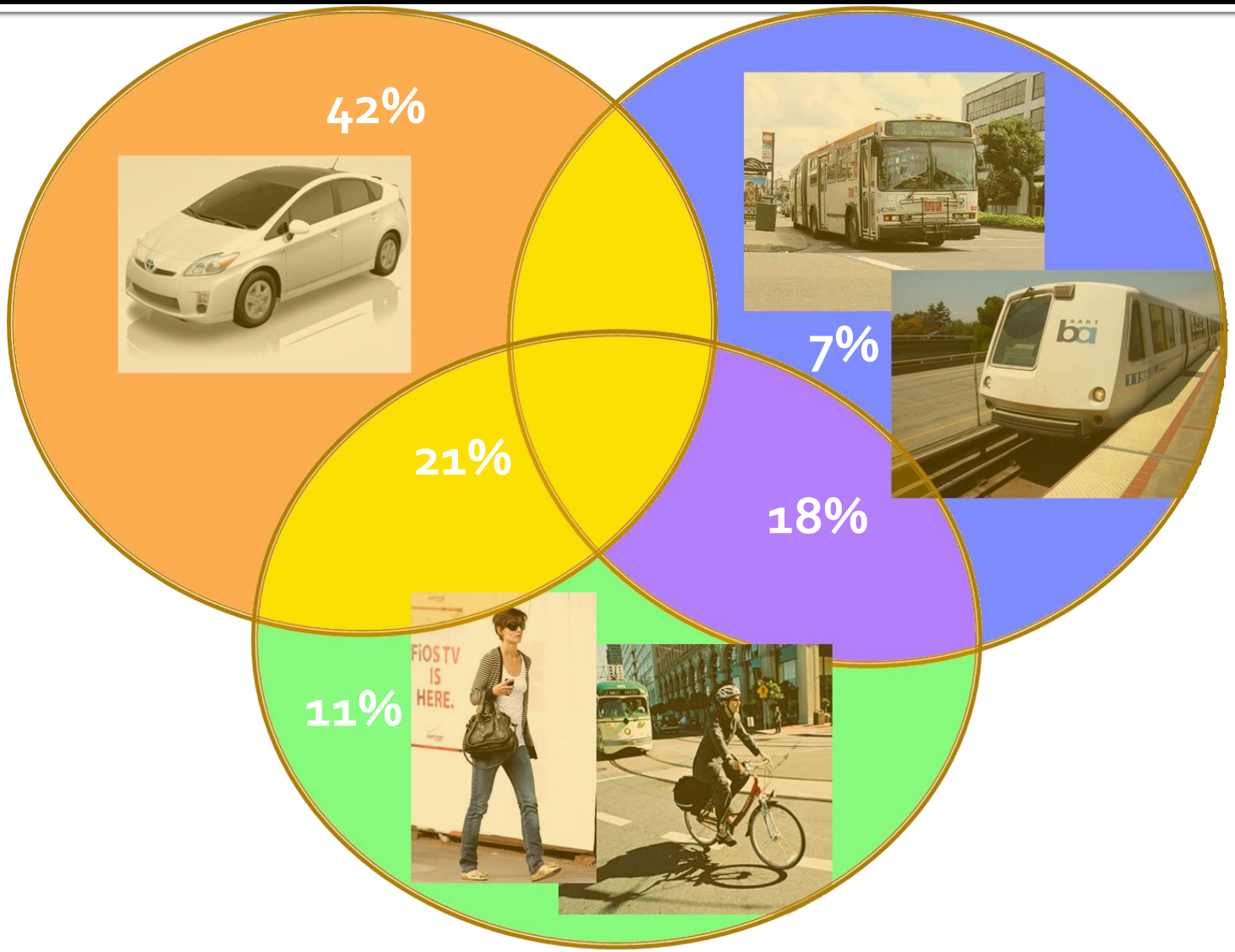
Mode choices in MobiDrive

- MobiDrive dataset:
  - Six-week continuous travel survey
  - Conducted in Karlsruhe & Halle (Germany), 1999.
  - 139 households and 317 participants

Definitions

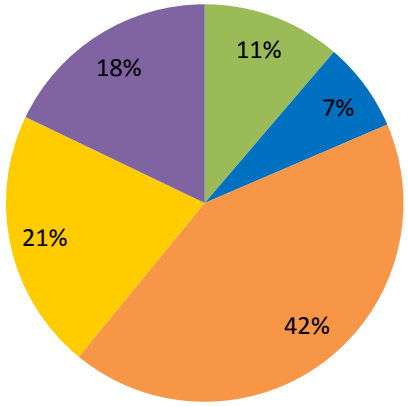
- Unimodal person: A person who uses only one and the same mode for ≥ 80% of all tours
- Multimodal person: A person who chooses different modes on different tours.
  - Including auto
  - Excluding auto – can have ≤ 10 % auto component

Mobility styles of work tour



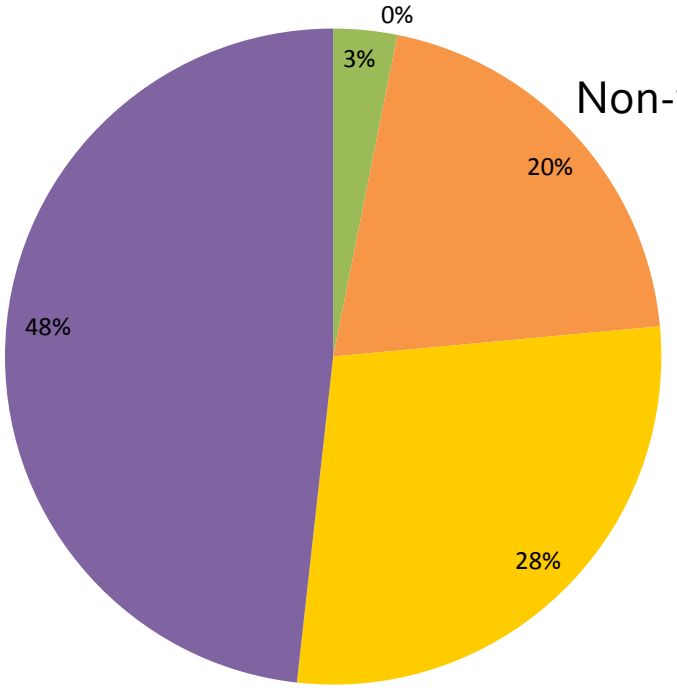
Work versus non-work tours

Work tours: 151 people



Unimodal walk/bike (17)
Unimodal transit (11)
Unimodal auto (64)
Multimodal incl. auto (32)
Multimodal excl. auto (27)

Non-work tours: 255 people



Unimodal walk/bike (8)
Unimodal transit (0)
Unimodal auto (52)
Multimodal incl. auto (72)
Multimodal excl. auto (123)

- Persistent group of **unimodal auto users**
- Of 123 **multimodal non-car users**,
  57 do not have access to a motor vehicle

Conclusion

Conclusion

- Model unobserved heterogeneity behaviorally
- Get lifestyle constructs much higher in tree
  - Beyond Mode Choice and Residential Choice: Activity space, Destination choice, …
- Important impacts
  - Forecasts of policy responses
  - Design of nudges
- GPS data critical