# VALUING BIODIVERSITY IN THE MANU NATIONAL PARK : A LATENT CLASSES APPROACH


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# Research Questions and contribution

01 **WTP** for **Changes** Biodiversity

02 **Heterogeneity among individuals**

03 **First empirical study addressing this issue in Peru.**

# Material and Methods: 4 Stages

**Results**

- **WTP for changes for** reduction of endangered species.
- **Identification of latent classes**

**3. Design a DCE**

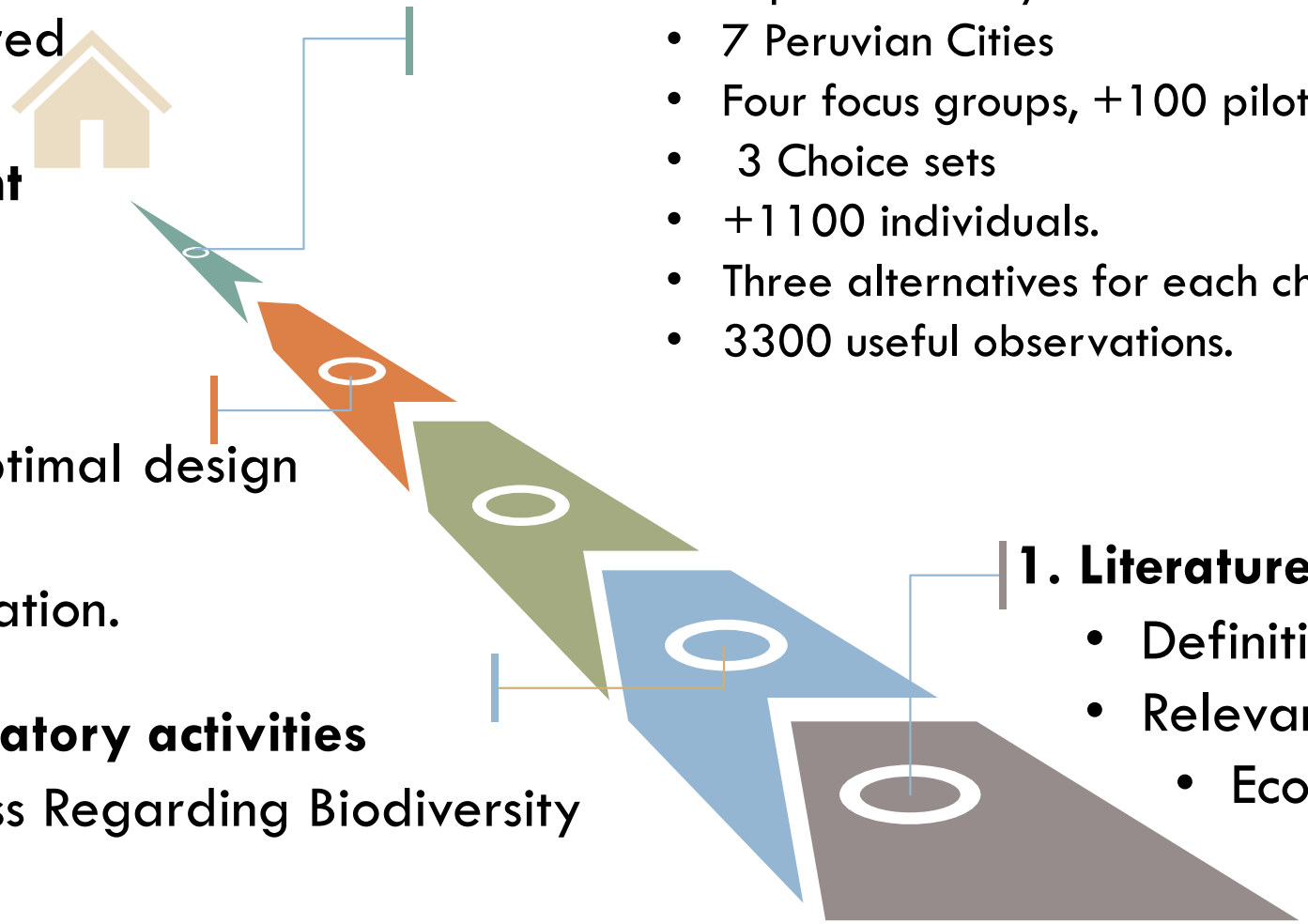
- Attribute selection, optimal design of experiment
- Flora, Fauna, Deforestation.

**2. Participatory activities**

- Awareness Regarding Biodiversity

**4. Application of DCE**

- In person survey between June- Dec. 2018
- 7 Peruvian Cities
- Four focus groups, +100 pilot surveys
- 3 Choice sets
- +1100 individuals.
- Three alternatives for each choice.
- 3300 useful observations.



**1. Literature review**

- Definition of Biodiversity
- Relevant Attributes
  - Economic problem

# Can We Value "**Biodiversity**"?



- What is Biodiversity?
- Is there any environmental-economic problem in the area of interest?
- Economic value of WHOM and of WHAT?
- Which Methodologies can be used to do this economic exercise?

# How to Measure Biodiversity



Common measures of biodiversity.
Compiled from Magurran (1996), Gotelli and Chao (2013) and Pereira et al. (2013).

| Level of diversity | Measures |
|---|---|
| Genetic diversity | • Allelic diversity (genotypic differences) |
| Species diversity | • Shannon entropy (a.k.a. Shannon–Wiener index)<br>• Gini–Simpson index<br>• Species richness |
| Phylogenetic/taxonomic/functional | • Rao's quadratic entropy<br>• Phylogenetic entropy |
| Ecosystem diversity | • Various similarity indices, mostly based on species diversity indices |

Multi-attribute biodiversity valuation studies.

| Study | Attributes | Proxy categories |
|---|---|---|
| Birol et al. (2009a) | • "Number of different species [and] their population levels" | • Species |
| | • "Number of different habitats and their size" | • Habitats |
| Christie et al. (2006) | • "Familiar species of wildlife" | • Species |
| | • "Rare (unfamiliar) species of wildlife" | • Species |
| | • "Habitat" | • Habitats |
| | • "Ecosystem processes" | • Functions |
| Czajkowski et al. (2009) | • "Natural ecological processes" | • Functions |
| | • "Rare species of fauna and flora" | • Species |
| | • "Ecosystem components" | • Habitats |
| Eggert and Olsson (2009) | • "Richness in species and richness within each species" | • Species |
| | • "Important for the sea's capacity to handle environmental disturbances, but also for productivity" | • Functions |
| Garber-Yonts et al. (2004) | • "Biodiversity reserves" | • Habitats |
| | • "Endangered species" | • Species |
| | • "Forest age management" | • Habitats |
| Jobstvogt et al. (2014) | • "Number of protected species" | • Species |
| | • "[Potential] new medicinal products" | • Genetics |
| Lehtonen et al. (2003) | • "Number of endangered species" | • Species |
| | • "Conservation areas" | • Habitats |
| | • "[Number of] biotopes at favourable levels of conservation" | • Habitats |
| Liebe and Preisendörfer (2007) | • "Biotopes of rare species" | • Habitats/Species |
| | • "Species richness" | • Numbers |
| | • "Age structure of the forests" | • Habitats |
| | • "Landscape diversity" | • Habitats |
| MacMillan et al. (2001) | • "Restoration of native forest" | • Habitats |
| | • "Reintroduction of the beaver/wolf" | • Species |
| Rajmis et al. (2010) | • "Dangers from alien species" | • Species |
| | • "Resilience" | • Functions |

# Environmental-Economic Problem



Cuadro 1: Cambios cuantitativos esperados en los atributos de BD en el PNM basado en Plan Maestro del PNM (2014)

| Statu Quo | Situación esperada (post-carretera): Statu Quo en el experimento de elección |
|---|---|
| **Diversidad de Flora: Actualmente existen 8 especies amenazadas** | Diversidad de Flora: Se esperan 24 especies amenazadas |
| **Diversidad de Fauna: Actualmente existen 8 especies amenazadas** | Diversidad de Fauna: Se esperan 24 especies amenazadas |
| **Deforestación actual: Actualmente se tiene una tasa de deforestación de 286 has promedio anual en el PNM** | Deforestación actual: Se estima una tasa de deforestación de 1400 has. promedio anual en el PNM |

# Relevant attributes

**Cuadro 2: Número de atributos y niveles de BD, a detalle, según la encuesta de CE aplicada al caso del PNM**

Elaboración propia

| | Atributo | Detalle | Niveles propuestos* |
|---|---|---|---|
| 1 | Flora | Número de especies de plantas amenazadas | Bajo (8)<br>Medio (16)<br>Alto (24) (Statu Quo) |
| 2 | Fauna | Número de especies de animales amenazadas | Bajo (8)<br>Medio (16)<br>Alto (24) (Statu Quo) |
| 3 | Deforestación | Tamaño de deforestación en una ANP en has. | Bajo (286)<br>Medio (700)<br>Alto (1400) (Statu Quo) |
| 4 | Precio | Contribución económica por conservar los demás atributos de BD en el PNM | S/. 0 (Statu Quo)<br>S/. 8, S/. 12, S/. 16, S/. 24, S/. 32 |

# Choice-set example

Cuadro 3: Ejemplo de un escenario presentado a los individuos

| Atributos | Opciones (de acuerdo a los diferentes niveles de cada uno de los atributos) | | |
|---|---|---|---|
| | Opción A | Opción B | Opción C |
| (1) Plantas | 24 | 16 | 8 |
| (2) Animales | 24 | 16 | 8 |
| (3) Deforestación | 1400 | 700 | 286 |
| (4) Contribución (precio) | S/.0 | S/.4 | S/.8 |

# Methologies





- Two approaches to capture heterogeneity:
  - Random parameters models (RPM)
  - Latent class models (LCM).
- Basic Model:
  - Discrete Choice model (Conditional logit model)
  - An individual faces J alternatives (products), characterized by a set of attributes.
  - Estimate a conditional logit model.
- RPM
  - Mixing parametric and continuous distribution for the parameters
- Latent Class Model:
  - Discrete mixing distribution

# Mixed logit versus Latent class



## Mixed logit

- Utility function $U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt}$
- Continuous Distribution: $\beta_n \sim f(\beta|\theta)$
- Likelihood
  - $\mathrm{P}_n(\theta) = \int \left\{ \prod_{t=1}^{T} \prod_{j=1}^{J} \left( \frac{\exp(\beta_n' \mathrm{x}_{njt})}{\sum_{\mathrm{i}}^{J} \exp(\beta_n' \mathrm{x}_{nit})} \right)^{y_{njt}} \right\} f(\beta_n) d\beta_n$
- Estimation: Simulated Max. Likelihood
  - $\check{P}_{nj} = \frac{1}{R} \sum_{r=1}^{R} P_{nj}(j|\beta^r)$
- Segments: individual level parameters
  - $\widehat{\beta_n} = \hat{E}(\beta_n|y_n, x_n) = \dfrac{\frac{1}{R} \sum_{r=1}^{R} \beta_n^r \prod_{t=1}^{T} \prod_{j=1}^{J} \left( \frac{\exp(\beta_n^r \mathrm{x}_{njt})}{\sum_{\mathrm{i}}^{J} \exp(\beta_n^r \mathrm{x}_{nit})} \right)^{y_{njt}}}{\frac{1}{R} \sum_{r=1}^{R} \prod_{t=1}^{T} \prod_{j=1}^{J} \left( \frac{\exp(\beta_n^r \mathrm{x}_{njt})}{\sum_{i}^{J} \exp(\beta_n^r \mathrm{x}_{nit})} \right)^{y_{njt}}}$

## Latent clases

- Utility function $U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt}$
- *Discrete distribution: Probability of belonging to class s:*
  - $w_{ns}(\gamma) = \frac{\exp(h_n \gamma_s)}{\sum_{s=1}^{S} \exp(h_n \gamma_s)}$
- Likelihood
  - $\mathrm{P}_n(\theta) = \sum_{s=1}^{S} w_{ns} \left[ \prod_{t=1}^{T} \prod_{j=1}^{J} \left( \frac{\exp(\beta_n' \mathrm{x}_{njt})}{\sum_{i}^{J} \exp(\beta_n' \mathrm{x}_{nit})} \right)^{y_{njt}} \right]$
- Estimation: Max. Likelihood
- Segments: Individual level parameters
  - $\widehat{\beta_n} = \hat{E}(\beta_n|y_n, x_n) = \sum_{s=1}^{S} \beta_s \dfrac{w_{ns} \prod_{t=1}^{T} \prod_{j=1}^{J} \left( \frac{\exp(\beta_s' \mathrm{x}_{njt})}{\sum_{i}^{J} \exp(\beta_s' \mathrm{x}_{nit})} \right)^{y_{njt}}}{\sum_{s=1}^{S} w_{ns} \prod_{t=1}^{T} \prod_{j=1}^{J} \left( \frac{\exp(\beta_s' \mathrm{x}_{njt})}{\sum_{i}^{J} \exp(\beta_s' \mathrm{x}_{nit})} \right)^{y_{njt}}}$

# RESULTS

# Sampling



| Departamento | | N° encuestados |
|---|---|---|
| Lima | | 588 |
| Arequipa | | 132 |
| Cusco | | 84 |
| Junin | | 108 |
| Piura | | 156 |
| San Martin | | 60 |
| Ucayali | | 36 |

# Resultados



| | Conditional Logit | Mixed Logit | S.D. | Latent Class 1 | Latent Class 2 |
|---|---|---|---|---|---|
| flora1 | 0.253*** | 0.606*** | 1.643*** | 0.00611 | 0.732*** |
| | (0.0494) | (0.111) | (0.175) | (0.275) | (0.0584) |
| flora2 | 0.282*** | 0.493*** | 1.635*** | -0.0468 | 0.941*** |
| | (0.0476) | (0.103) | (0.180) | (0.268) | (0.0603) |
| fauna1 | 0.215*** | -0.0791 | 3.378*** | -0.000983 | 0.812*** |
| | (0.0500) | (0.148) | (0.235) | (0.336) | (0.0589) |
| fauna2 | 0.210*** | 0.249* | 2.035*** | 0.142 | 0.717*** |
| | (0.0488) | (0.112) | (0.159) | (0.289) | (0.0593) |
| deforestacion1 | 0.575*** | 1.020*** | 1.760*** | -0.166 | 1.253*** |
| | (0.0491) | (0.110) | (0.150) | (0.313) | (0.0601) |
| deforestacion2 | 0.564*** | 0.792*** | 2.206*** | 0.726** | 1.192*** |
| | (0.0491) | (0.118) | (0.167) | (0.274) | (0.0595) |
| Precio | -0.114*** | -0.203*** | | -0.893*** | -0.0866*** |
| | (0.00463) | (0.00916) | | (0.0883) | (0.00480) |
| share | | | | 0.336 | 0.664 |
| _cons | | | | -0.683*** | |
| | | | | (0.0650) | |

Standard errors in parentheses $^{+}\ p < 0.1$, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

# WTP for each level of the atributes and different models

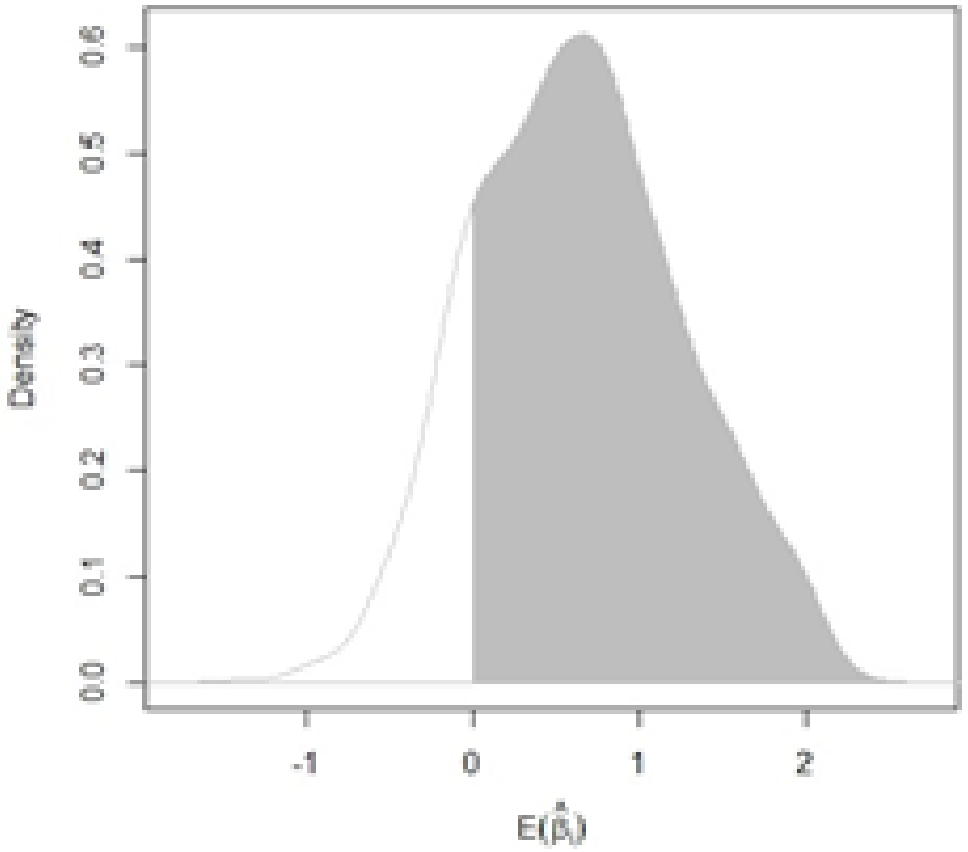


| WTP | Conditional Logit | Mixed Logit | Latent Class 1 | Latent Class 2 |
|---|---|---|---|---|
| flora1 | 2,22 | 2,99 | 0,00 | 8,45 |
| flora2 | 2,47 | 2,43 | 0,00 | 10,87 |
| fauna1 | 1,89 | 0,39 | 0,00 | 9,38 |
| fauna2 | 1,84 | 1,23 | 0,00 | 8,28 |
| deforestacion1 | 5,04 | 5,02 | 0,00 | 14,47 |
| deforestacion2 | 4,95 | 3,90 | 0,81 | 13,76 |
| share | | | 0,34 | 0,66 |

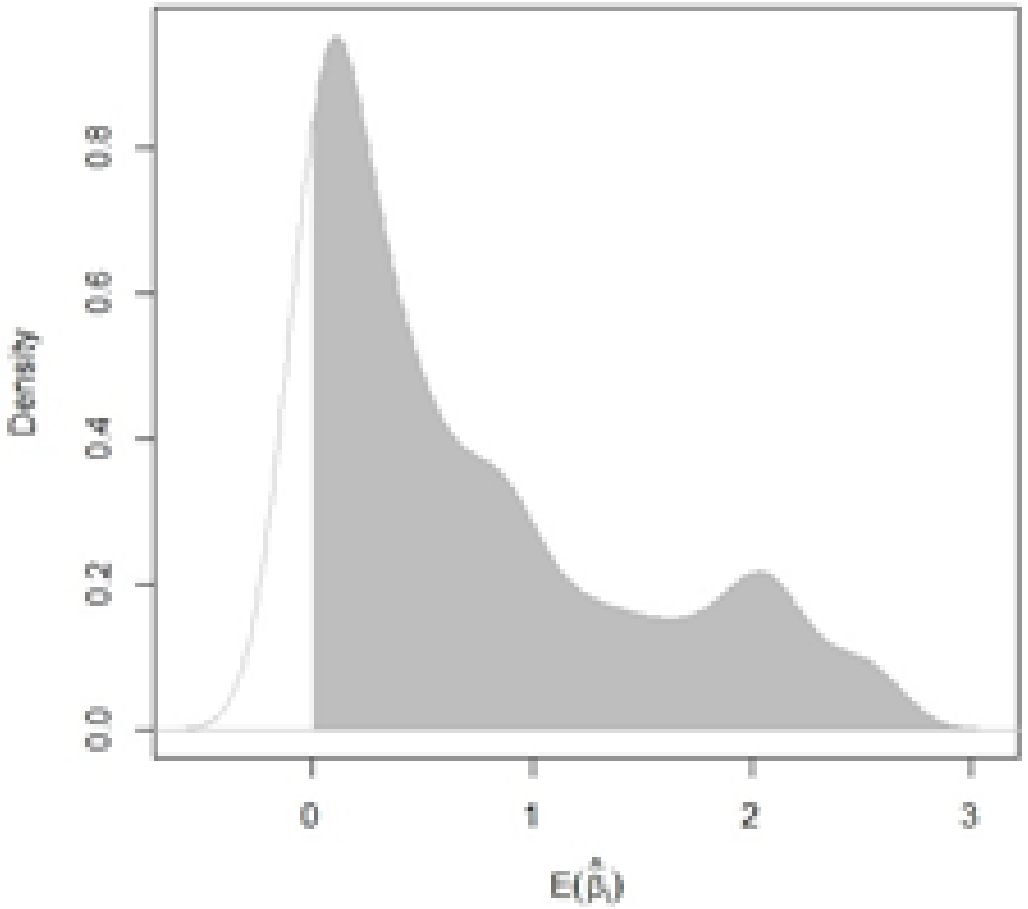
# Discussion and conclusions

- **POSITIVE WTP FOR ATTRIBUTES and SIGNIFICANT HETEREGONEITY AMONG RESPONDENTS**

## Distribution for mixed logit model



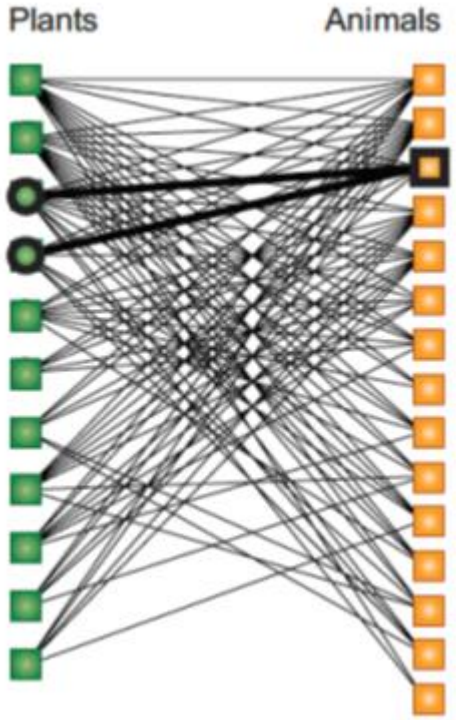

## Distribution for Latent Class Model

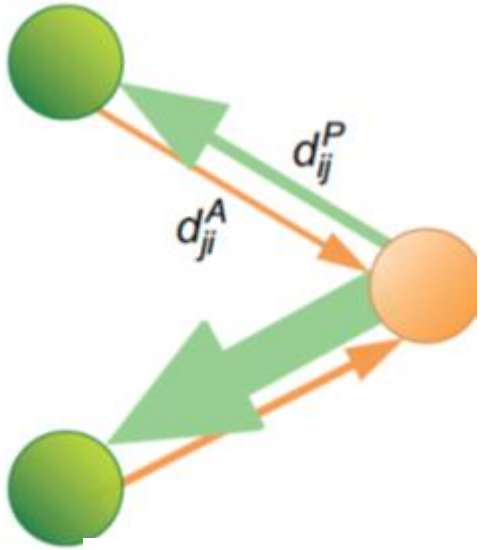


# Discussion and conclusions: Future Research



- We need better ways to Define Biodiversity in Surveys

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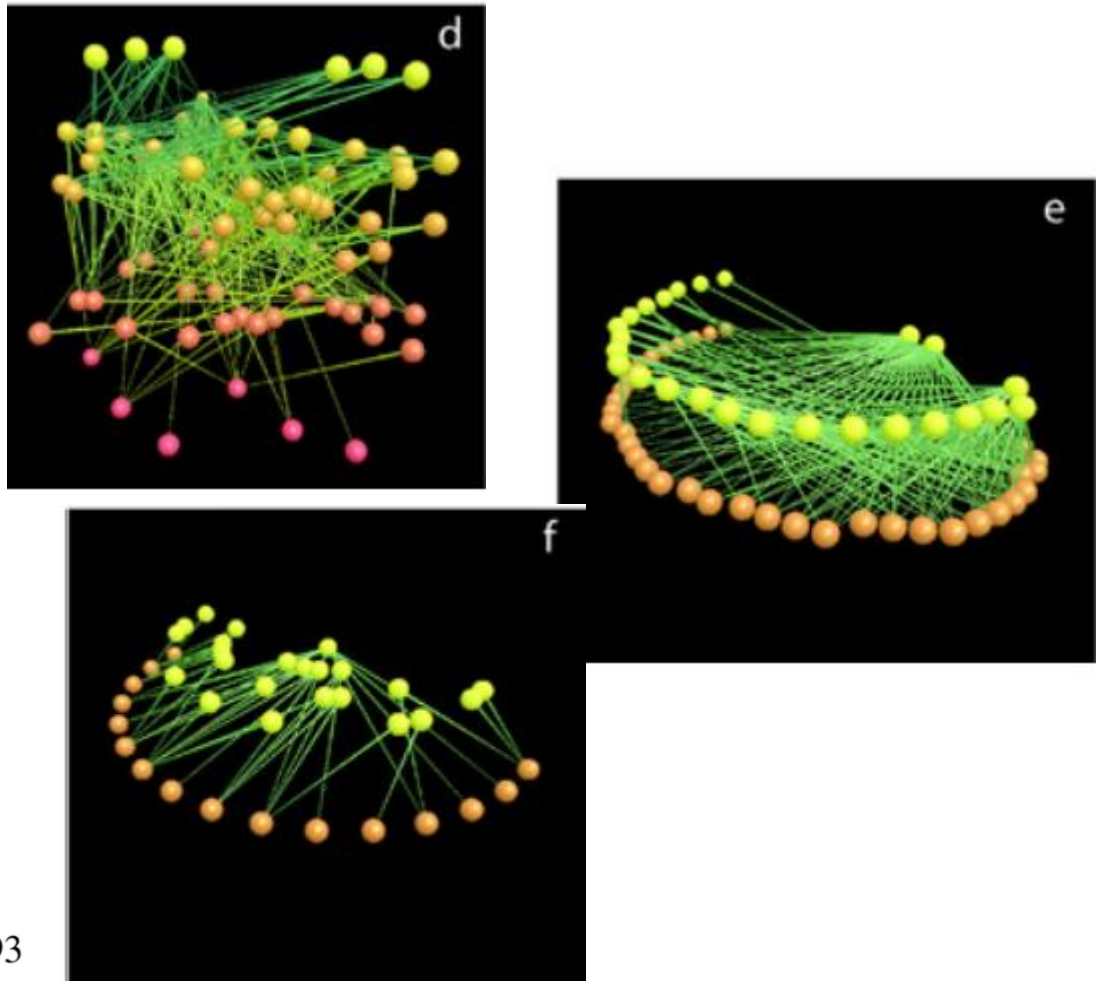

# THANKS

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