

The efficacy of Euler diagrams and linear diagrams for visualizing set cardinality using proportions and numbers

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4 Bloomberg

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This document is supplementary material for the associated paper submitted to PLOSOne. It contains the following information:

- Appendix A contains information on how the questions were generated for the tasks in the study.
- Appendix B presents the examples used for training participants.
- Appendix C presents the questions and associated diagrams used in the studies.
- Appendix D provides information on the statistical methods used to analyse the data.
- Appendices E-G present all of the statistical output generated from the methods employed for the three studies.

All of the diagrams included in this document are scaled to 50% of the actual size used in the study in order to fit within the page width.

A - Question Generation

For the S-type questions, a random permutation of the list of labels was generated using the website www.random.org. The first label in this permuted list then became the label which would appear in the question, and the next four labels in the permuted list were the labels which would appear as check-boxes, alongside the “None of the above” option. (Where there were only five sets in the diagram, the second step was redundant.)

For the I-type questions, a random permutation of the list containing those intersections containing at most three labels, was generated using the website www.random.org. The first intersection in this permuted list became the intersection which would appear in the question, and the next four intersections in the permuted list were the intersections which would appear as check-boxes, alongside the “None of the above” option.

A check was performed on the number of check-boxes that appeared in the correct answer, which ranged from 0 (representing “None of the above”) to 4. These numbers were:

- 0/“None of the above”: 7 questions
- 1 check-box to be checked: 6 questions
- 2 check-boxes to be checked: 7 questions
- 3 check-boxes to be checked: 7 questions
- 4 check-boxes to be checked: 5 questions

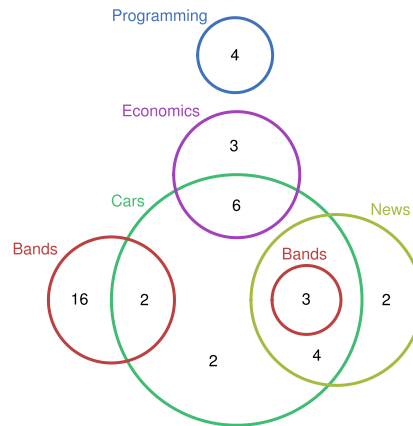
Thus, there was no systematic bias towards any number of check-boxes appearing in the correct answer.

B - Training for Studies A, B & C

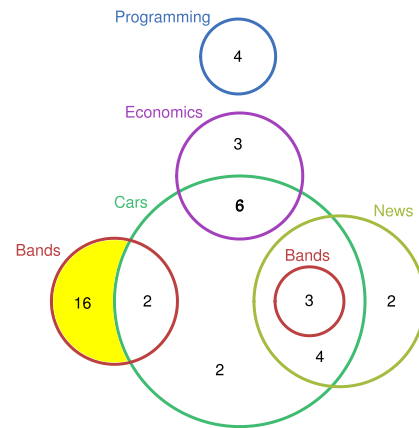
This section contains the data presented to participants for the purposes of training. After attempting each question, participants were given the correct answer, an explanation of the correct answer (with reference to the diagram) and a modified diagram with the regions of interest highlighted. An exception was for training question 4, as the correct answer was “None of the above”, and thus no regions were highlighted. These modified diagrams for training questions 1 to 3 are presented alongside the respective question.

Question 1

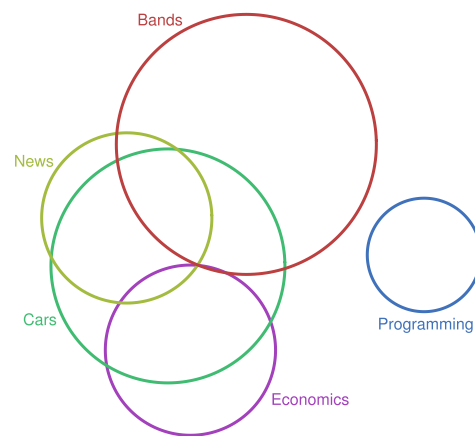
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Cars and Economics only**.
- **Check boxes to be ticked:** Bands
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 44130462
- ED-N



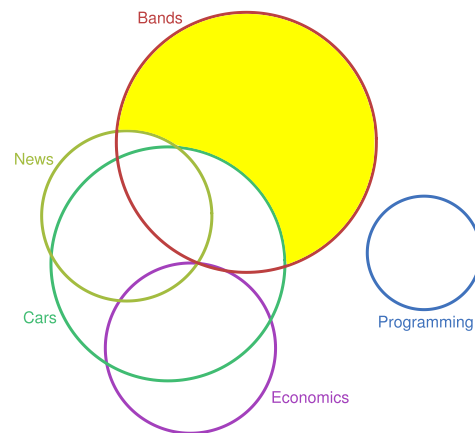
- ED-N:Explanation



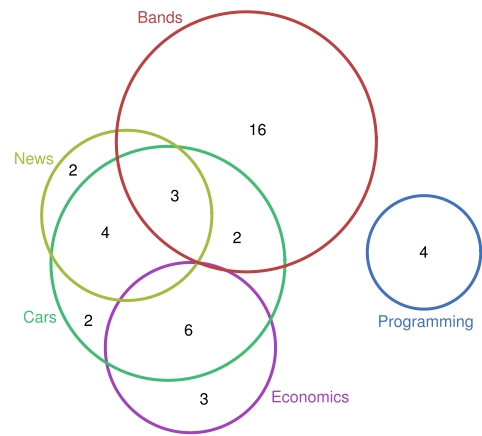
- ED-P



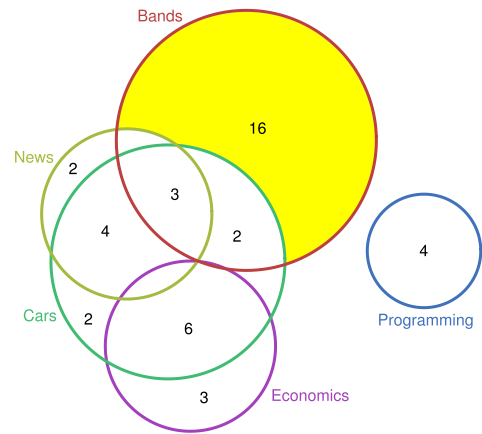
- ED-P:Explanation



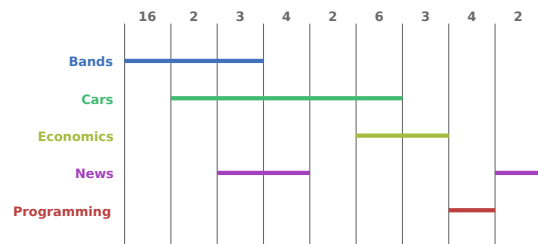
- ED-P&N



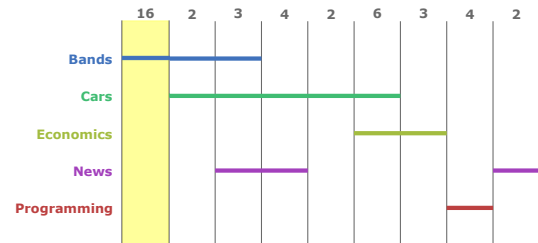
- ED-P&N:Explanation



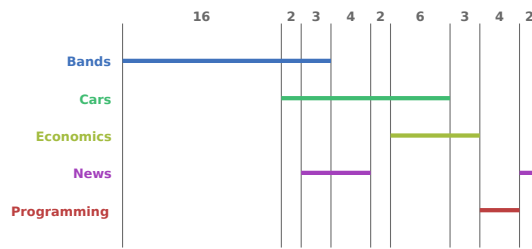
- LD-N



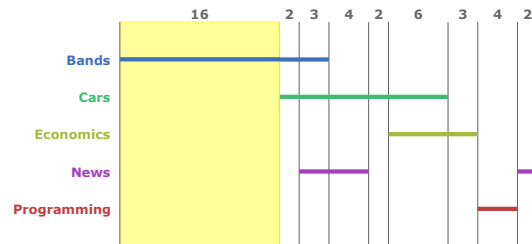
- LD-N:Explanation



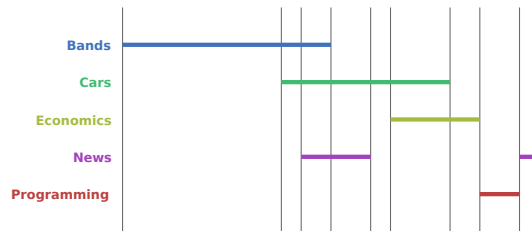
- LD-P



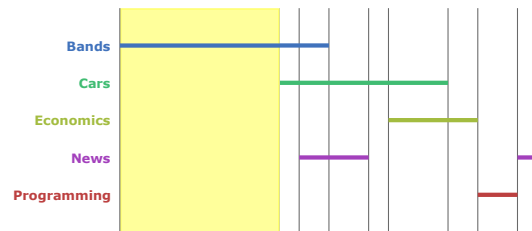
- LD-P:Explanation



- LD-P&N

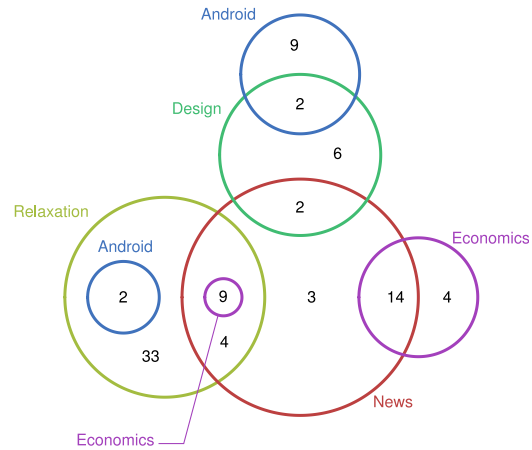


- LD-P&N:Explanation

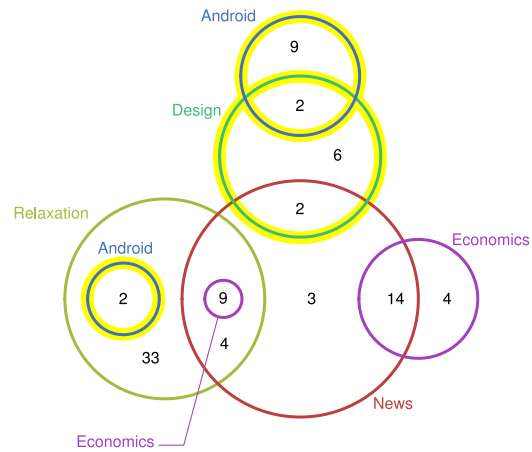


Question 2

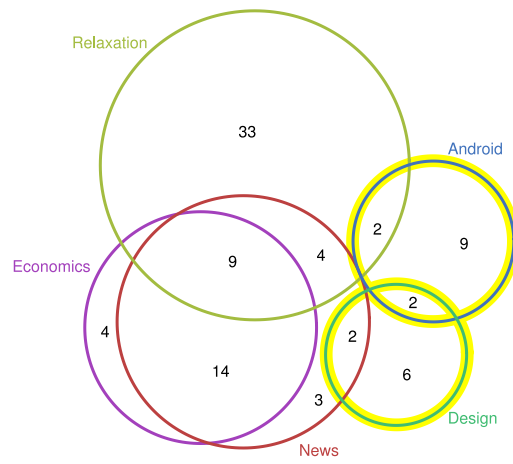
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Economics**.
- **Check boxes to be ticked:** Android, Design
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 16652550
- ED-N



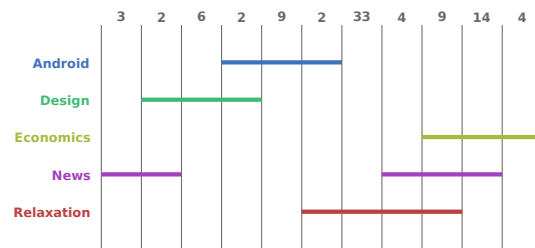
- ED-N:Explanation



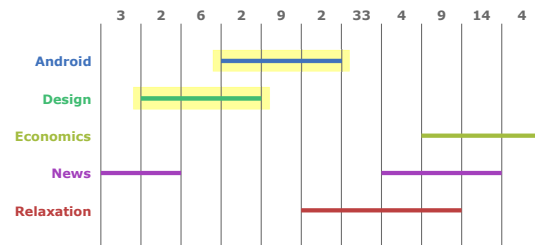
- ED-P



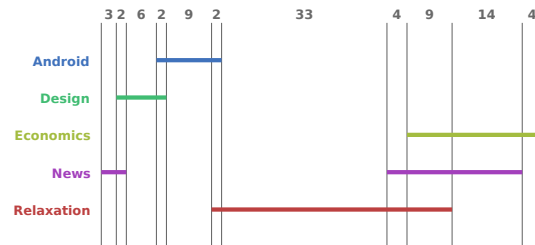
- LD-N



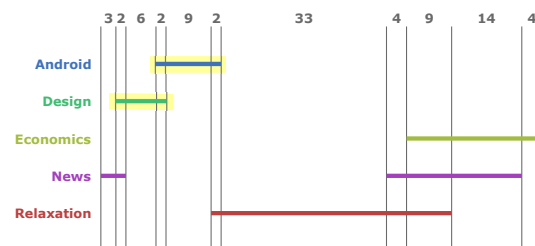
- LD-N:Explanation



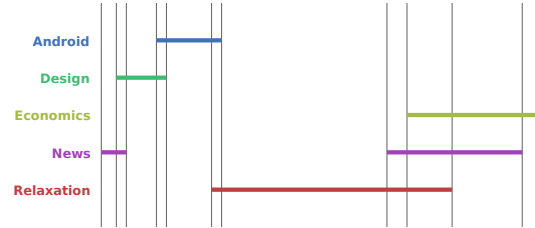
- LD-P



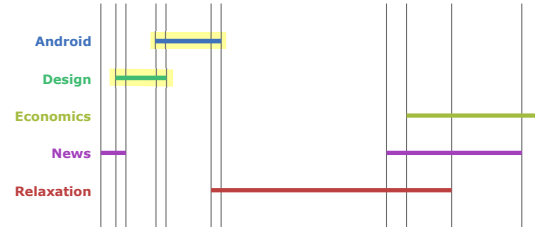
- LD-P:Explanation



- LD-P&N

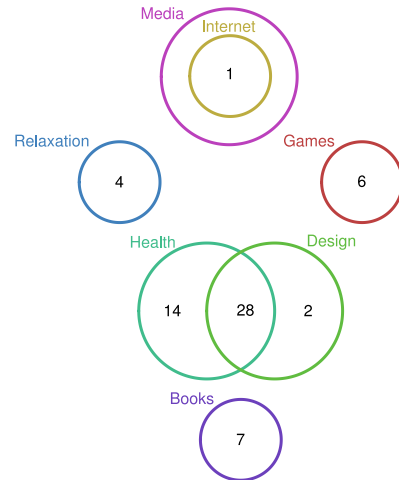


- LD-P&N:Explanation

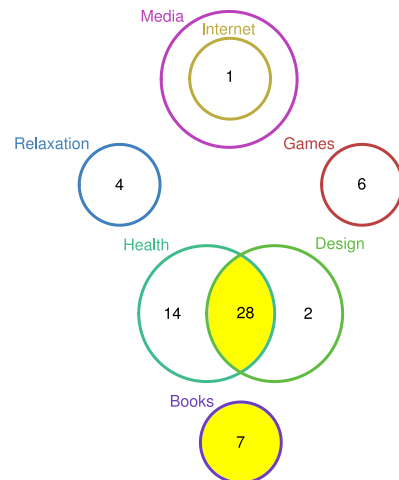


Question 3

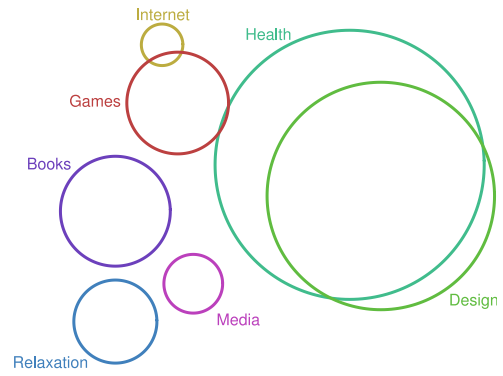
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Games only**.
- **Check boxes to be ticked:** Books, Design and Health
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 19492215
- ED-N



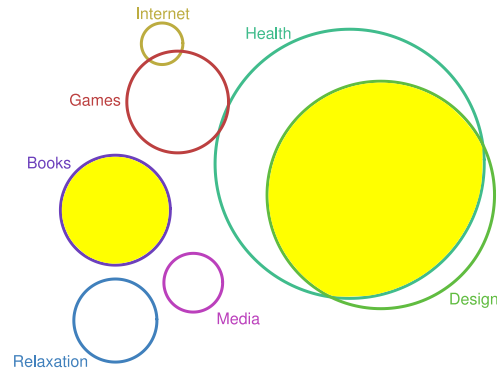
- ED-N:Explanation



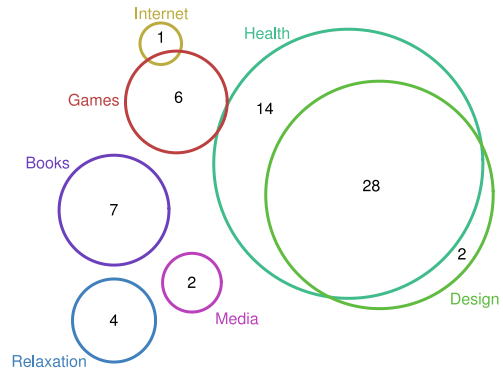
- ED-P



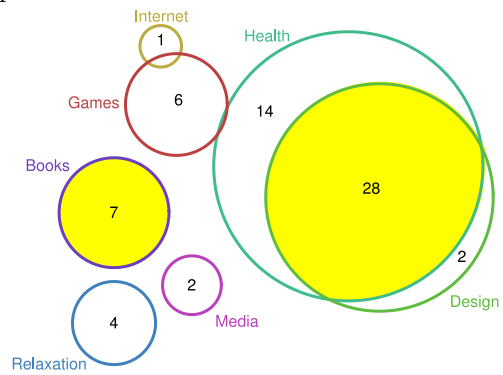
- ED-P:Explanation



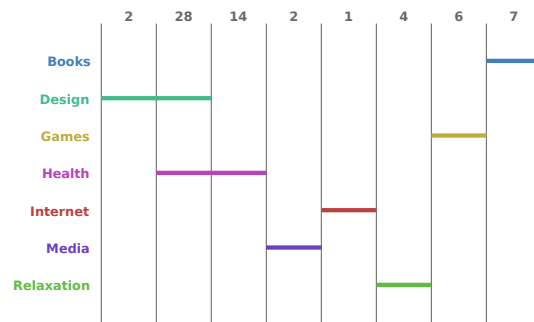
- ED-P&N



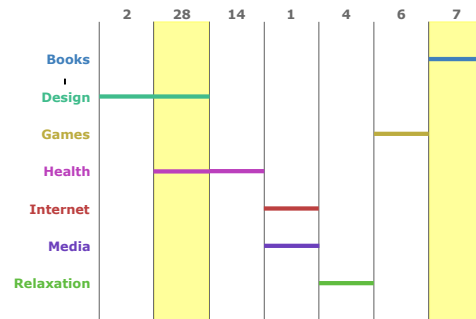
- ED-P&N:Explanation



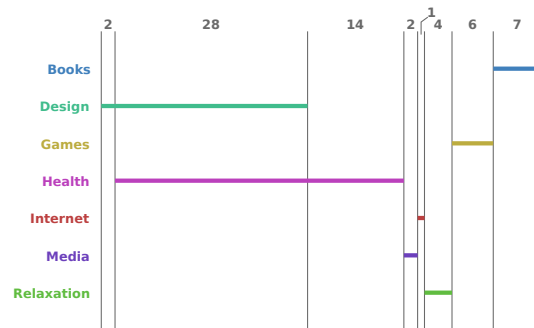
- LD-N



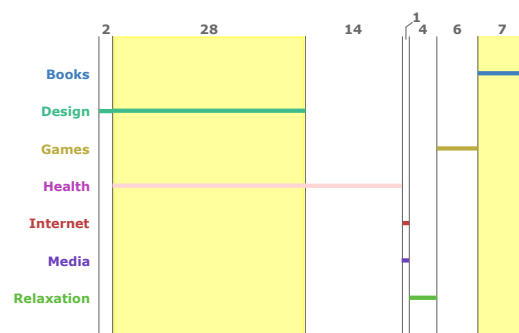
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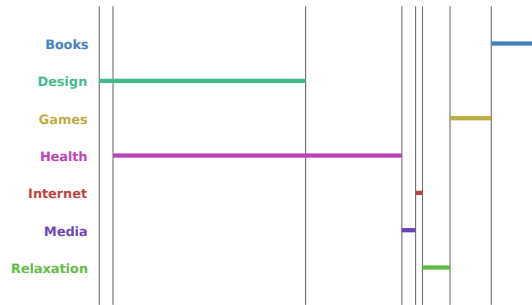
- LD-P



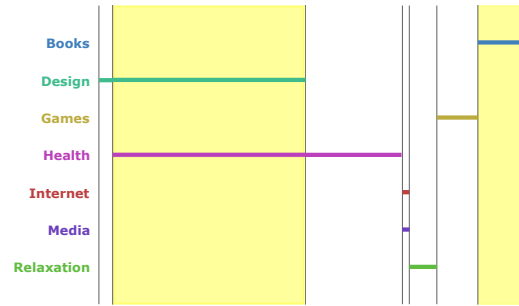
- LD-P:Explanation



- LD-P&N

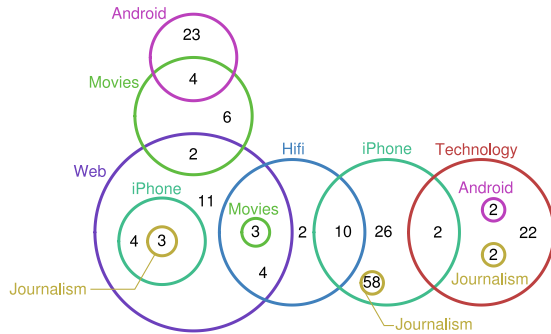


- LD-P&N:Explanation

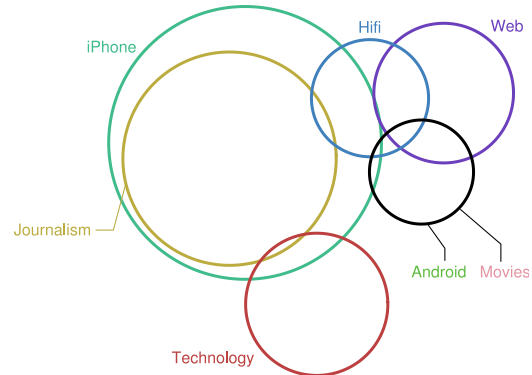


Question 4

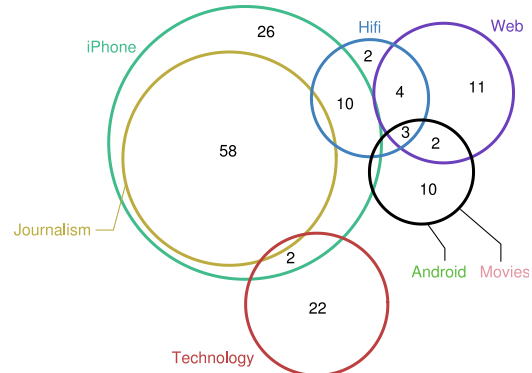
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **iPhone**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 105918870
- ED-N



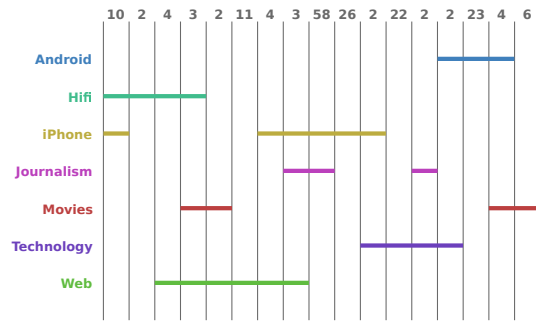
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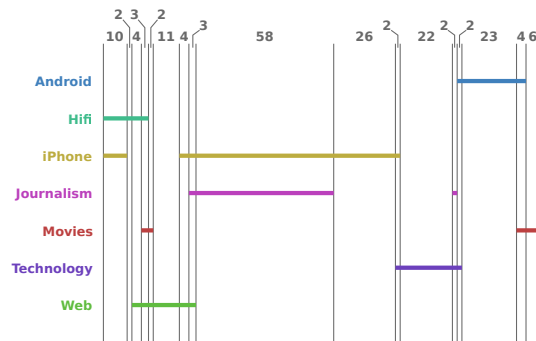
- ED-P&N



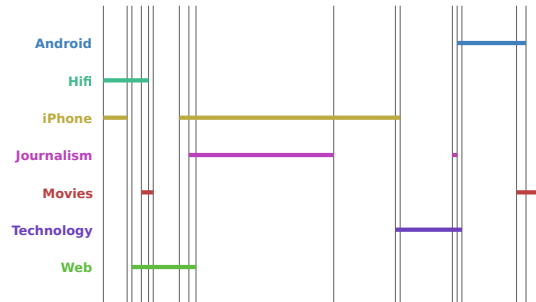
- LD-N



- LD-P



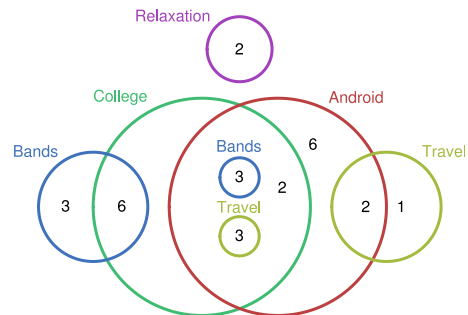
- LD-P&N



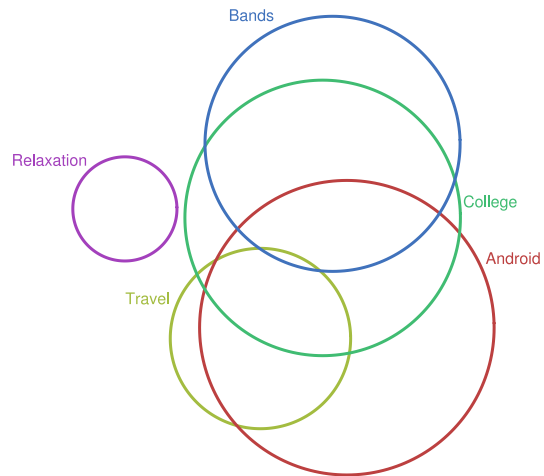
C - Studies A, B & C

Question 1

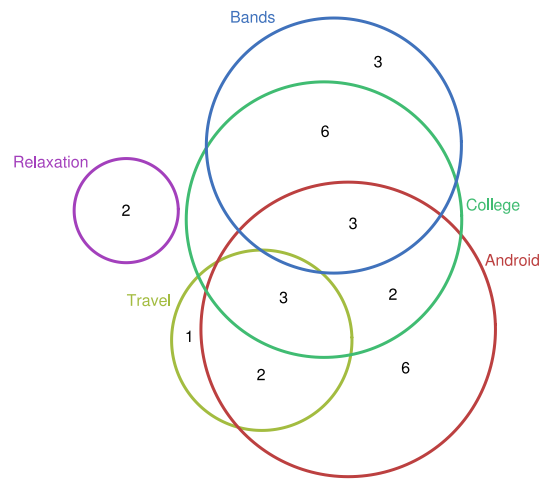
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Relaxation**.
- **Check boxes to be ticked:** Android, Bands, College, Travel
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 73024519
- ED-N



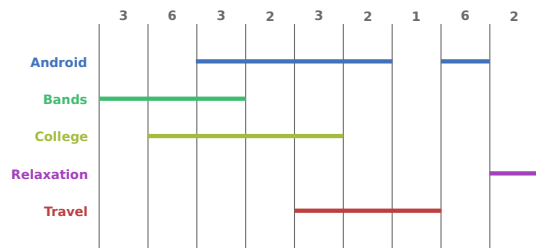
- ED-P



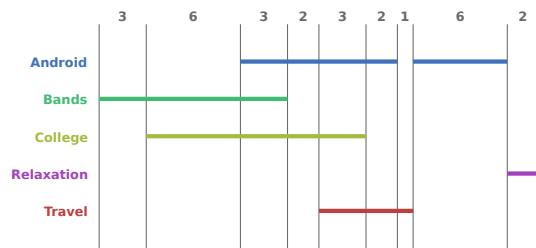
- ED-P&N



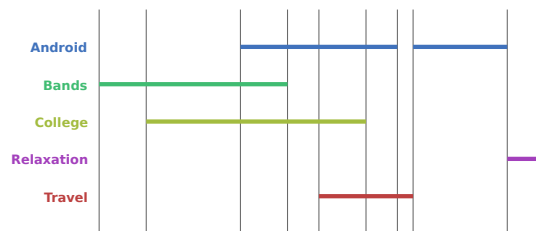
- LD-N



- LD-P

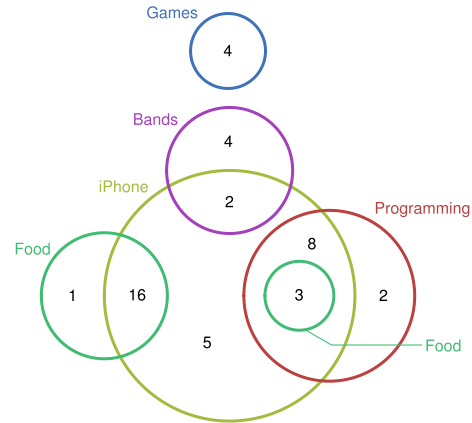


- LD-P&N

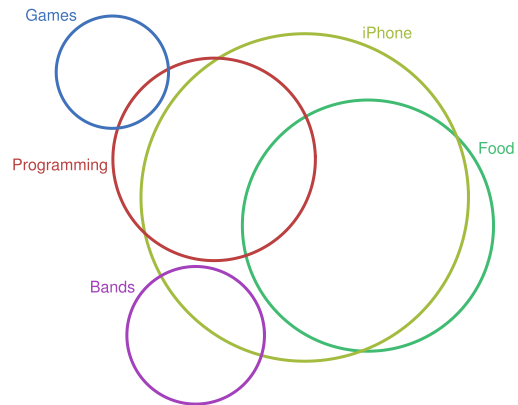


Question 2

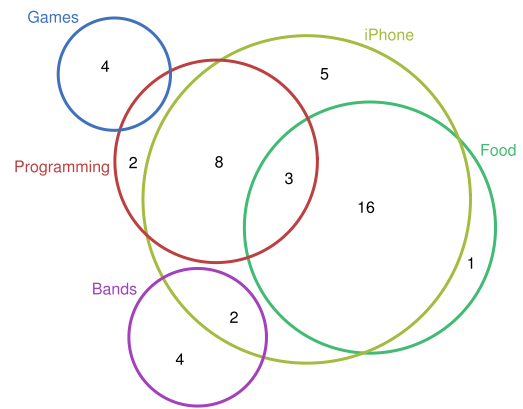
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Programming**.
- **Check boxes to be ticked:** Bands, Games
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 73738774
- ED-N



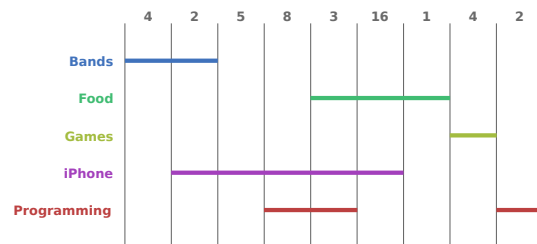
- ED-P



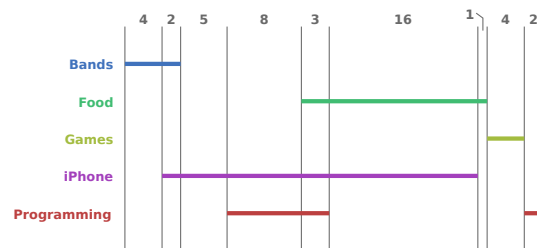
- ED-P&N



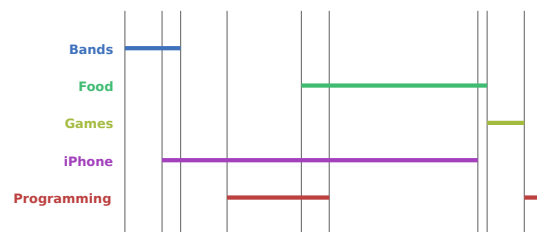
- LD-N



- LD-P

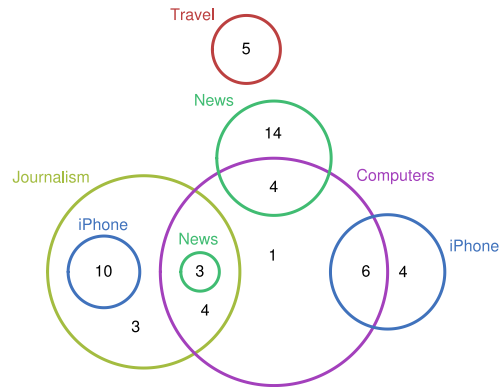


- LD-P&N

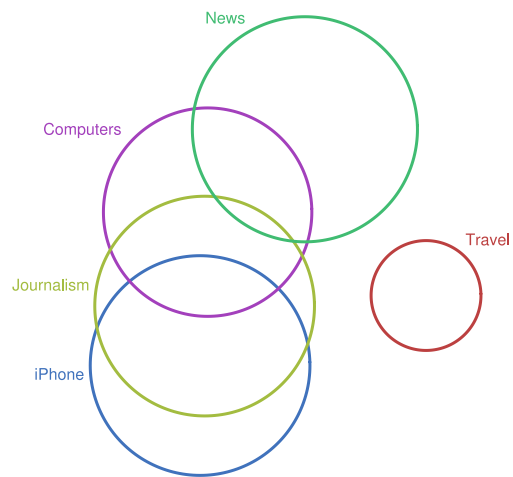


Question 3

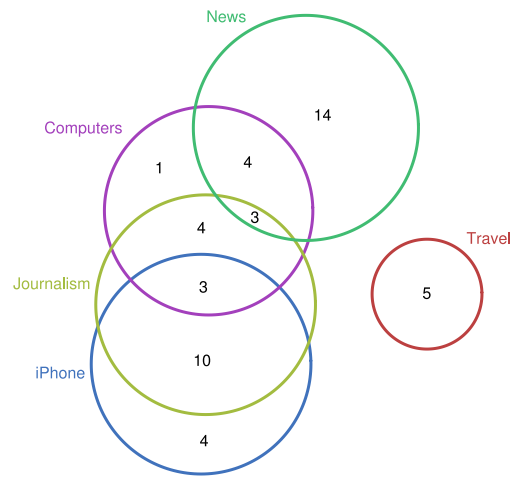
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **News only**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 14957252
- ED-N



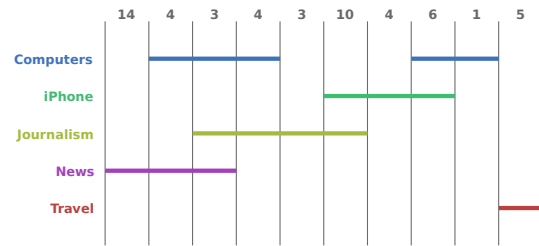
- ED-P



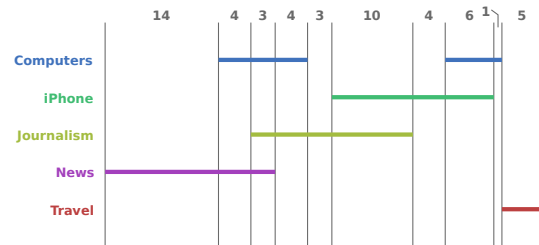
- ED-P&N



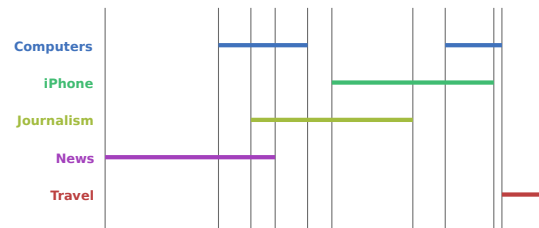
- LD-N



- LD-P

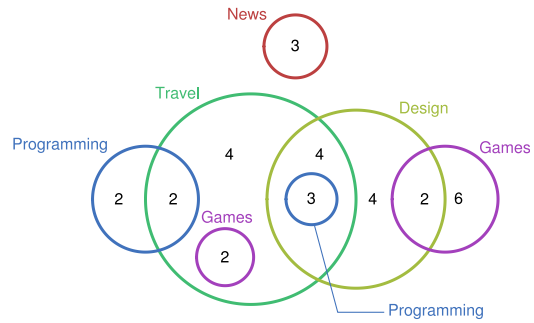


- LD-P&N

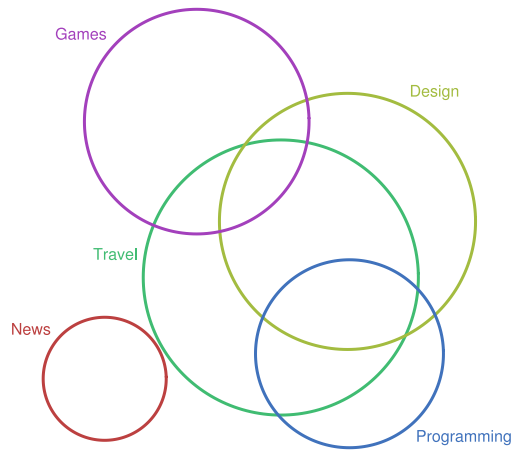


Question 4

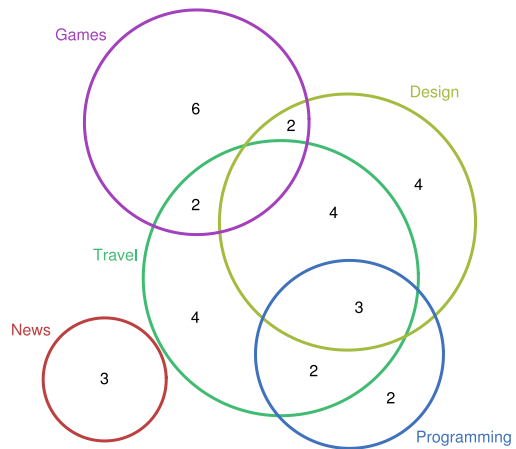
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Design and Games only**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 18687625
- ED-N



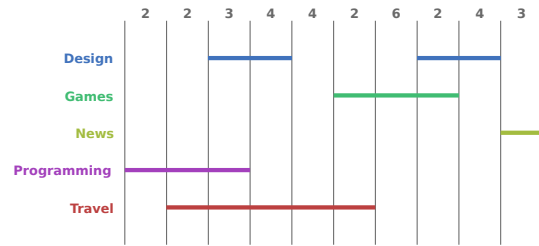
- ED-P



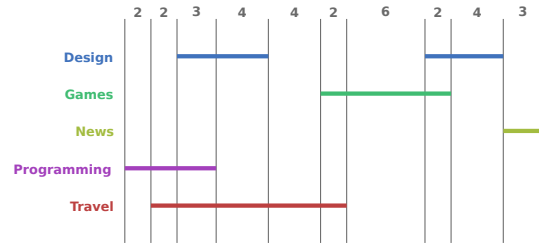
- ED-P&N



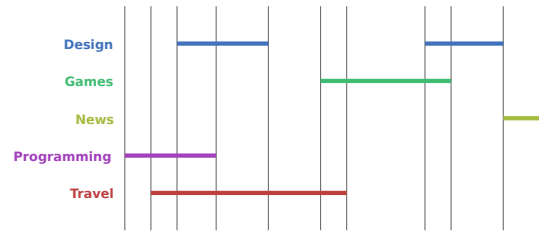
- LD-N



- LD-P

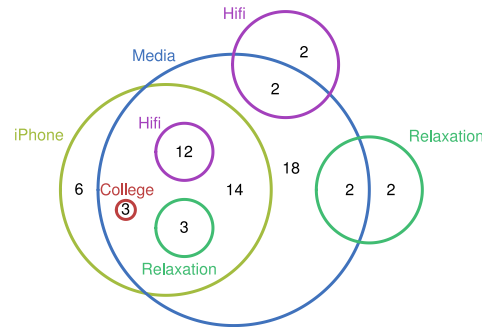


- LD-P&N

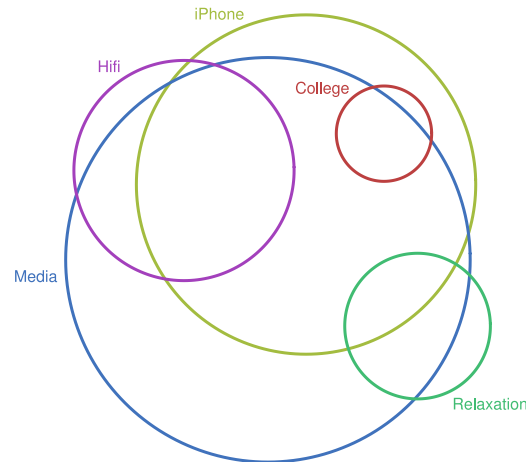


Question 5

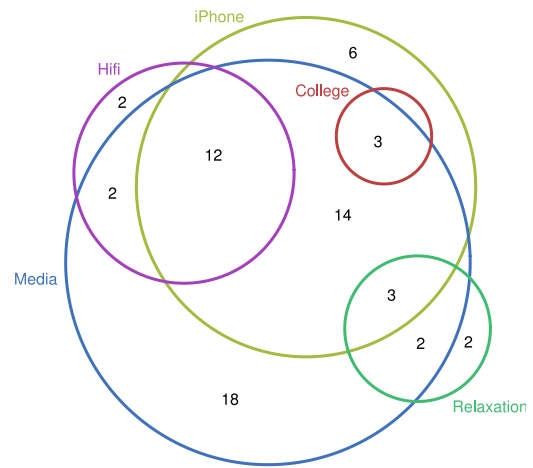
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Relaxation**.
- **Check boxes to be ticked:** Hifi, iPhone, Media
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 234169190
- ED-N



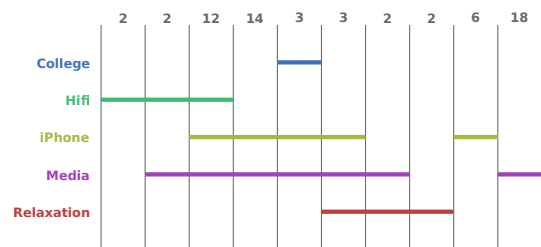
- ED-P



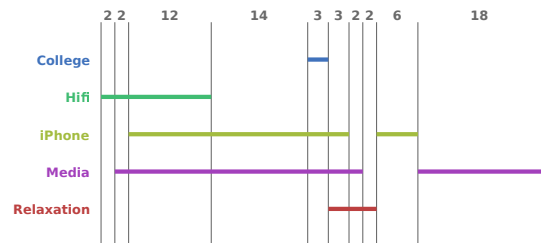
- ED-P&N



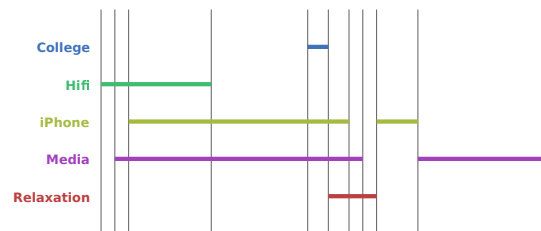
- LD-N



- LD-P

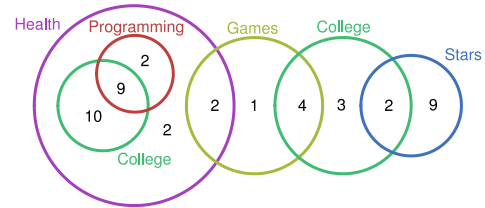


- LD-P&N

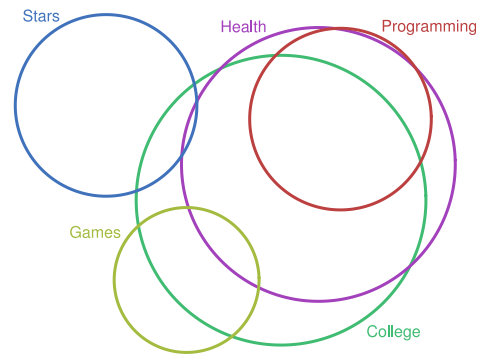


Question 6

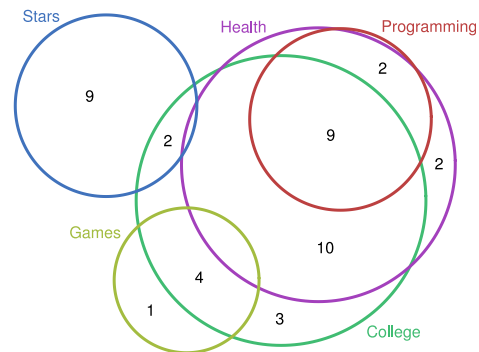
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Stars**.
- **Check boxes to be ticked:** Games
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 46160500
- ED-N



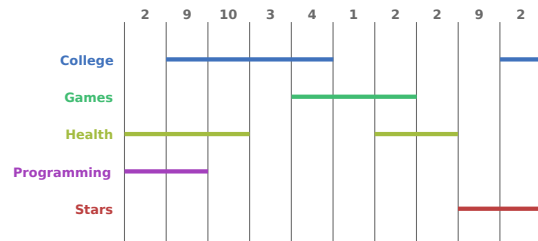
- ED-P



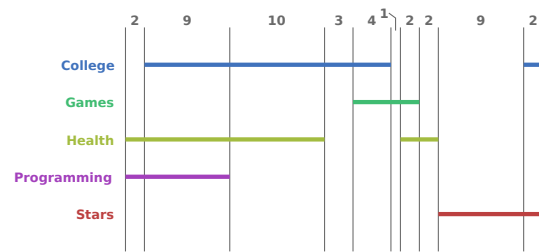
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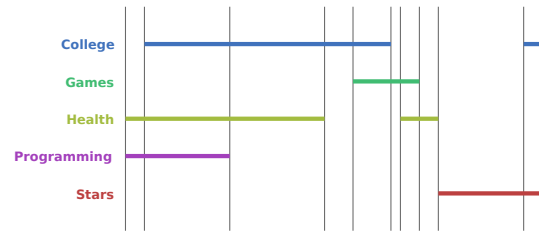
- LD-N



- LD-P

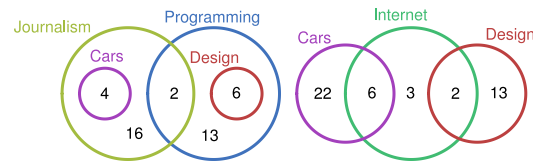


- LD-P&N

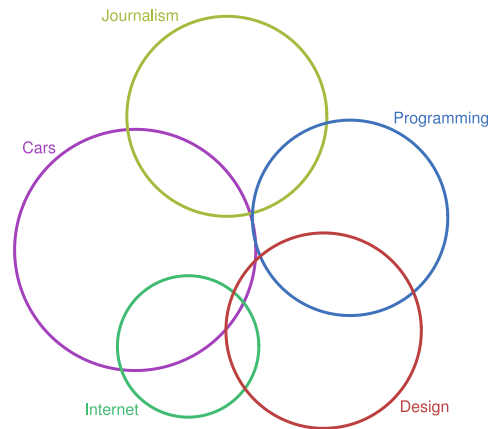


Question 7

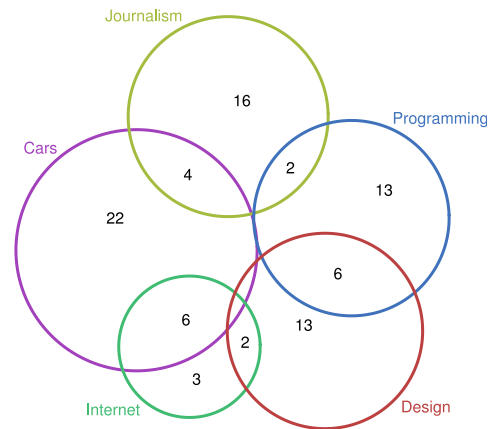
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Internet only**.
- **Check boxes to be ticked:** Cars, Cars and Internet, Design and Programming, Programming
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 87004822
- ED-N



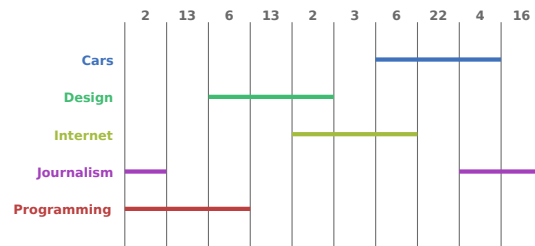
- ED-P



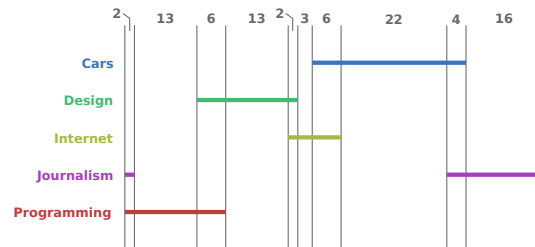
- ED-P&N



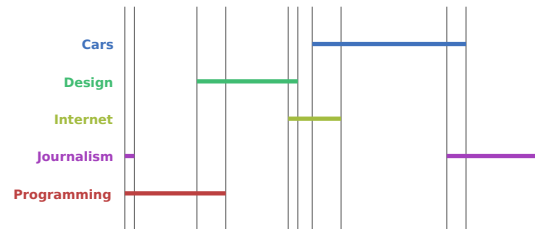
- LD-N



- LD-P

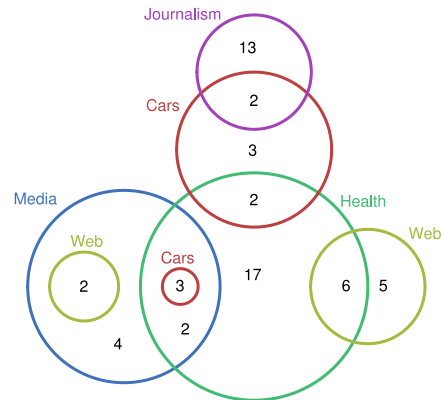


- LD-P&N

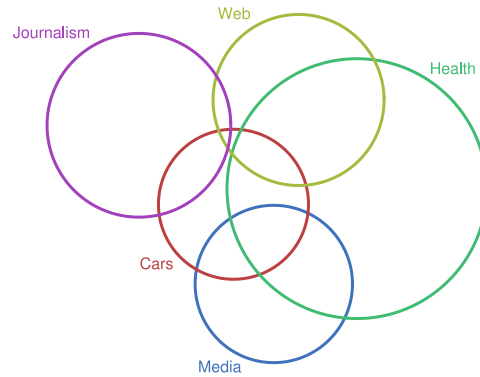


Question 8

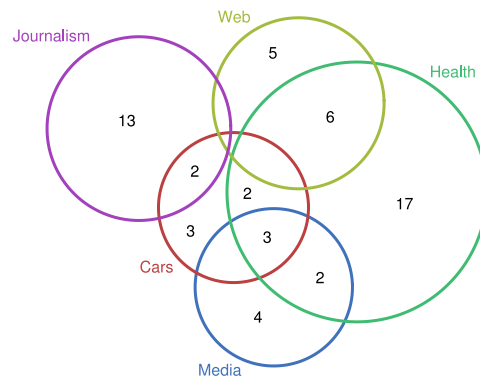
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Web only**.
- **Check boxes to be ticked:** Cars, Health and Media, Media
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 14528221
- ED-N



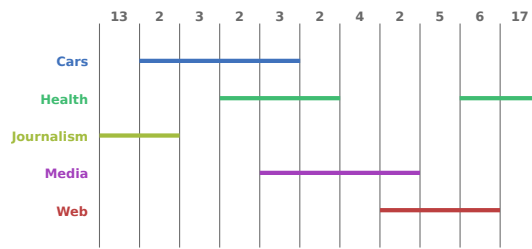
- ED-P



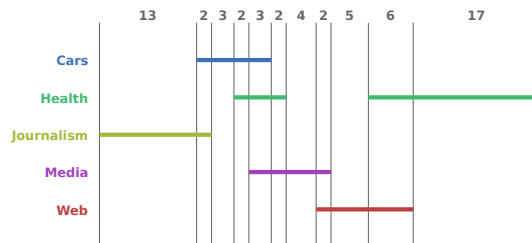
- ED-P&N



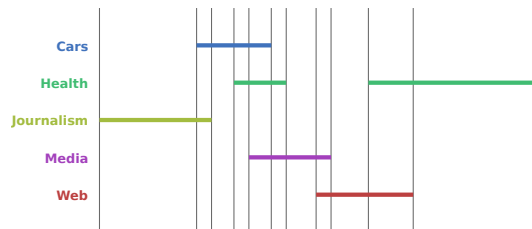
- LD-N



- LD-P

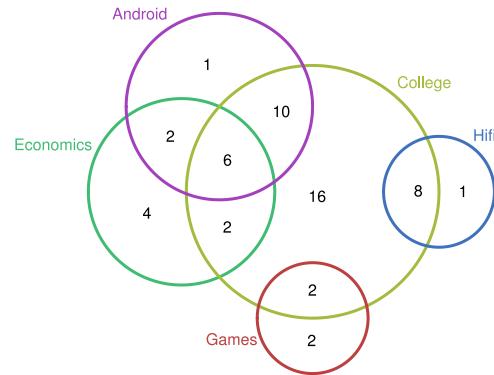


- LD-P&N

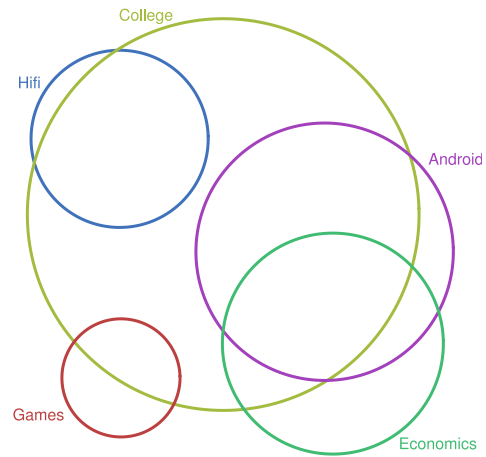


Question 9

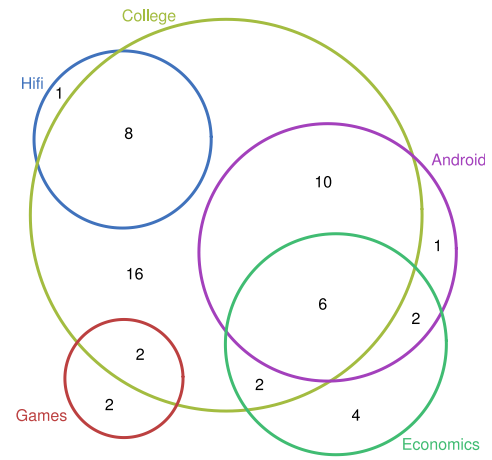
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Games**.
- **Check boxes to be ticked:** Android, College, Economics, Hifi
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 17561785
- ED-N



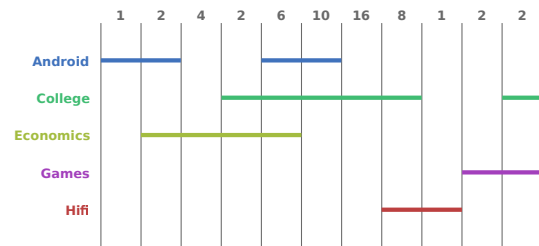
- ED-P



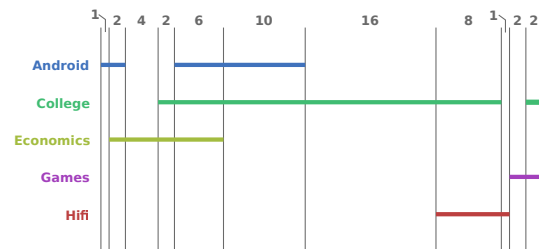
- ED-P&N



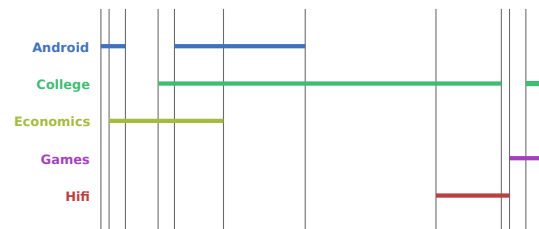
- LD-N



- LD-P

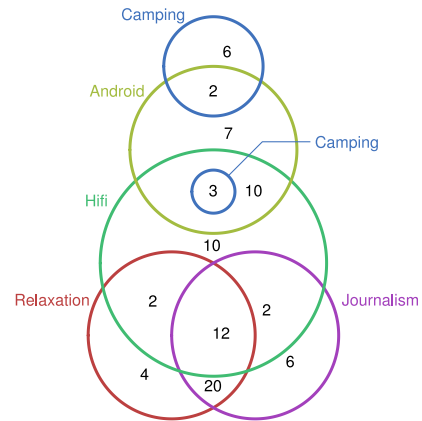


- LD-P&N

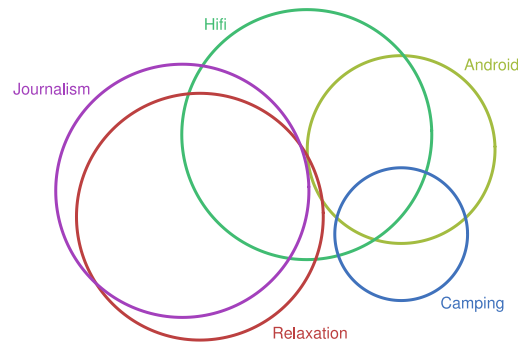


Question 10

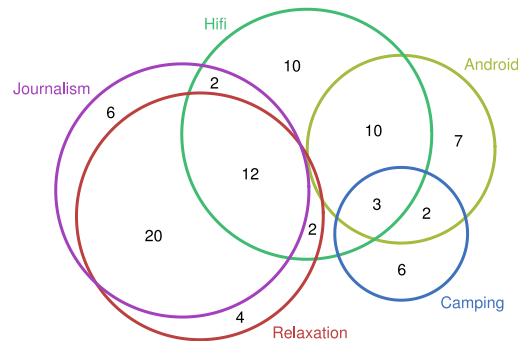
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Camping**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 105150583
- ED-N



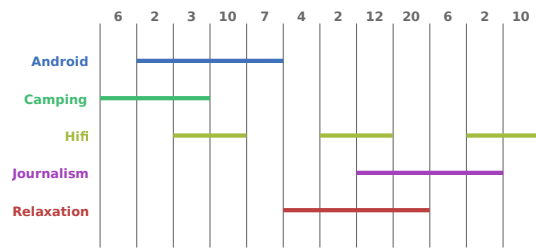
- ED-P



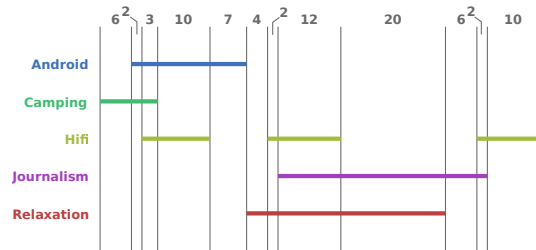
- ED-P&N



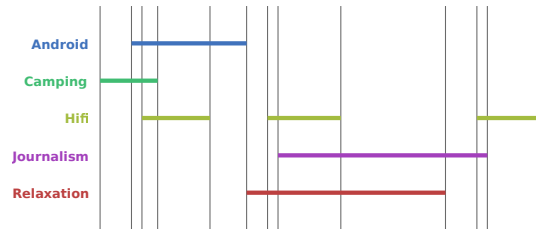
- LD-N



- LD-P

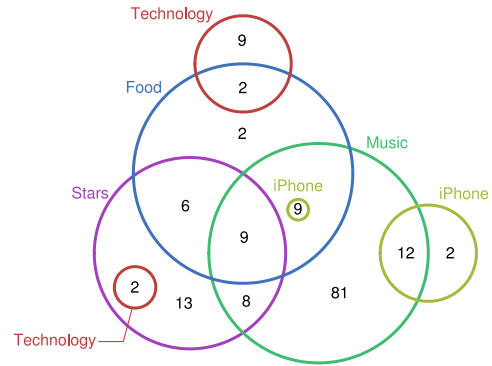


- LD-P&N

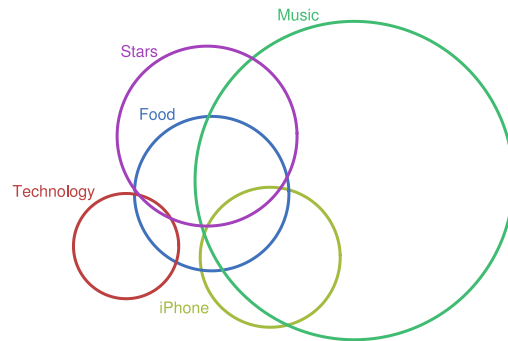


Question 11

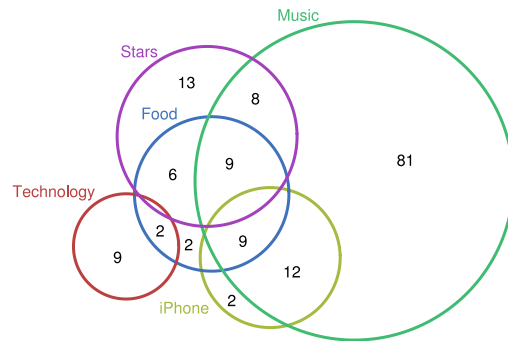
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Technology only**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 18534908
- ED-N



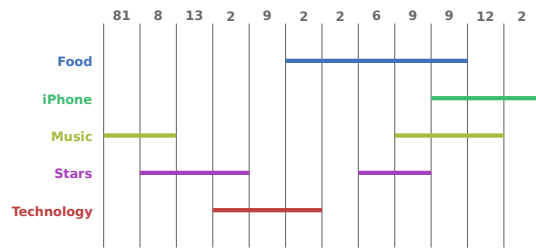
- ED-P



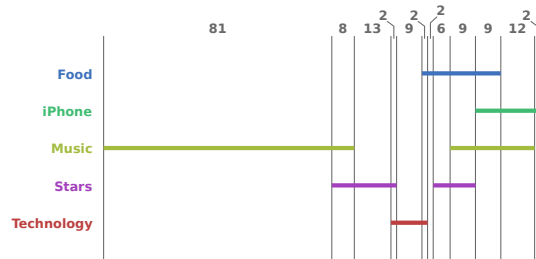
- ED-P&N



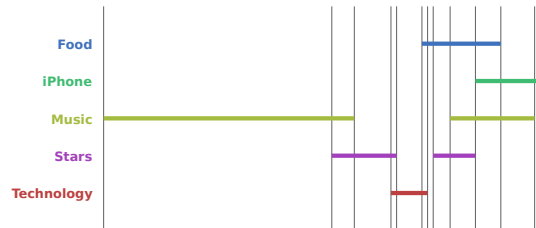
- LD-N



- LD-P

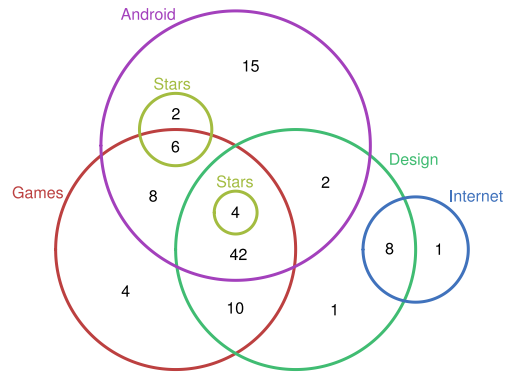


- LD-P&N

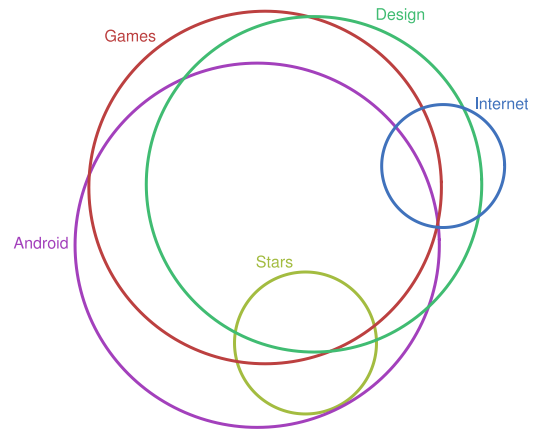


Question 12

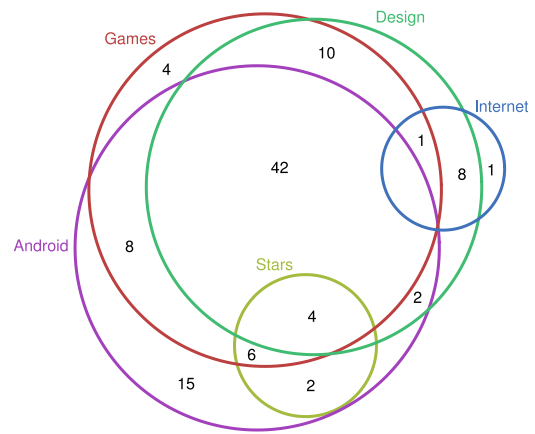
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Android and Games only**.
- **Check boxes to be ticked:** Android and Design, Android and Stars
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 59588845
- ED-N



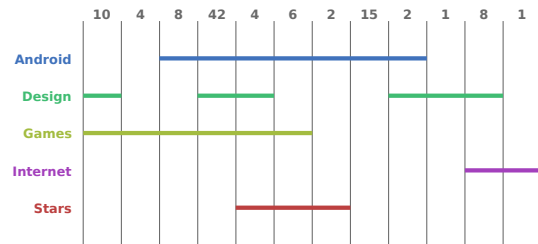
- ED-P



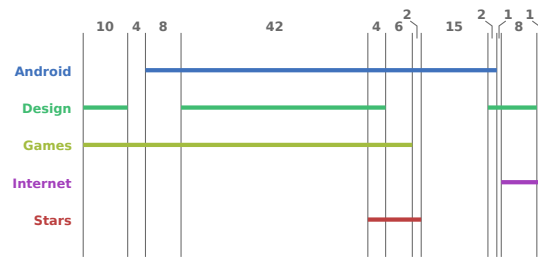
- ED-P&N



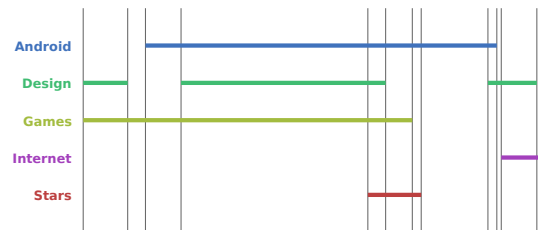
- LD-N



- LD-P

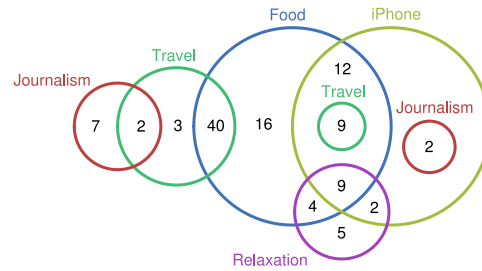


- LD-P&N

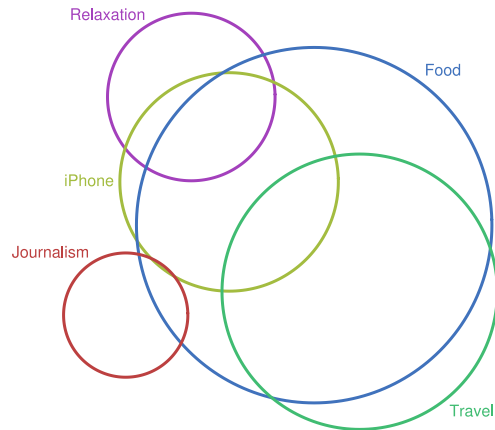


Question 13

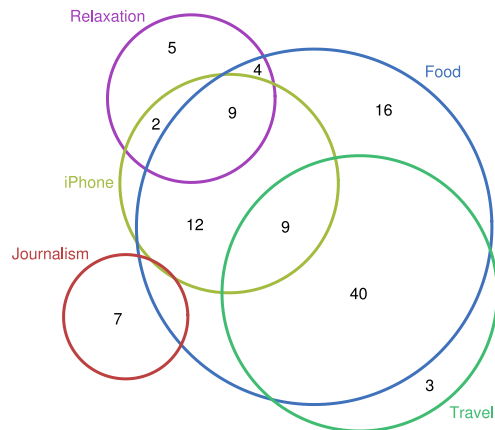
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Relaxation**.
- **Check boxes to be ticked:** Food, iPhone, Travel
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 64441390
- ED-N



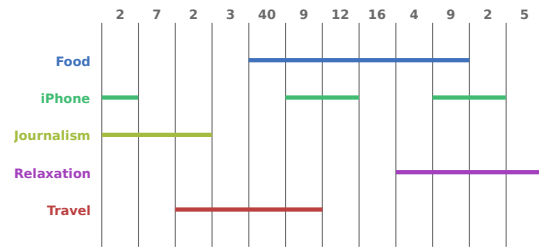
- ED-P



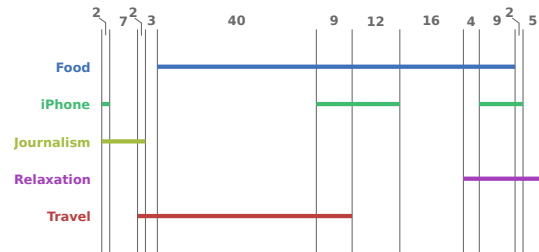
- ED-P&N



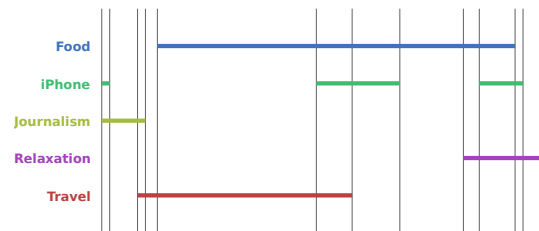
- LD-N



- LD-P

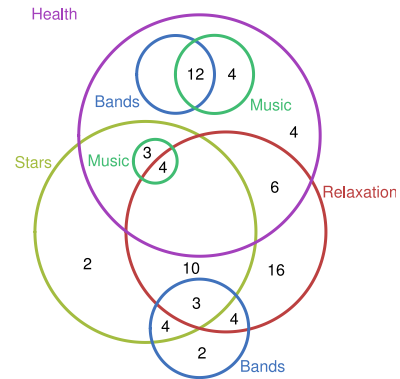


- LD-P&N

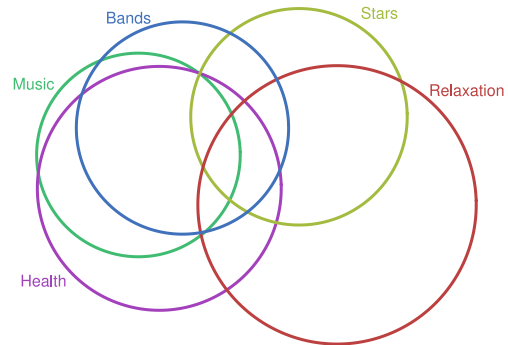


Question 14

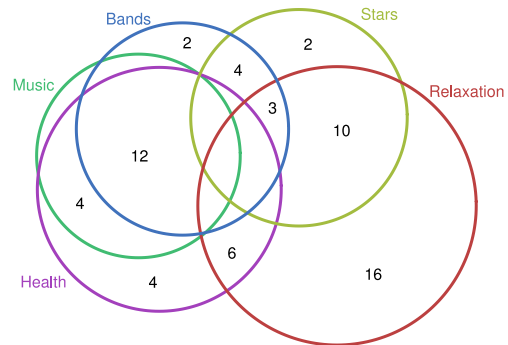
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Stars**.
- **Check boxes to be ticked:** Music
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 190696559
- ED-N



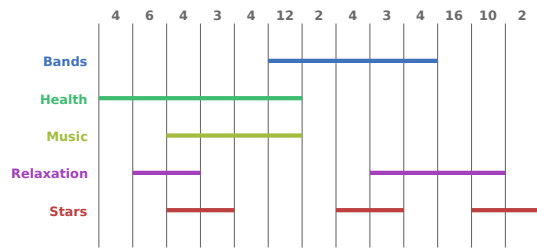
- ED-P



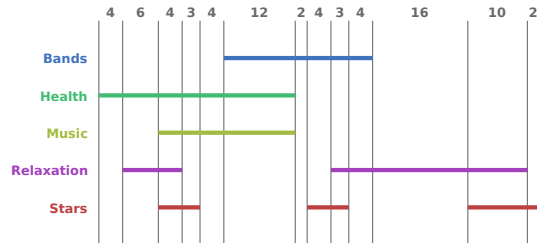
- ED-P&N



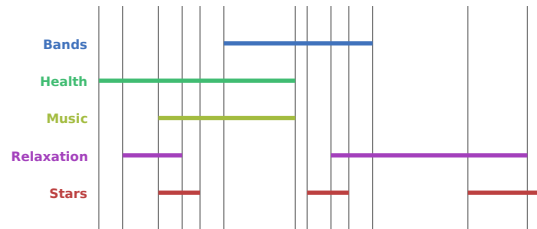
- LD-N



- LD-P

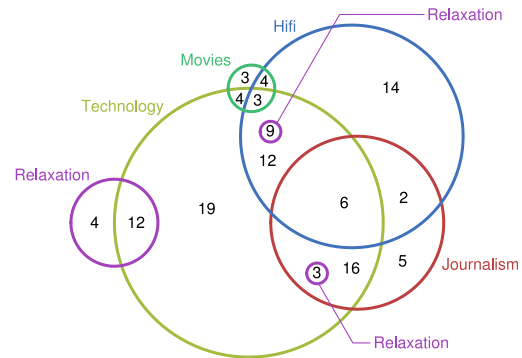


- LD-P&N

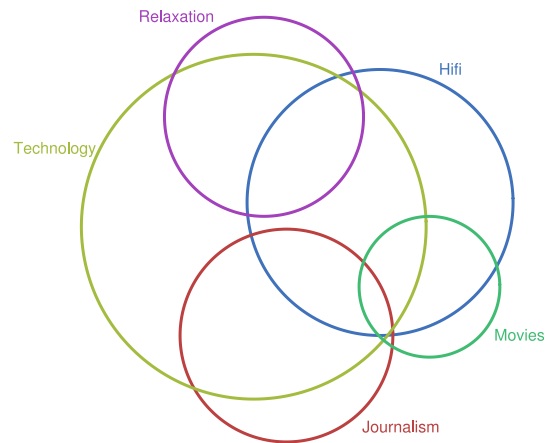


Question 15

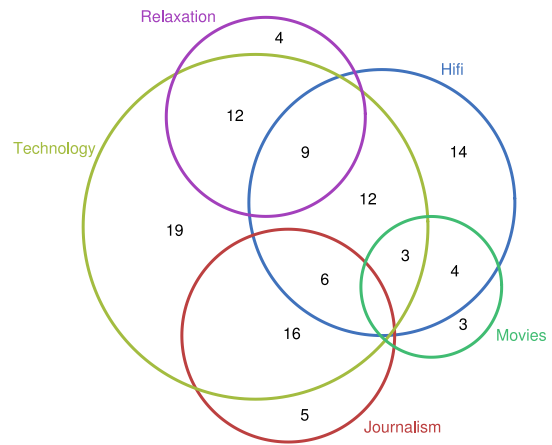
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Hifi, Movies and Technology only**.
- **Check boxes to be ticked:** Hifi, Journalism and Technology, Hifi and Journalism and Technology, Hifi and Relaxation and Technology
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 22863638
- ED-N



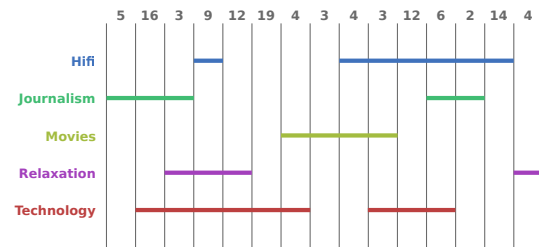
- ED-P



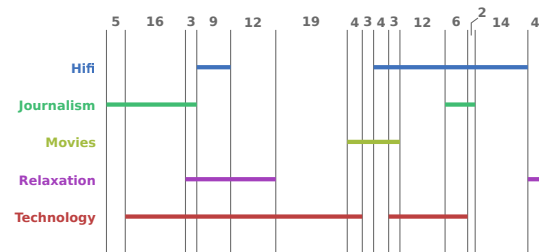
- ED-P&N



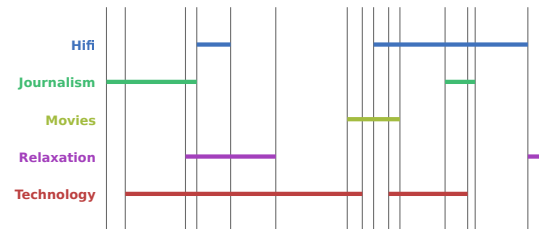
- LD-N



- LD-P

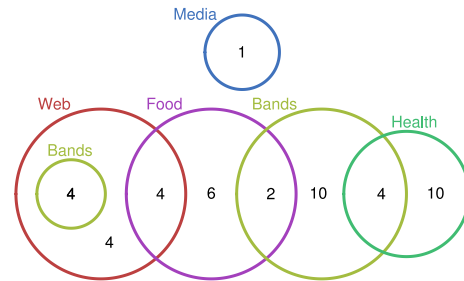


- LD-P&N

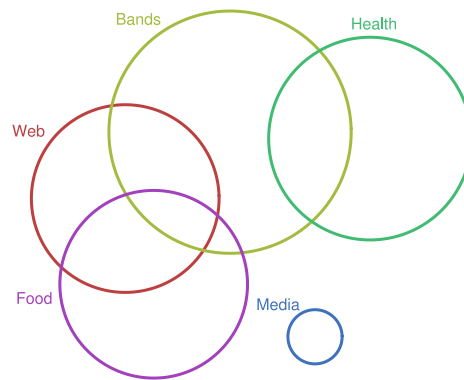


Question 16

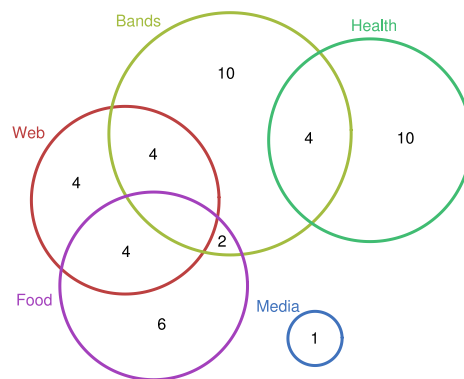
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Bands and Web only**.
- **Check boxes to be ticked:** Bands and Food
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 15864197
- ED-N



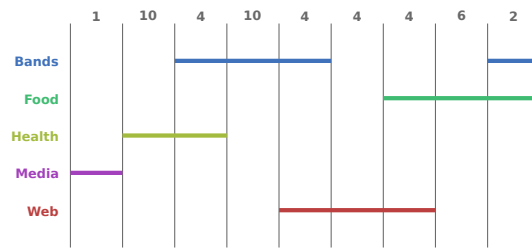
- ED-P



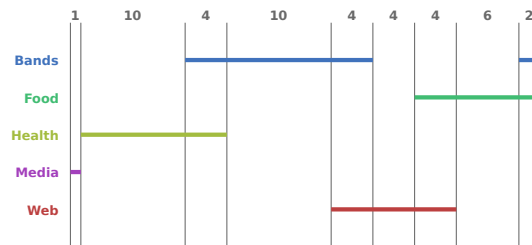
- ED-P&N



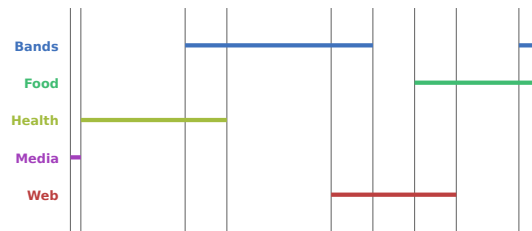
- LD-N



- LD-P

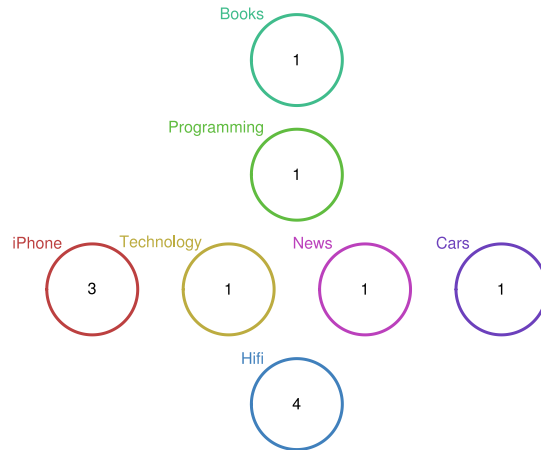


- LD-P&N

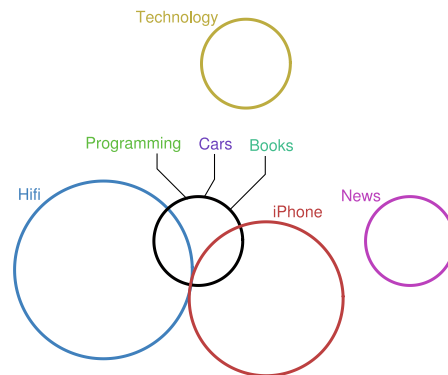


Question 17

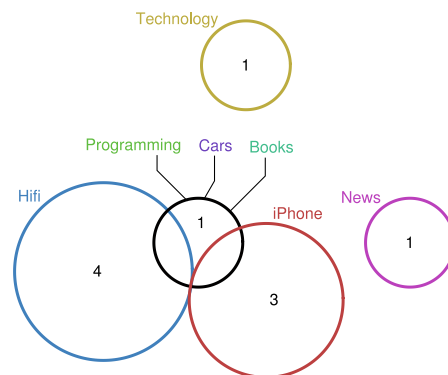
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Books**.
- **Check boxes to be ticked:** Hifi, iPhone
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 1046661
- ED-N



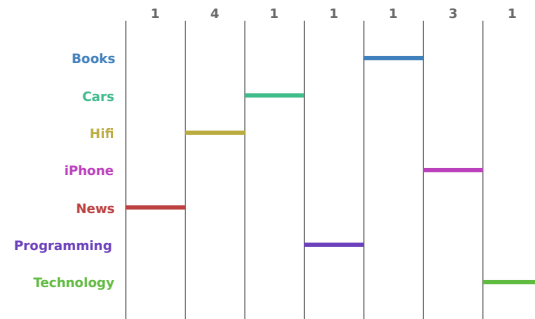
- ED-P



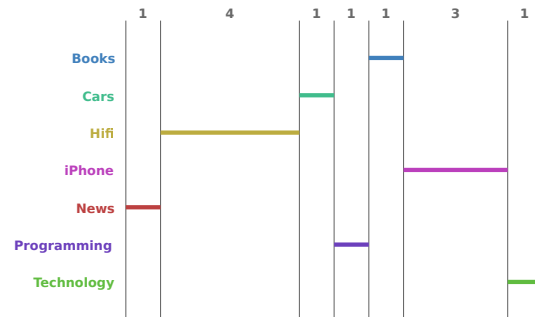
- ED-P&N



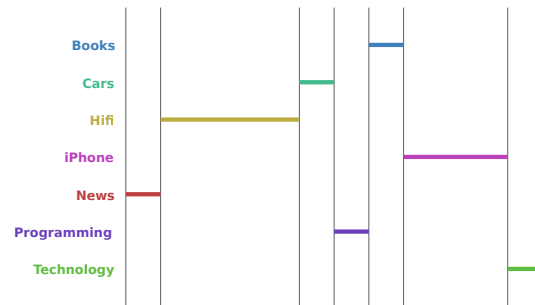
- LD-N



- LD-P

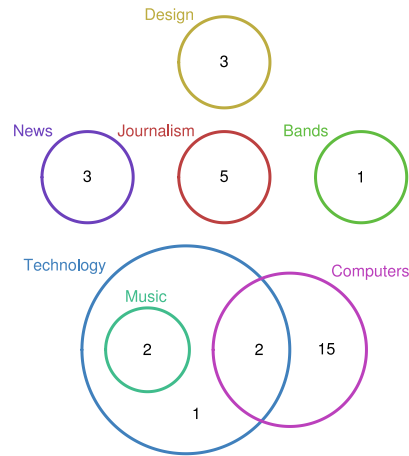


- LD-P&N

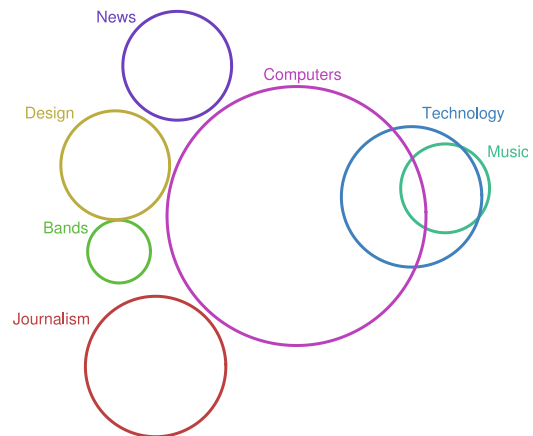


Question 18

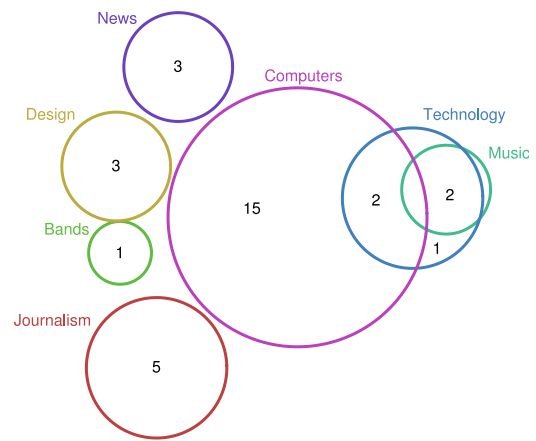
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Journalism**.
- **Check boxes to be ticked:** Bands, Design, Music, News
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 124296976
- ED-N



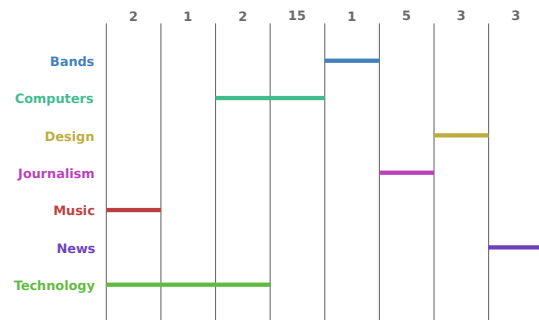
- ED-P



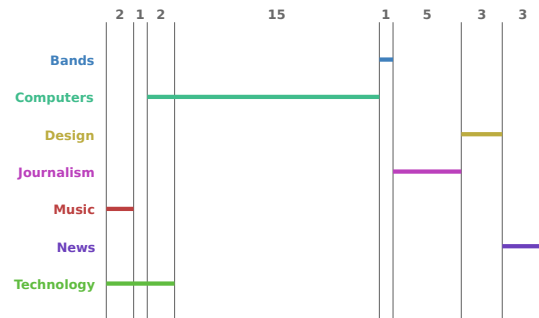
- ED-P&N



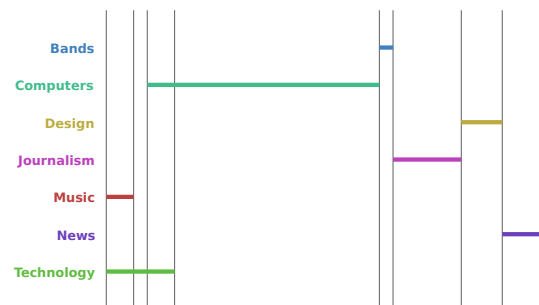
- LD-N



- LD-P

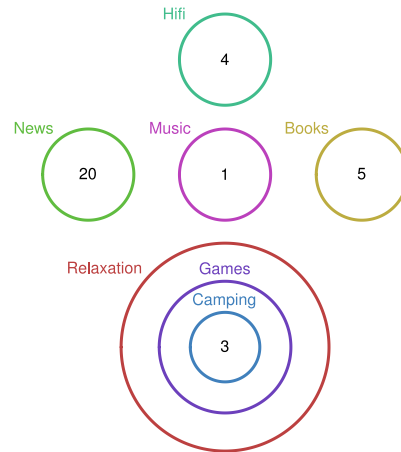


- LD-P&N

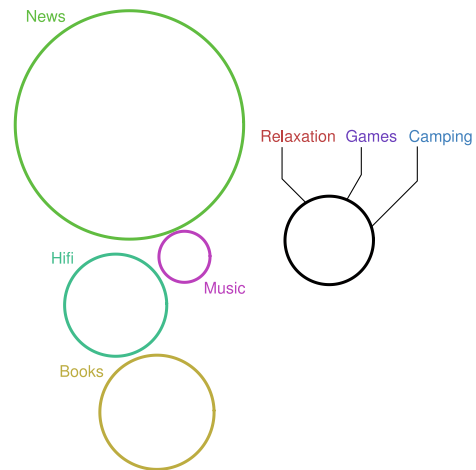


Question 19

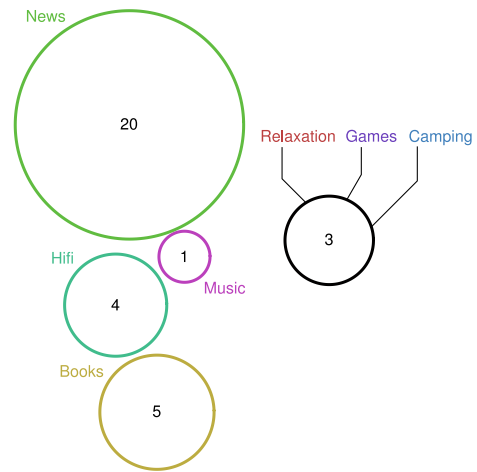
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Camping, Games and Relaxation only**.
- **Check boxes to be ticked:** News, Hifi, Books
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 13747362
- ED-N



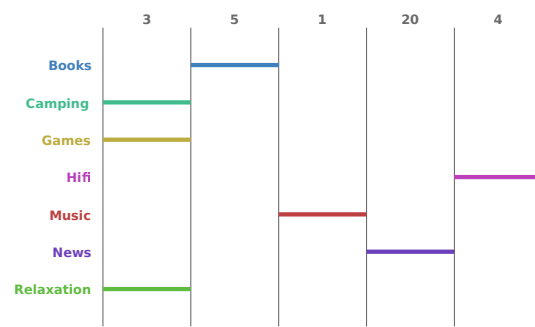
- ED-P



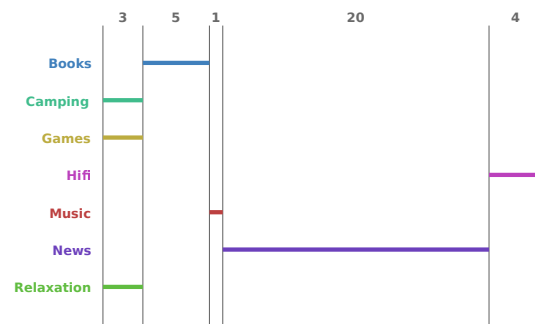
- ED-P&N



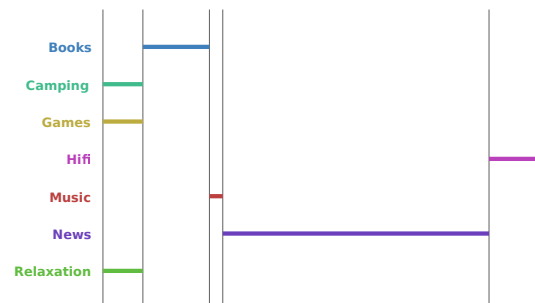
- LD-N



- LD-P

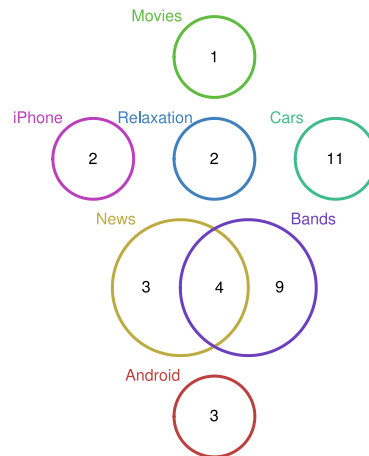


- LD-P&N

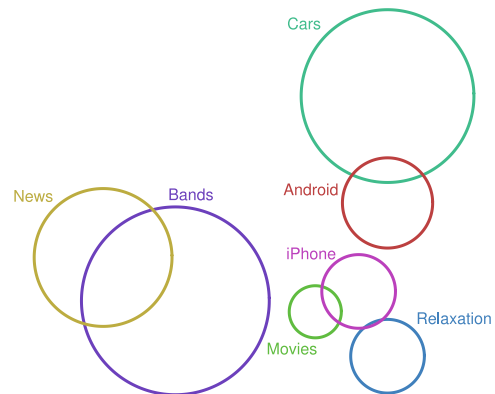


Question 20

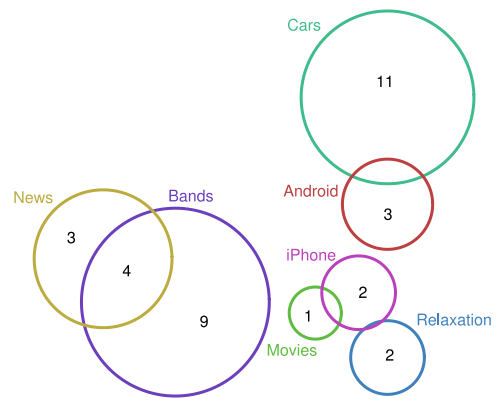
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **iPhone only**.
- **Check boxes to be ticked:** Movies
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 23790454
- ED-N



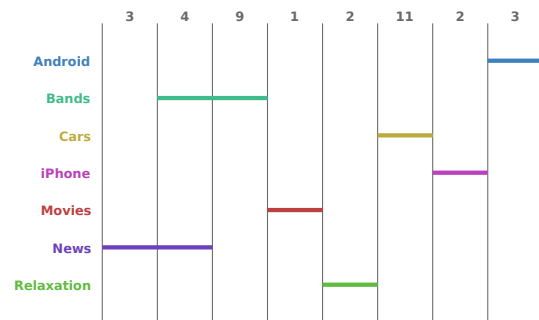
- ED-P



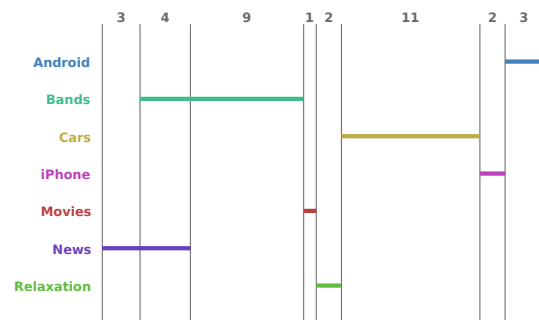
- ED-P&N



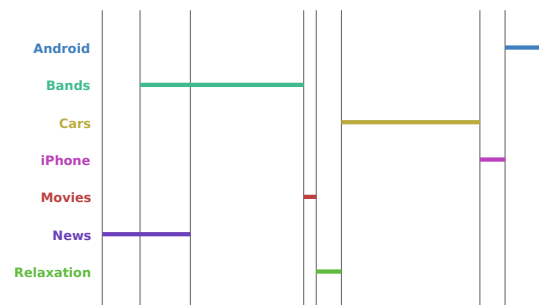
- LD-N



- LD-P

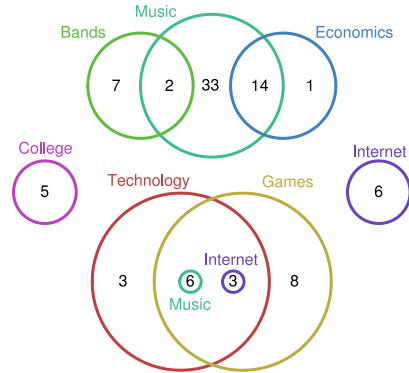


- LD-P&N

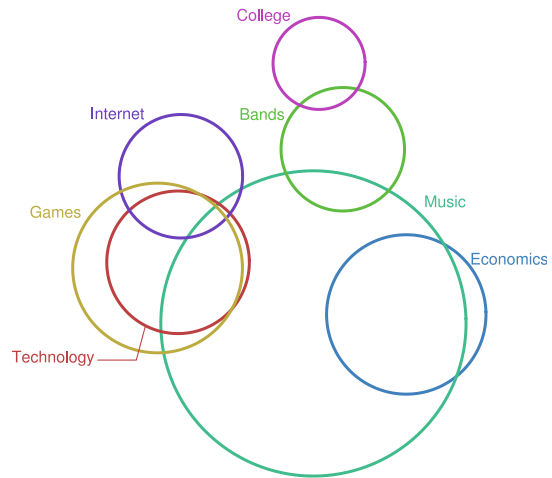


Question 21

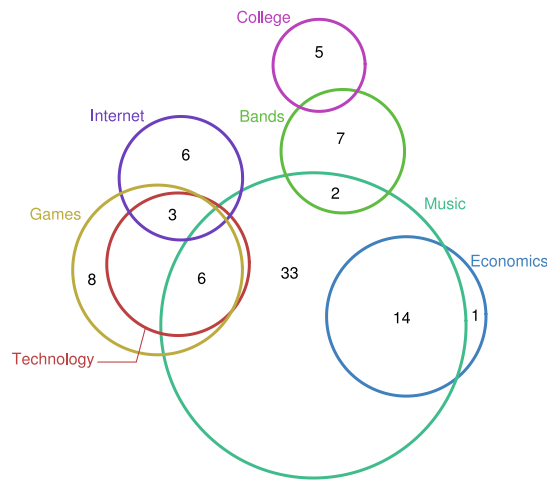
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Bands**.
- **Check boxes to be ticked:** Games, Music
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 13274152
- ED-N



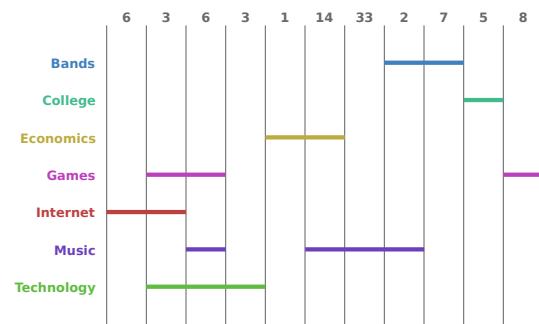
- ED-P



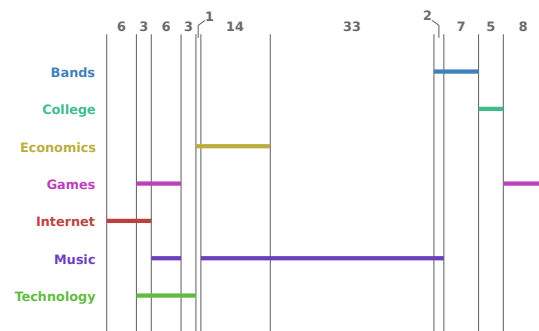
- ED-P&N



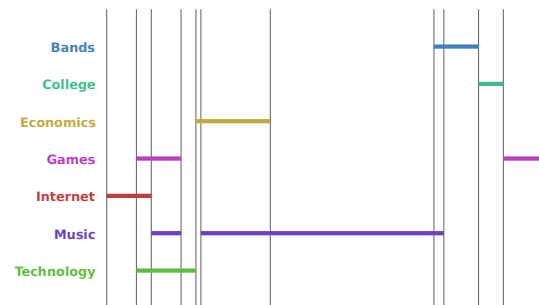
- LD-N



- LD-P

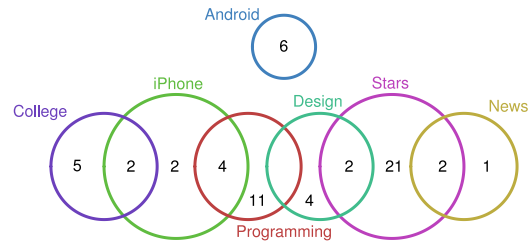


- LD-P&N

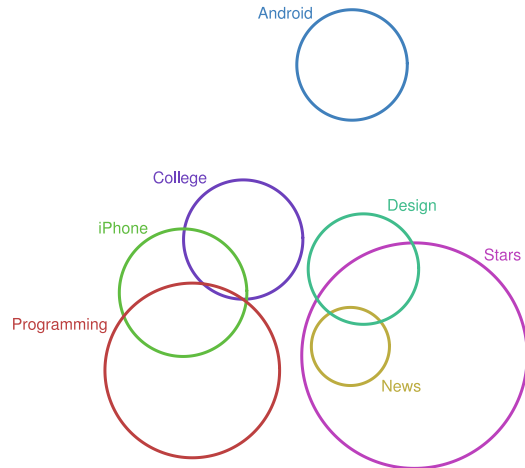


Question 22

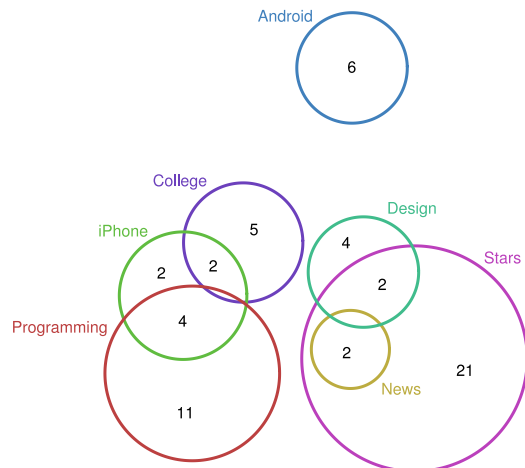
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Design**.
- **Check boxes to be ticked:** News
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 16834201
- ED-N



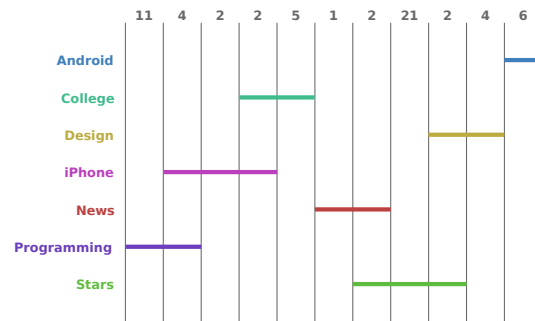
- ED-P



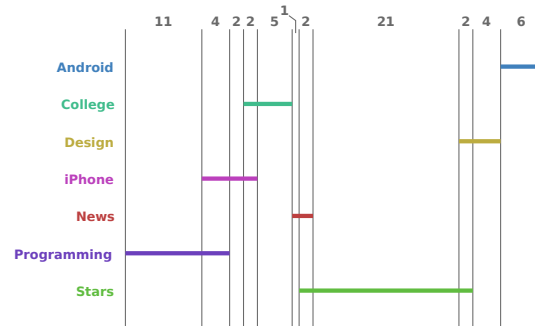
- ED-P&N



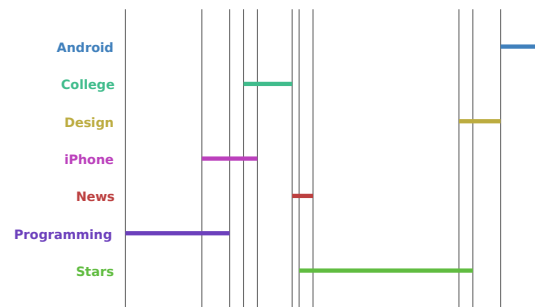
- LD-N



- LD-P

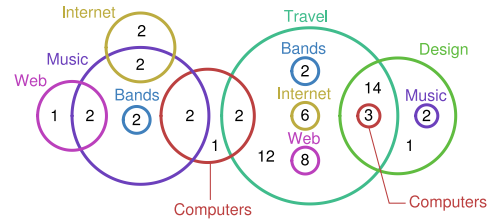


- LD-P&N

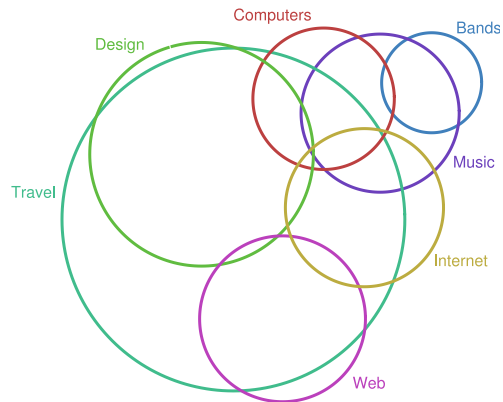


Question 23

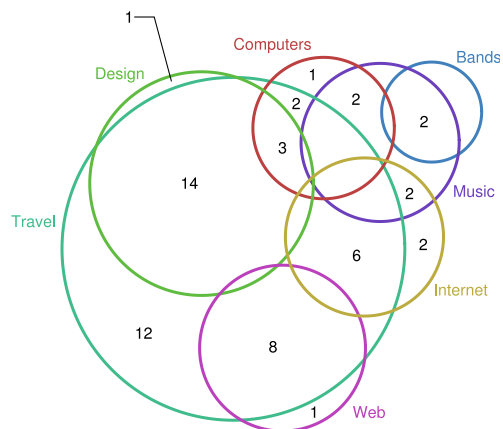
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Computers, Design and Travel only**.
- **Check boxes to be ticked:** Internet and Travel
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 29514951
- ED-N



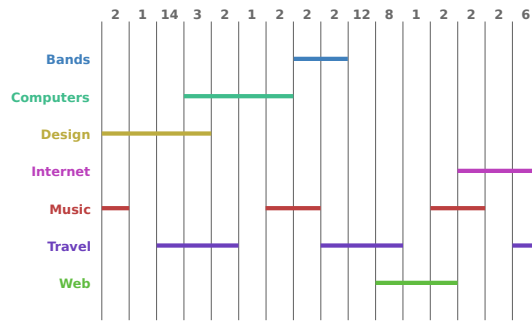
- ED-P



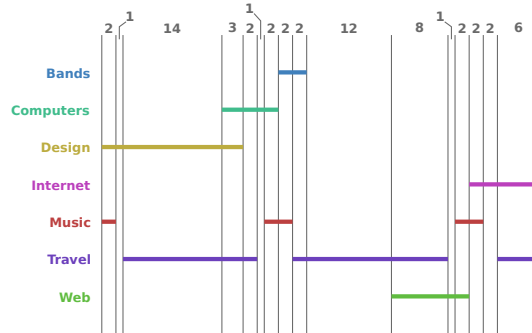
- ED-P&N



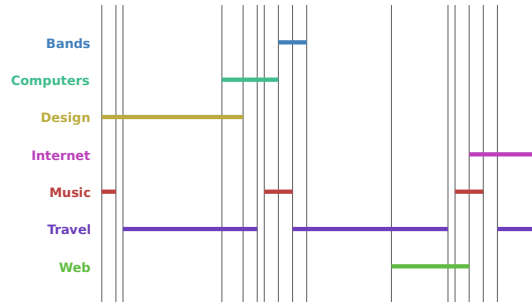
- LD-N



- LD-P

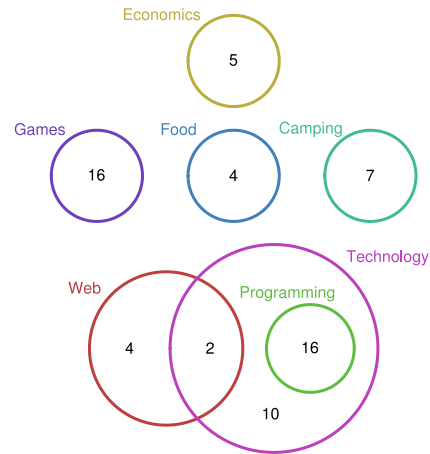


- LD-P&N

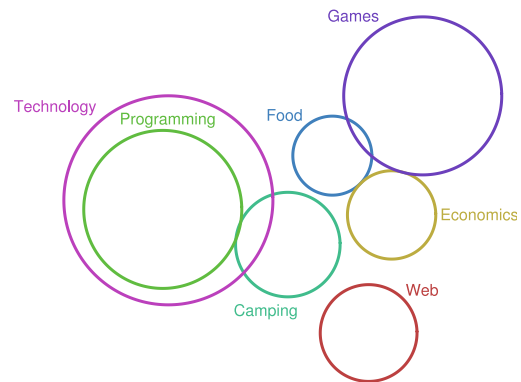


Question 24

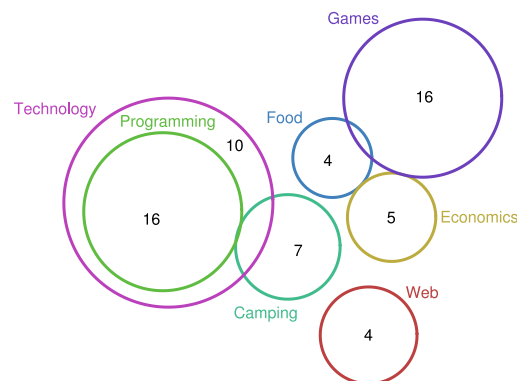
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Camping only**.
- **Check boxes to be ticked:** Camping, Food, Economics
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 17767841
- ED-N



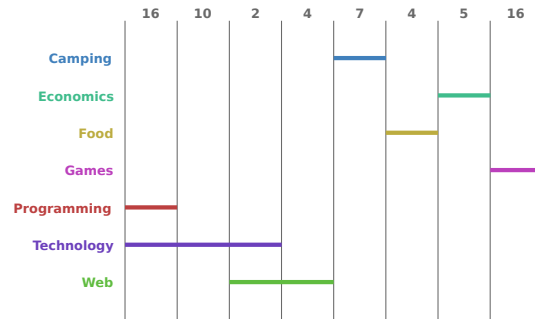
- ED-P



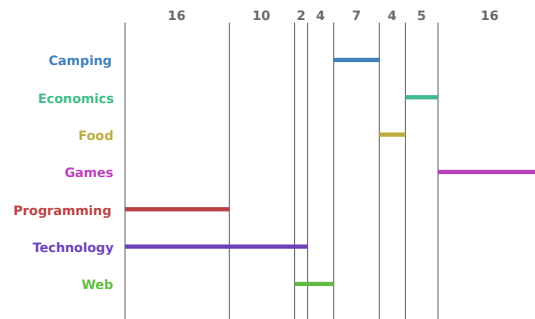
- ED-P&N



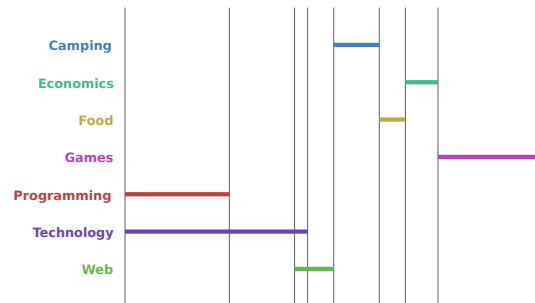
- LD-N



- LD-P

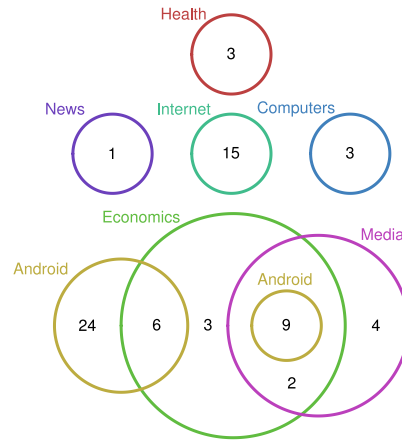


- LD-P&N

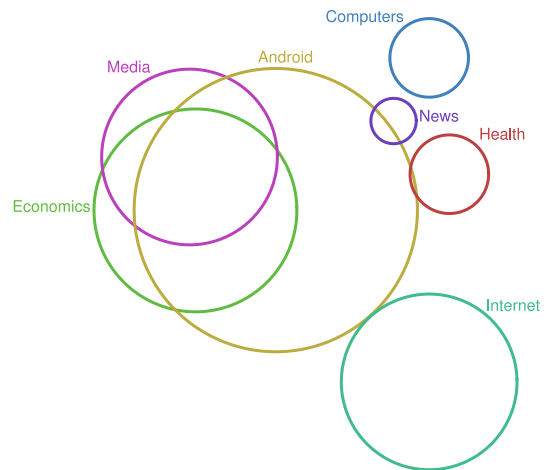


Question 25

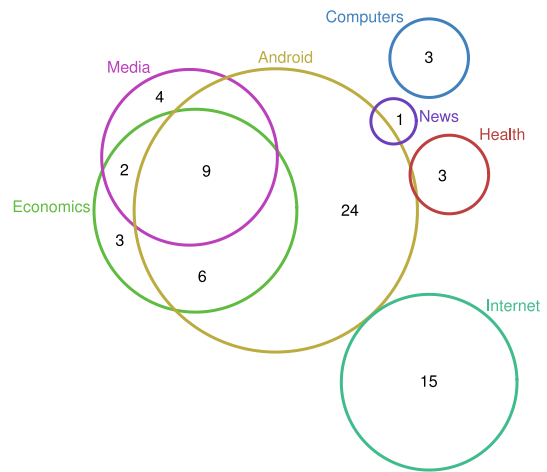
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Health**.
- **Check boxes to be ticked:** Economics, Internet, Media
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 22121627
- ED-N



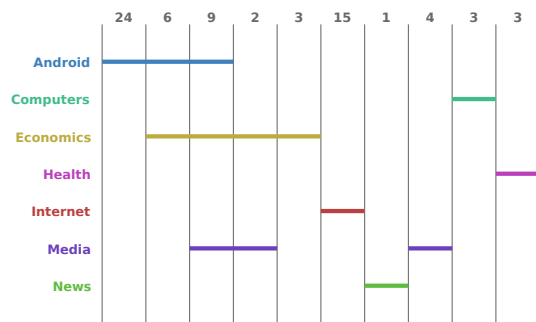
- ED-P



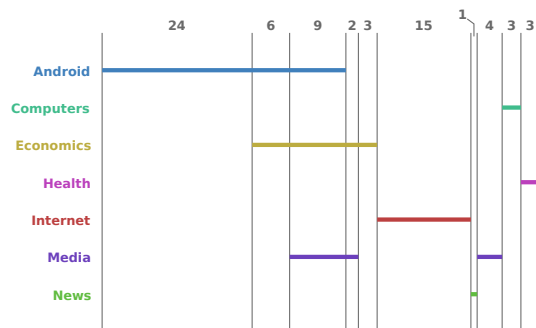
- ED-P&N



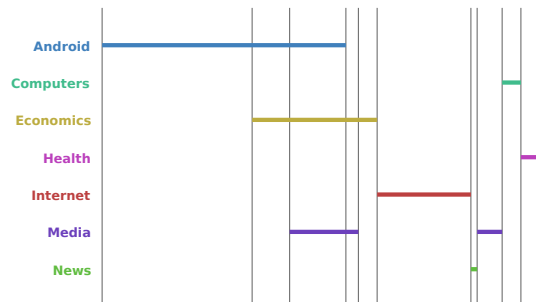
- LD-N



- LD-P

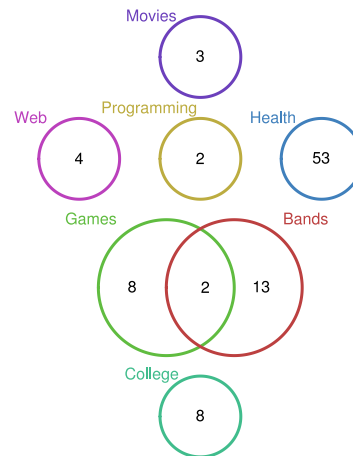


- LD-P&N

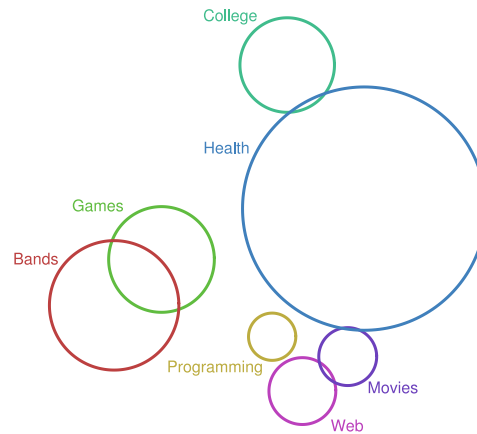


Question 26

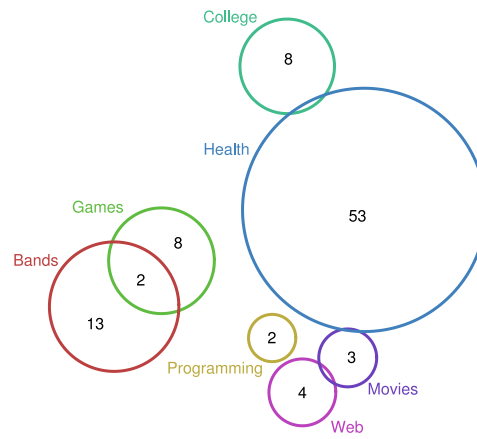
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Health**.
- **Check boxes to be ticked:** Bands, Games, Movies, Programming
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 2029971
- ED-N



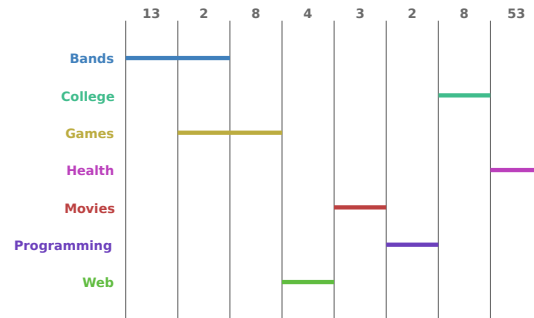
- ED-P



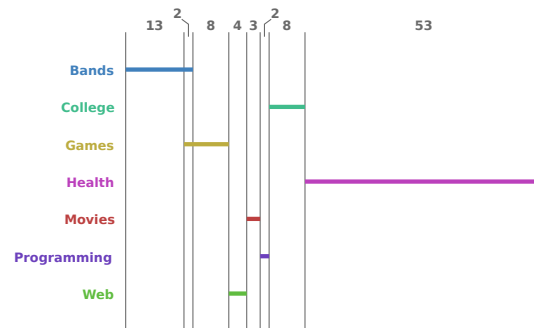
- ED-P&N



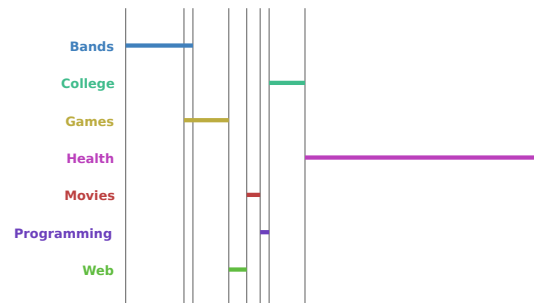
- LD-N



- LD-P

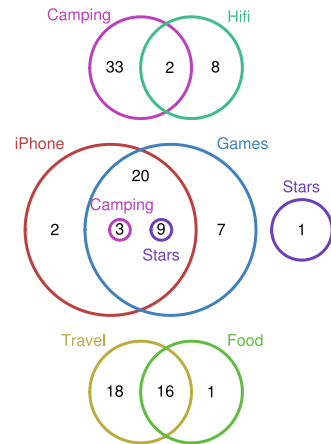


- LD-P&N

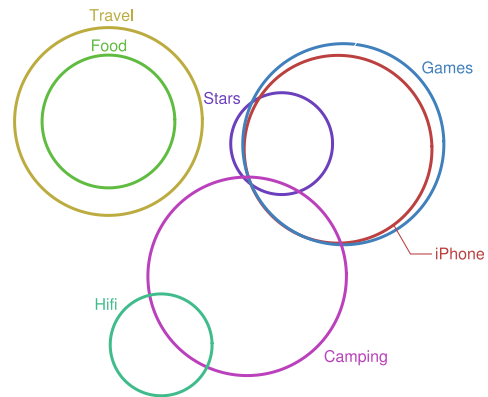


Question 27

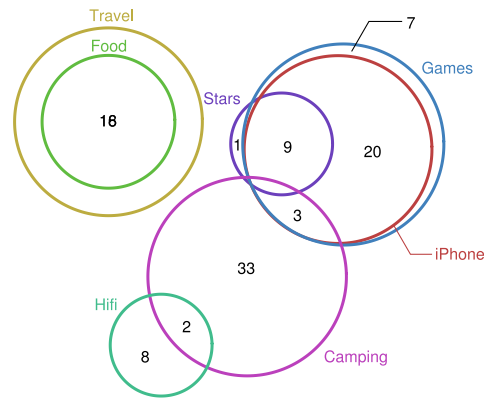
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Hifi only**.
- **Check boxes to be ticked:** Games and iPhone, Food and Travel
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 629863
- ED-N



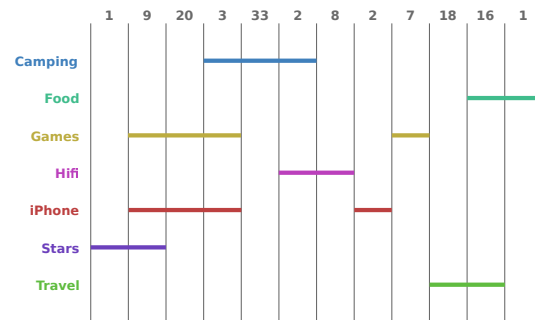
- ED-P



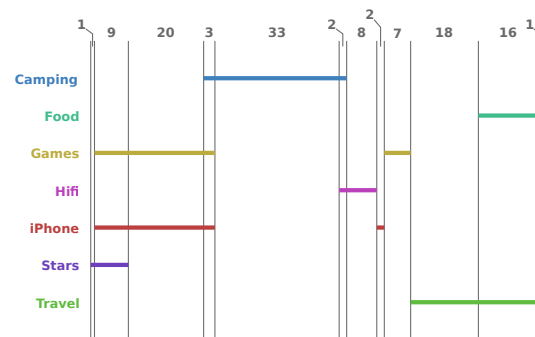
- ED-P&N



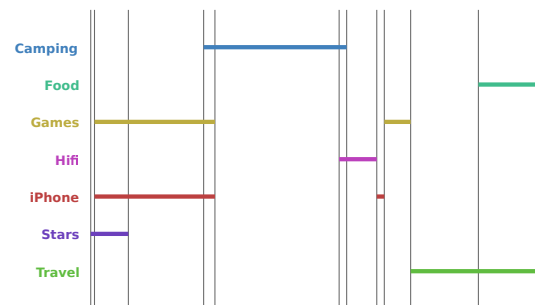
- LD-N



- LD-P

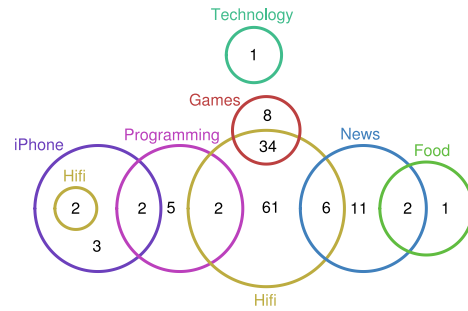


- LD-P&N

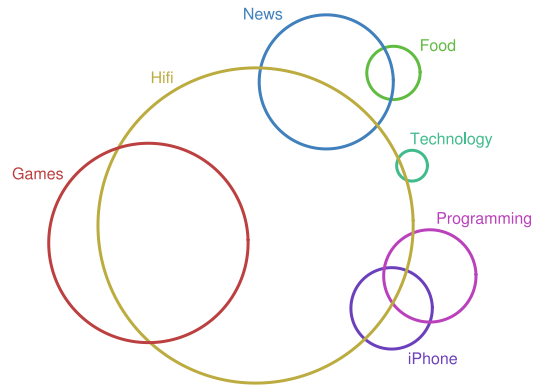


Question 28

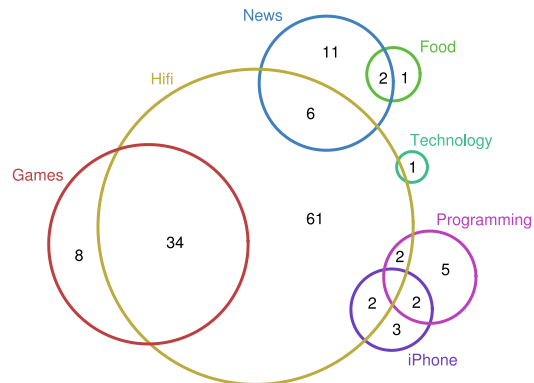
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Food only**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 30031265
- ED-N



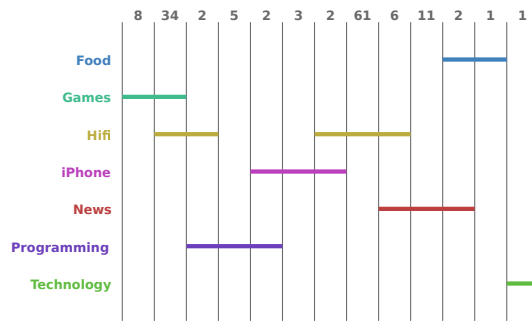
- ED-P



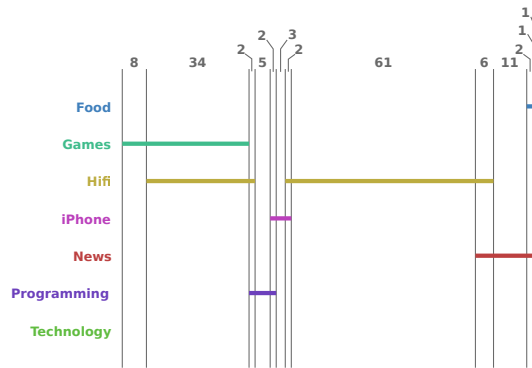
- ED-P&N



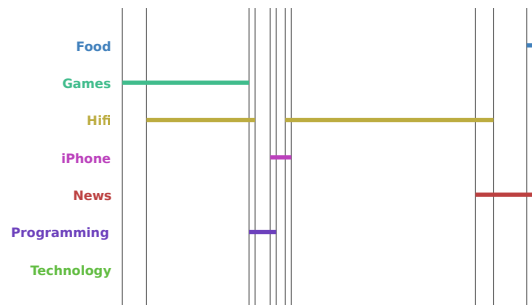
- LD-N



- LD-P

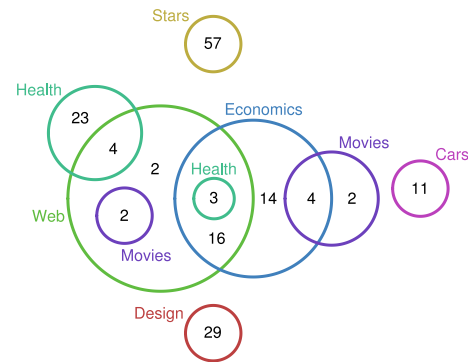


- LD-P&N

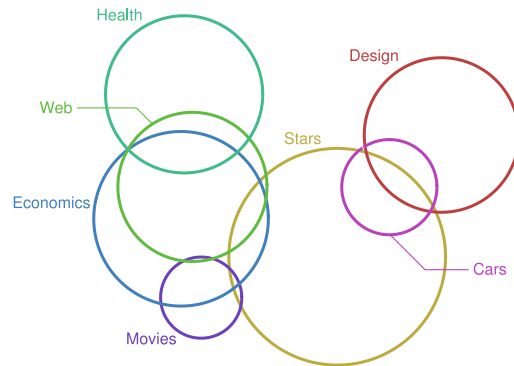


Question 29

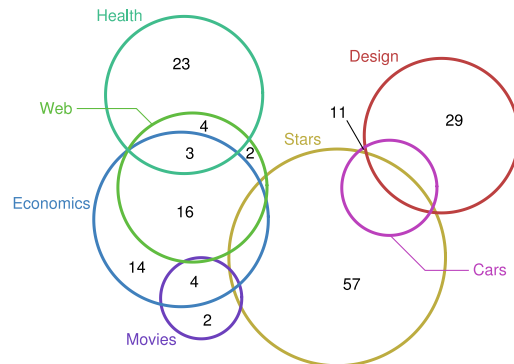
- **Question:** Tick the check boxes where the total number of people interested in that topic is **greater than** the total number of people interested in **Web**.
- **Check boxes to be ticked:** Design, Health, Stars
- **Task Type:** Set comparison - More than.
- **SNAP Data Set Used:** 20436059
- ED-N



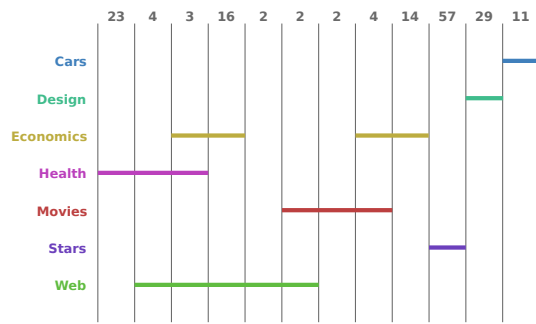
- ED-P



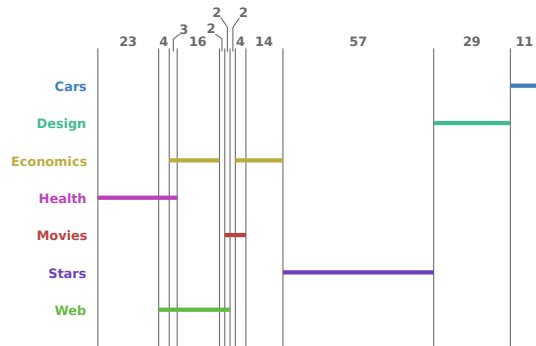
- ED-P&N



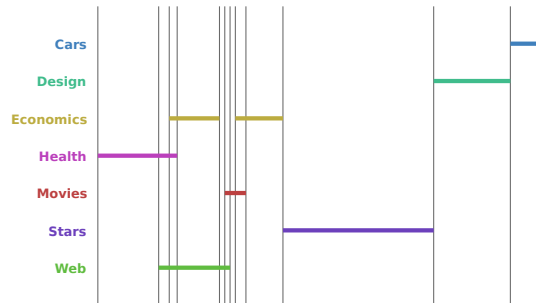
- LD-N



- LD-P

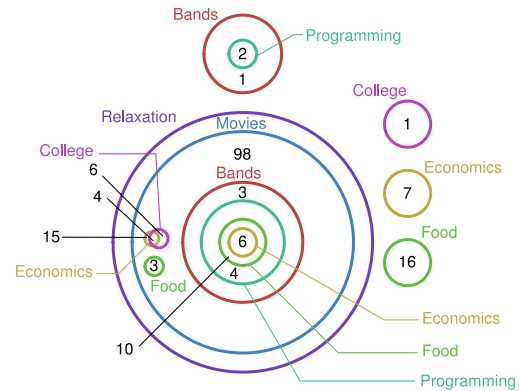


- LD-P&N

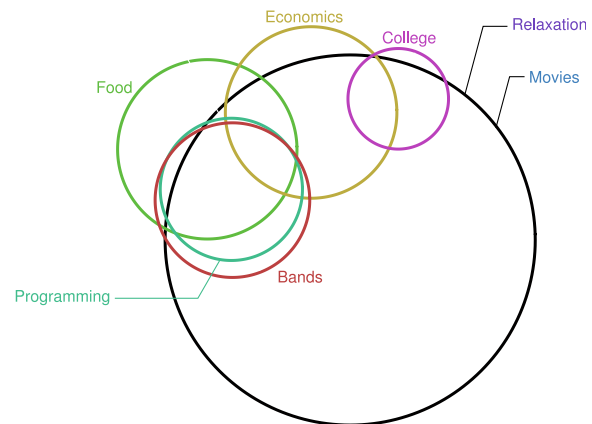


Question 30

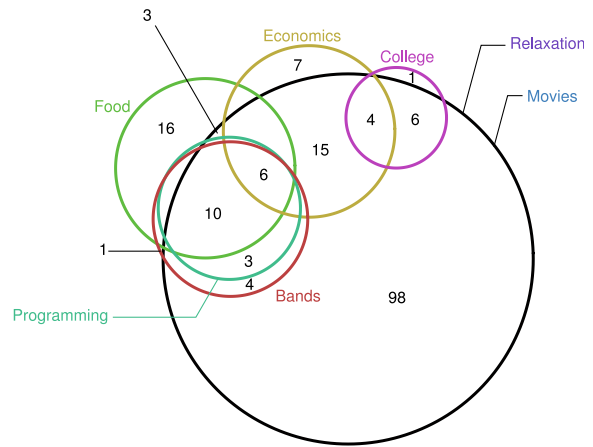
- **Question:** Tick the check boxes where the total number of people interested in that topic is **less than** the total number of people interested in **Economics**.
- **Check boxes to be ticked:** College, Programming
- **Task Type:** Set comparison - Less than.
- **SNAP Data Set Used:** 30207757
- ED-N



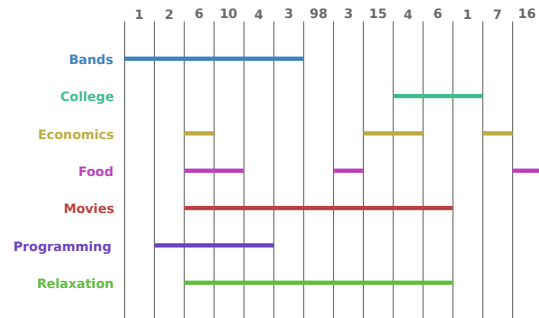
- ED-P



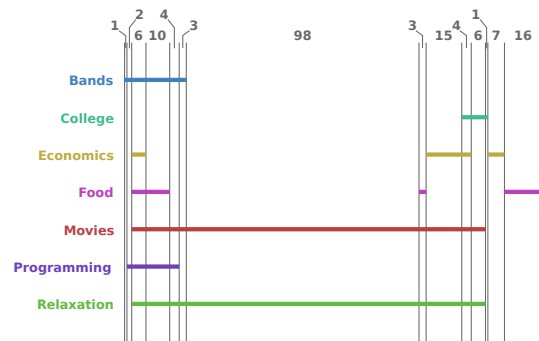
- ED-P&N



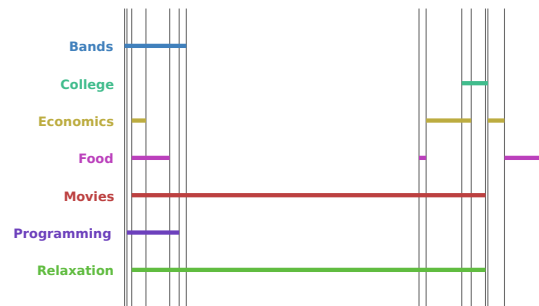
- LD-N



- LD-P

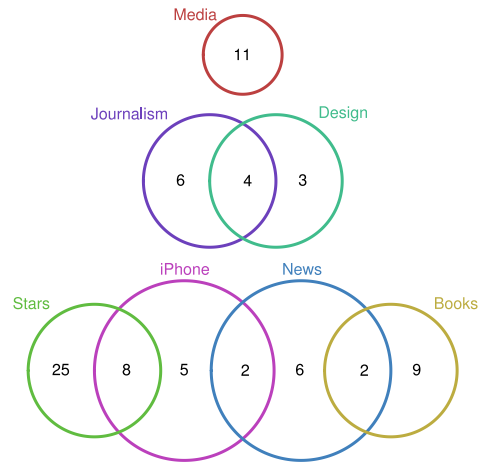


- LD-P&N

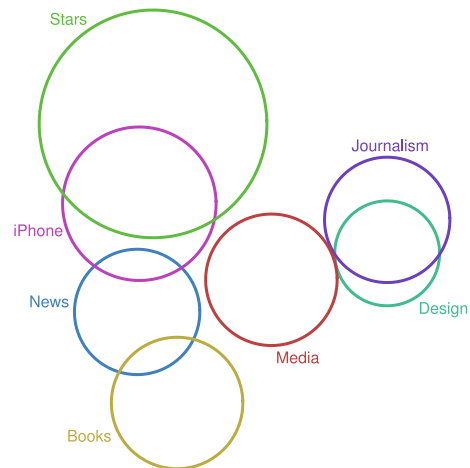


Question 31

- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Stars only**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Intersection comparison - More than.
- **SNAP Data Set Used:** 14060856
- ED-N



- ED-P

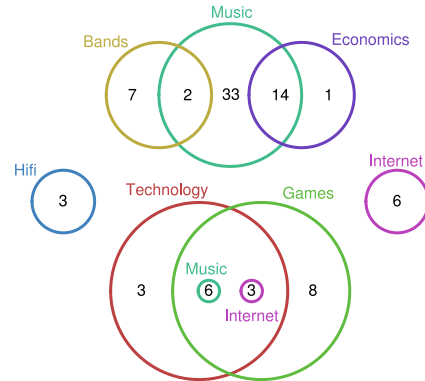


- ED-P&N

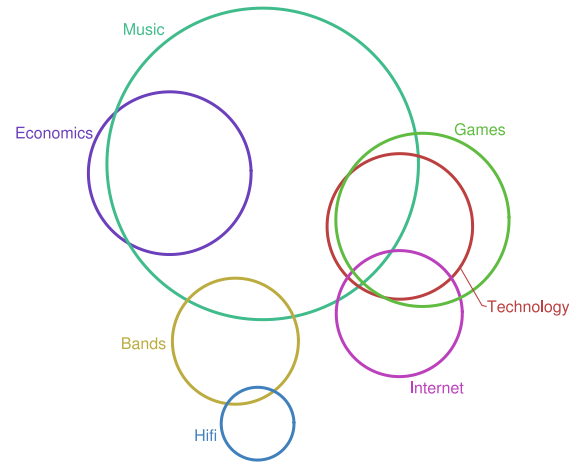


Question 32

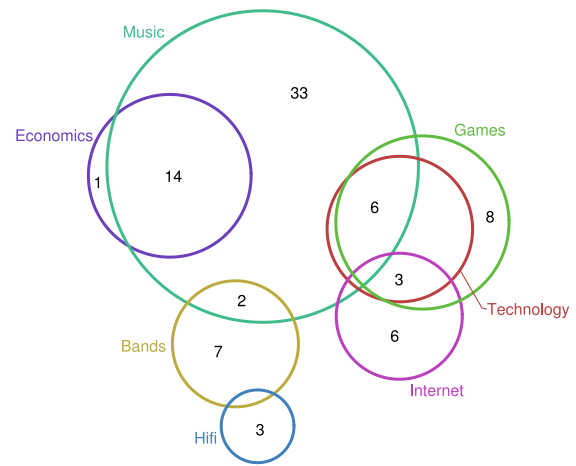
- **Question:** Tick the check boxes where **more people** have exactly that combination of interests than **Games, Internet and Technology only**.
- **Check boxes to be ticked:** None of the above
- **Task Type:** Intersection comparison - Less than.
- **SNAP Data Set Used:** 13274152
- ED-N



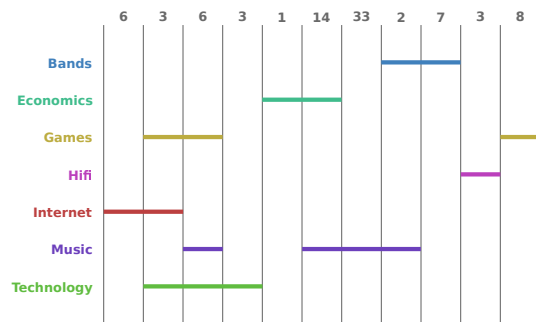
- ED-P



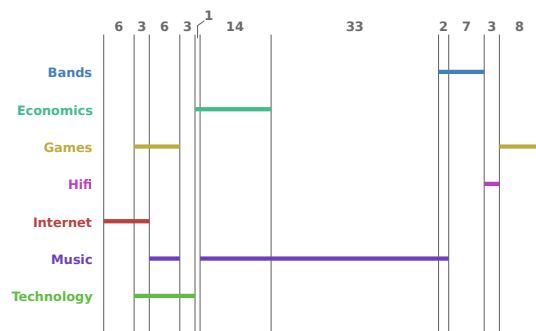
- ED-P&N



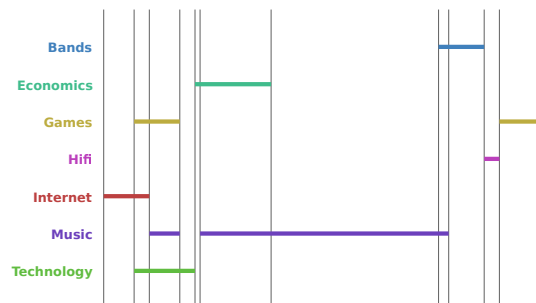
- LD-N



- LD-P



- LD-P&N



D - Statistical Methods

Here we present in detail the statistical models used for the first two studies, each of which included three treatment groups. The models used for the last study were simpler, as there were only two treatments.

For each of the three empirical studies, we employed two local odds ratios generalized estimating equations models [2] to analyse the accuracy data. An ANOVA calculation was not appropriate for these data as they violated the normality assumption of an ANOVA test. The non-parametric version of ANOVA, Kruskal-Wallis, was also not appropriate, as the responses for each individual are correlated, and thus not independent. The first model, for the first two studies, was employed to answer RQ1, RQ2 and RQ3, compared the visualization types overall irrespective of task category:

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2}$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for subject i to provide at most $j - 1$ correct answers to question k and where $j = 1, \dots, 5$ ¹.
- x_{ik1} is the indicator that the diagram given to subject i for answering question k was *proportional*, and
- x_{ik2} is the indicator that the diagram given to subject i for answering question k was *both proportional and numerical*

for $i = 1, \dots, n$, given n participants, and $k = 1, \dots, 32$. With this model, we could determine whether the odds of providing j or fewer correct answers for one of the visualization types (proportional, numerical, or both) was significantly different from others while taking into account the expected correlation among the responses provided by each individual participant.

The second model, for the first two studies, was employed to see whether the answers to RQ1, RQ2 and RQ3 still held when we take into account task category (set or intersection):

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2} + \beta_3 x_{ik3} + \beta_4 (x_{ik1} \times x_{ik3}) + \beta_5 (x_{ik2} \times x_{ik3})$$

where the variables are as above and, in addition, x_{ik3} is the indicator that the diagram given to subject i for answering question k was of type I . This model allowed us to estimate the odds of providing j or fewer correct answers with one combination of visualization type and task category compared to other combinations and determine whether significant differences existed.

For the time data, we used two generalized estimation models [1] that allowed us to estimate whether the time taken to provide answers was significantly different. Again we present details of the two models used for the first two studies. Following a similar approach for the accuracy data, the first of the two models directly addressed RQ1, RQ2 and RQ3 and the more complex model delved deeper into the data to see whether task category was important. The more complex model is given here, which

¹ j takes values from 1 to 5 since, for each question, there are 5 checkboxes which need to be correctly checked or not.

accounts for the different combinations of visualization type (proportional, numerical, or both) and task category (set or intersection):

$$\begin{aligned}\log(t_{ik}) = & \delta_0 + \delta_1 x_{ik1} + \delta_2 x_{ik2} + \delta_3 x_{ik3} + \\ & \delta_4(x_{ik1} \times x_{ik3}) + \delta_5(x_{ik2} \times x_{ik3})\end{aligned}$$

where

- t_{ik} is the time needed for subject i to answer question k , and
- x_{ik1} , x_{ik2} and x_{ik3} are defined in the previous model

for $i = 1, \dots, n$, given n participants, and $k = 1, \dots, 32$. This model allowed us to estimate the ratio of times of answering a question, given a pair of combinations of visualization type and task category. The simpler model excluded all terms involving x_{ik3} .

Statistical output is included in the submitted supplementary material. We report on the main findings in the associated paper.

E - Study A (ED) - Statistical Analysis

Here we present the statistical models used specifically for study 1 and the associated output.

Models

For the overall comparison, the following model was fitted to the accuracy data

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2}$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for participant i to provide at most $j - 1$ correct answers to question k and where $j = 1, 2, 3, 4, 5$.
- x_{ik1} is the indicator that the diagram given to participant i for answering question k was *ED-P*,
- x_{ik2} is the indicator that the diagram given to participant i for answering question k was *ED-P&N*

for $i = 1, \dots, 277$ and $j = 1, \dots, 32$.

For the overall comparison, the following model was fitted to the time data

$$\log(t_{ik}) = \delta_0 + \delta_1 x_{ik1} + \delta_2 x_{ik2}$$

where

- t_{ik} is the time needed for participant i to answer question k ,
- x_{ik1} and x_{ik2} are defined in the previous model

for $i = 1, \dots, 277$ and $k = 1, \dots, 32$.

For the set and intersection comparisons, following model was fitted to the accuracy data

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2} + \beta_3 x_{ik3} + \beta_4 (x_{ik1} \times x_{ik3}) + \beta_5 (x_{ik2} \times x_{ik3})$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for participant i to provide at most $j - 1$ correct answers to question k and where $j = 1, 2, 3, 4, 5$.
- x_{ik1} is the indicator that the diagram given to participant i for answering question k was *ED-P*,
- x_{ik2} is the indicator that the diagram given to participant i for answering question k was *ED-P&N*
- x_{ik3} is the indicator that the diagram given to participant i for answering question k was of type *I*

for $i = 1, \dots, 277$ and $j = 1, \dots, 32$.

For the set and intersection comparisons, the following model was fitted to the time data

$$\log(t_{ik}) = \delta_0 + \delta_1 x_{ik1} + \delta_2 x_{ik2} + \delta_3 x_{ik3} + \delta_4 (x_{ik1} \times x_{ik3}) + \delta_5 (x_{ik2} \times x_{ik3})$$

where

- t_{ik} is the time needed for participant i to answer question k ,
- x_{ik1} , x_{ik2} and x_{ik3} are defined in the previous model

for $i = 1, \dots, 277$ and $k = 1, \dots, 32$.

Overall results

The accuracy analysis:

```
# ED-P vs ED-N
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, 0))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.315777 1.058239 1.635991 0.013500
```

```
# ED-P&N vs ED-N
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 0, 1))
```

```
## Estimate    95% LB    95% UB    p-value
## 0.8866999 0.6888363 1.1413985 0.3506000
```

```
# ED-P vs ED-P&N
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, -1))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.483904 1.183448 1.860640 0.000600
```

The inference will be based on the model based estimated odds ratios (the value under Estimate). The results will be declared statistically significant only if the corresponding p -value is less than 0.05 and/or if the corresponding 95% confidence interval does not contain 1. The two middle columns correspond to the lower and the upper bound of the 95% confidence interval for the odds ratios. The interpretation of

the above analysis is the following: The estimated odds of having j or less correct answers with *ED-P* diagrams is 1.3158 times that with *ED-N* diagrams (p -value = 0.0135). The estimated odds of having j or less correct answers with *ED-P* diagrams is 1.4839 times that with *ED-P&N* diagrams (p -value = 0.0006). In other words, *ED-N* and *ED-P&N* diagrams are more likely to produce a higher ammount of correct answers than *ED-P* diagrams.

The fitted probabilities for j for each group are

```
X1 <- matrix(fitted(fitmodel)[c(1000,8000,3000),],3,6)
rownames(X1) <- dataset1$diagram[c(1000,8000,3000)]
colnames(X1) <- 0:5
X1

##           0           1           2           3           4
## ED-P      0.02431216 0.03763469 0.07304745 0.1789546 0.1394637
## ED-P&N    0.01651485 0.02609171 0.05255504 0.1405389 0.1228714
## ED-N      0.01858585 0.02920467 0.05824127 0.1520142 0.1286269
##           5
## ED-P      0.5465874
## ED-P&N    0.6414281
## ED-N      0.6133271
```

The time analysis:

```
# ED-P vs ED-N
ComparisonStats(fittimemodel,c(0, 1, 0))

## Estimate    95% LB    95% UB    p-value
## 0.7809330 0.7081761 0.8611648 0.0000000

# ED-P&N vs ED-N
ComparisonStats(fittimemodel,c(0, 0, 1))

## Estimate    95% LB    95% UB    p-value
## 0.9125743 0.8188579 1.0170163 0.0980000

# ED-P vs ED-P&N
ComparisonStats(fittimemodel,c(0, 1, -1))

## Estimate    95% LB    95% UB    p-value
## 0.8557473 0.7741852 0.9459021 0.0023000
```

The inference will be based on the model based estimated ratios (the value under Estimate). The results will be declared statistically significant only if the corresponding p -value is less than 0.05 and/or if the corresponding 95% confidence interval does not contain 1. The p -values and the 95% confidence intervals suggest that participants needed less time with *ED-P* diagrams than with *ED-P&N* or *ED-N* diagrams and that there is no significance difference between *ED-P&N* and *ED-N* diagrams.

Set cardinalities results

Accuracy comparisons:

```
# (ED-P and type S) vs (ED-N and type S)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, 0, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB      p-value
## 0.8069548 0.6083496 1.0703979 0.1367000
# (ED-P&N and type S) vs (ED-N and type S)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 0, 1, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB      p-value
## 0.5059211 0.3544472 0.7221277 0.0002000
# (ED-P and type S) vs (ED-P&N and type S)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1,-1, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB      p-value
## 1.595021 1.094169 2.325136 0.015200
```

The inference will be based on the model based estimated odds ratios (the value under Estimate). The results will be declared statistically significant only if the corresponding p -value is less than 0.05 and/or if the corresponding 95% confidence interval does not contain 1. The two middle columns correspond to the lower and the upper bound of the 95% confidence interval for the odds ratios. The interpretation of the above analysis is the following: For type S diagrams, the estimated odds of having j or less correct answers with $ED-P$ diagrams is 0.8070 times that with $ED-N$ diagrams (p -value = 0.1367). The estimated odds of having j or less correct answers with $ED-P$ diagrams is 1.5950 times that with $ED-P\&N$ diagrams (p -value = 0.0152). In other words, for type S , $ED-N$ and $ED-P\&N$ diagrams are more likely to produce a higher ammount of correct answers than $ED-P$ diagrams and there is no difference between $ED-N$ and $ED-P\&N$ diagrams.

Time comparisons:

```
# (ED-P and type S) vs (ED-N and type S)
ComparisonStats(fittimemodel,c(0, 1, 0, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB      p-value
## 0.6839369 0.6223542 0.7516133 0.0000000
```

```
# (ED-P&N and type S) vs (ED-N and type S)
ComparisonStats(fittimemodel,c(0, 0, 1, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB      p-value
## 0.8750651 0.7878886 0.9718872 0.0127000
```

```
# (ED-P and type S) vs (ED-P&N and type S)
ComparisonStats(fittimemodel,c(0, 1,-1, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB      p-value
## 0.7815840 0.7073398 0.8636211 0.0000000
```

The inference will be based on the model based estimated ratios (the value under Estimate). The results will be declared statistically significant only if the corresponding p -value is less than 0.05 and/or if the corresponding 95% confidence interval does not contain 1. For type I , the p -values and the 95% confidence intervals suggest that participants needed less time with $ED-P$ diagrams than with $ED-P\&N$ or $ED-N$ diagrams, and that participants needed less time with $ED-P\&N$ than $ED-N$ diagrams.

Intersection cardinalities results

Accuracy analysis:

```
# (ED-P and type I) vs (ED-N and type I)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, 0, 0, 1, 0))
```

```
## Estimate    95% LB    95% UB  p-value
## 1.862365 1.445066 2.400170 0.000000
```

```
# (ED-P&N and type I) vs (ED-N and type I)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 0, 1, 0, 0, 1))
```

```
## Estimate    95% LB    95% UB  p-value
## 1.266412 0.944948 1.697235 0.113900
```

```
# (ED-P and type I) vs (ED-P&N and type I)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1,-1, 0, 1,-1))
```

Time analysis:

```
# (ED-P and type I) vs (ED-N and type I)
ComparisonStats(fittimemodel,c(0, 1, 0, 0, 1, 0))
```

```
## Estimate    95% LB    95% UB  p-value
## 0.8916851 0.7972190 0.9973450 0.0448000
```

```
# (ED-P&N and type I) vs (ED-N and type I)
ComparisonStats(fittimemodel,c(0, 0, 1, 0, 0, 1))
```

```
## Estimate    95% LB    95% UB  p-value
## 0.9516914 0.8449521 1.0719146 0.4146000
```

```
# (ED-P and type I) vs (ED-P&N and type I)
ComparisonStats(fittimemodel,c(0, 1,-1, 0, 1,-1))
```

```
## Estimate    95% LB    95% UB  p-value
## 0.9369478 0.8377156 1.0479345 0.2542000
```

F - Study B (LD) - Statistical models and output

Here we present the statistical models used specifically for study 2 and the associated output.

Models

For the overall comparison, the following model was fitted to the accuracy data

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2}$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for participant i to provide at most $j - 1$ correct answers to question k and where $j = 1, 2, 3, 4, 5$.

- x_{ik1} is the indicator that the diagram given to participant i for answering question k was *LD-P*,
- x_{ik2} is the indicator that the diagram given to participant i for answering question k was *LD-P&N*

for $i = 1, \dots, 272$ and $k = 1, \dots, 32$.

For the overall comparison, the following model was fitted to the time data

$$\log(t_{ik}) = \delta_0 + \delta_1 x_{ik1} + \delta_2 x_{ik2}$$

where

- t_{ik} is the time needed for participant i to answer question k ,
- x_{ik1} and x_{ik2} are defined in the previous model

for $i = 1, \dots, 272$ and $k = 1, \dots, 32$.

For the set and intersection comparisons, the following model was fitted to the accuracy data

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2} + \beta_3 x_{ik3} + \beta_4 (x_{ik1} \times x_{ik3}) + \beta_5 (x_{ik2} \times x_{ik3})$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for participant i to provide at most $j - 1$ correct answers to question k and where $j = 1, 2, 3, 4, 5$.
- x_{ik1} is the indicator that the diagram given to participant i for answering question k was *LD-P*,
- x_{ik2} is the indicator that the diagram given to participant i for answering question k was *LD-P&N*
- x_{ik3} is the indicator that the diagram given to participant i for answering question k was of type *I*

for $i = 1, \dots, 272$ and $k = 1, \dots, 32$.

For the set and intersection comparisons, the following model was fitted to the time data

$$\log(t_{ik}) = \delta_0 + \delta_1 x_{ik1} + \delta_2 x_{ik2} + \delta_3 x_{ik3} + \delta_4 (x_{ik1} \times x_{ik3}) + \delta_5 (x_{ik2} \times x_{ik3})$$

where

- t_{ik} is the time needed for participant i to answer question k ,
- x_{ik1} , x_{ik2} and x_{ik3} are defined in the previous model

for $i = 1, \dots, 272$ and $k = 1, \dots, 32$.

Overall results

Accuracy analysis:

```
# LD-P vs LD-N
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, 0))

## Estimate      95% LB      95% UB    p-value
## 1.1348457 0.9399509 1.3701512 0.1882000
```

```
# LD-P&N vs LD-N
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 0, 1))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.1018091 0.8897432 1.3644198 0.3741000
```

```
# LD-P vs LD-P&N
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, -1))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.0299840 0.8456953 1.2544318 0.7690000
```

There is no difference between the three types of diagrams.

Time analysis:

```
# LD-P vs LD-N
ComparisonStats(fittimemodel,c(0, 1, 0))
```

```
## Estimate    95% LB    95% UB    p-value
## 0.8134194 0.7435824 0.8898155 0.0000000
```

```
# LD-P&N vs LD-N
ComparisonStats(fittimemodel,c(0, 0, 1))
```

```
## Estimate    95% LB    95% UB    p-value
## 0.9797777 0.8980481 1.0689453 0.6457000
```

```
# LD-P vs LD-P&N
ComparisonStats(fittimemodel,c(0, 1, -1))
```

```
## Estimate    95% LB    95% UB    p-value
## 0.8302082 0.7636182 0.9026049 0.0000000
```

Participants needed less time with *LD-P* diagrams than with *LD-P&N* or *LD-N* diagrams and that there is no significance difference between *LD-P&N* and *LD-N* diagrams.

Set cardinalities results

Accuracy analysis:

```
# (LD-P and type S) vs (LD-N and type S)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, 0, 0, 0, 0))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.0263526 0.7901575 1.3331515 0.8454000
```

```
# (LD-P&N and type S) vs (LD-N and type S)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 0, 1, 0, 0, 0))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.2253349 0.9403471 1.5966931 0.1324000
```

```
# (LD-P and type S) vs (LD-P&N and type S)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1,-1, 0, 0, 0))
```

```
## Estimate    95% LB    95% UB    p-value
```

```
## 0.8376098 0.6365894 1.1021079 0.2057000
```

For type *S*, there is no difference among the three types of diagrams.

Time analysis:

```
# (LD-P and type S) vs (LD-N and type S)
ComparisonStats(fittimemodel,c(0, 1, 0, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB    p-value
## 0.7846409 0.7208330 0.8540971 0.0000000
```

```
# (LD-P&N and type S) vs (LD-N and type S)
ComparisonStats(fittimemodel,c(0, 0, 1, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB    p-value
## 0.9970524 0.9150658 1.0863846 0.9462000
```

```
# (LD-P and type S) vs (LD-P&N and type S)
ComparisonStats(fittimemodel,c(0, 1,-1, 0, 0, 0))
```

```
## Estimate      95% LB      95% UB    p-value
## 0.7869606 0.7257799 0.8532986 0.0000000
```

For type *S*, participants needed less time with *LD-P* diagrams than with *LD-P&N* or *LD-N* and there is no significance difference between *LD-P&N* and *LD-N* diagrams.

Intersection cardinalities results

Accuracy analysis:

```
# (LD-P and type I) vs (LD-N and type I)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1, 0, 0, 1, 0))
```

```
## Estimate      95% LB      95% UB    p-value
## 1.2038819 0.9449141 1.5338235 0.1332000
```

```
# (LD-P&N and type I) vs (LD-N and type I)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 0, 1, 0, 0, 1))
```

```
## Estimate      95% LB      95% UB    p-value
## 1.0341693 0.7835026 1.3650321 0.8125000
```

```
# (LD-P and type I) vs (LD-P&N and type I)
ComparisonStats(fitmodel,c(0, 0, 0, 0, 0, 1,-1, 0, 1,-1))
```

```
## Estimate      95% LB      95% UB    p-value
## 1.1641052 0.9025326 1.5014869 0.2419000
```

Time analysis:

```
# (LD-P and type Z) vs (LD-N and type Z)
ComparisonStats(fittimemodel,c(0, 1, 0, 0, 1, 0))
```

```
## Estimate      95% LB      95% UB    p-value
## 0.8432534 0.7600814 0.9355265 0.0013000
```

```
# (LD-P&N and type Z) vs (LD-N and type Z)
ComparisonStats(fittimemodel,c(0, 0, 1, 0, 0, 1))
```



```
## Estimate      95% LB      95% UB      p-value
## 0.9628023 0.8730566 1.0617733 0.4477000
```

```
# (LD-P and type Z) vs (LD-P&N and type Z)
ComparisonStats(fittimemodel,c(0, 1,-1, 0, 1,-1))
```

```
## Estimate      95% LB      95% UB      p-value
## 0.8758324 0.7958562 0.9638455 0.0067000
```

G - Study C (ED vs LD) - Statistical models and output

Here we present the statistical models used specifically for study 3 and the associated output.

Models

For the overall comparison, the following regression model was fitted to the accuracy data

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1}$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for participant i to provide at most $j - 1$ correct answers to question k and where $j = 1, 2, 3, 4, 5$.
- x_{ik1} is the indicator that an *ED-P&N* diagram was given to participant i for answering question k ,

for $i = 1, \dots, 185$ and $k = 1, \dots, 32$.

For the overall comparison, the following regression model was fitted to the time data

$$\log(t_{ik}) = \delta_0 + \delta_1 x_{ik1}$$

where

- t_{ik} is the time needed for participant i to answer question t ,
- x_{ik1} is defined as in the model for the accuracy data

for $i = 1, \dots, 185$ and $k = 1, \dots, 32$.

For the set and intersection comparisons, the following regression model was fitted to the accuracy data

$$\log \left[\frac{\Pr(Y_{ik} \leq j)}{1 - \Pr(Y_{ik} \leq j)} \right] = \beta_{0j} + \beta_1 x_{ik1} + \beta_2 x_{ik2} + \beta_3 (x_{ik1} \times x_{ik2})$$

where

- $\Pr(Y_{ik} \leq j)$ is the probability for participant i to provide at most $j - 1$ correct answers to question k and where $j = 1, 2, 3, 4, 5$.
- x_{ik1} is the indicator that an *ED-P&N* diagram was given to participant i for answering question k ,
- x_{ik2} is the indicator that the k -th question given to participant i was type I

for $i = 1, \dots, 185$ and $k = 1, \dots, 32$.

For the set and intersection comparisons, the following regression model was fitted to the time data

$$\log(t_{ik}) = \delta_0 + \delta_1 x_{ik1} + \delta_2 x_{ik2} + \delta_3 (x_{ik1} \times x_{ik2})$$

where

- t_{ik} is the time needed for participant i to answer question k ,
- x_{ik1} and x_{ik2} are defined as in the model for the accuracy data

for $i = 1, \dots, 185$ and $k = 1, \dots, 32$.

Overall results

Accuracy analysis:

```
# (ED-P&N) vs (LD-P)
ComparisonStats(fitmodel, c(0, 0, 0, 0, 0, 1))

## Estimate    95% LB    95% UB    p-value
## 0.7814704 0.6249702 0.9771602 0.0306000
```

The *ED-P&N* diagrams are better than *LD-P* when the questions type is ignored.

Time analysis:

```
# (ED-P&N) vs (LD-P)
ComparisonStats(fittimemodel, c(0, 1))

## Estimate    95% LB    95% UB    p-value
## 1.159591 1.037295 1.296306 0.009200
```

The time needed with a *ED-P&N* diagram is 1.15 times that needed with a *LD-P* diagram when the question type was ignored.

Set cardinalities results

Accuracy analysis:

```
# (ED-P&N and typeS) vs (LD-P and typeS)
ComparisonStats(fitmodel, c(0, 0, 0, 0, 0, 1, 0, 0))

## Estimate    95% LB    95% UB    p-value
## 0.9628247 0.6884480 1.3465527 0.8248000
```

There is no difference between *ED-P&N* and *LD-P* diagrams with for questions of type *S*.

Time analysis:

```
# (ED-P&N and typeS) vs (LD-P and typeS)
ComparisonStats(fittimemodel, c(0, 1, 0, 0))

## Estimate    95% LB    95% UB    p-value
## 1.255564 1.130982 1.393870 0.000000
```

To answer questions of type *S*, the time needed with a *ED-P&N* diagram is 1.26 times that needed with a *LD-P* diagram.

Intersection cardinalities results

Accuracy analysis:

```
# (ED-P&N and typeI) vs (LD-P and typeI)
ComparisonStats(fitmodel, c(0, 0, 0, 0, 0, 1, 0, 1))
```

```
## Estimate    95% LB    95% UB    p-value
## 0.6571699 0.5113266 0.8446114 0.0010000
```

For questions of type *I*, *ED-P&N* diagrams are more likely to increase the number of correct answers when compared to *LD-P* diagrams.

Time analysis:

```
# (ED-P&N and typeI) vs (LD-P and typeI)
ComparisonStats(fittimemodel, c(0, 1, 0, 1))
```

```
## Estimate    95% LB    95% UB    p-value
## 1.0709541 0.9448343 1.2139088 0.2836000
```

References

1. K. Y. Liang and S. L. Zeger. Longitudinal data analysis using generalized linear models. *Biometrika*, 73:13–22, 1986.
2. A. Touloumis, A. Agresti, and M. Kateri. Generalized estimating equations for multinomial responses using a local odds ratios parameterization. *Biometrics*, 69(3):633–640, 2013.