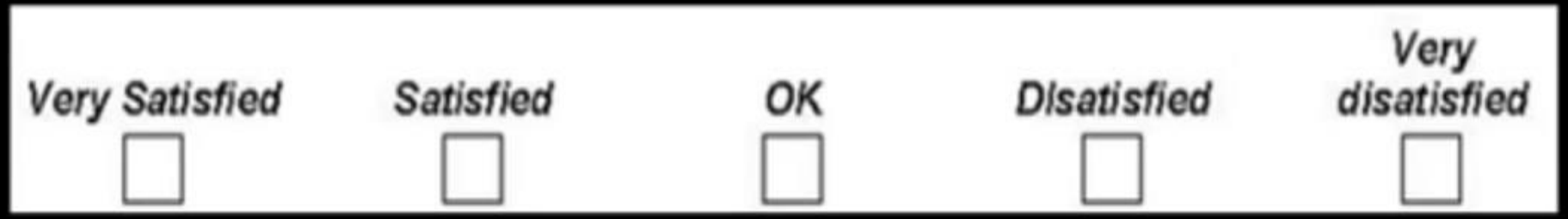
# Ordinal Logistic Regression

# Ordinal Logistic Regression

- ✓ What is ordinal logistic regression?
- ✓ Where do we need to apply ordinal logistic regression?
- ✓ How it is solved / worked?
- ✓ How does it predict the outcome?

## What is Ordinal logistic regression?

- General logistic Regression - Two possible outcome like
  - ✓ Responder / Non responder
  - ✓ Buyer / non buyer
- At times, the dependent variable is ordinal variable.
- Like, if we conduct a survey after presentation, say on predictive machine learning, the audience can respond like




- Here there is order in dependent variable. They are not nominal variables.
- A logistic regression model trying to use independent variables to predict, what is the likely response of each individual in the survey is ordinal logistic regression.
- in some sense the situation is intermediate between regression and classification

# Another examples of ordinal logistic regression

- What do you think about state spending on health programs
  - ✓ Poor
  - ✓ Average
  - ✓ Good
- Level of insurance coverage
  - ✓ None
  - ✓ Partial
  - ✓ Full
- Employment status
  - ✓ Unemployed
  - ✓ Employed part-time
  - ✓ Fully employed

## Other names of ordinal logistic regression

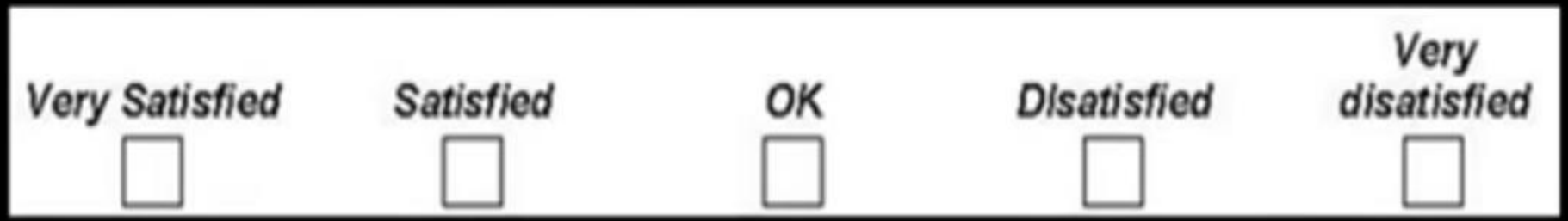
- Ordinal regression
- Ordered logit model
- Ordered probit model (very similar to ordered logit – The main difference is in the interpretation of the coefficients)
- Ordered logistic regression
- Proportional odds model
- In machine learning, ordinal regression may also be called ranking learning

# How to solve the ordinal logistic regression?

- the proportional odds assumption

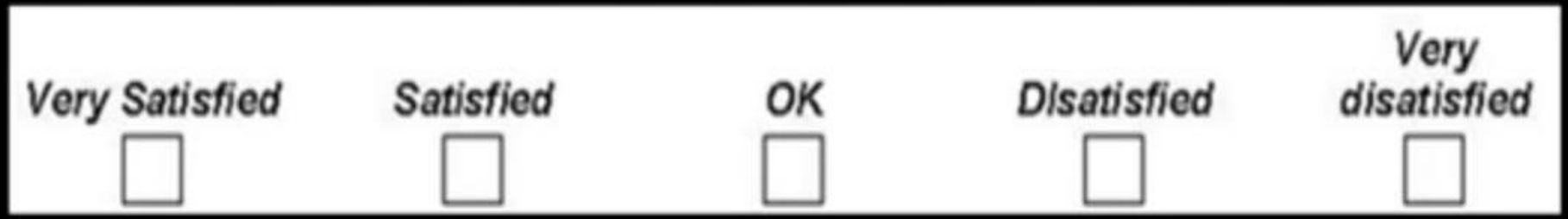
# What is proportional odds assumption

- The model only applies to data that meet the proportional odds assumption
- Let me explain - Proportional odds assumption
- If probabilities of below events are




- Then the logarithms of odds (please note – not the probabilities) form an arithmetic series.
- Let's see it

# What is proportional odds assumption




| Text meaning | Formula | Value | Value_1 | Simple sequence |
|---|---|---|---|---|
| Very Dissatisfied | $\text{Log}\left(\frac{P1}{(P2+P3+P4+P5)}\right)$ | A | B-3x | 1 |
| Dissatisfied or worse | $\text{Log}\left(\frac{(P1+P2)}{(P3+P4+P5)}\right)$ | A + D | B-2x | 2 |
| Neutral or worse | $\text{Log}\left(\frac{(P1+P2+P3)}{(P4+P5)}\right)$ | A + 2D | B-X | 3 |
| Satisfied, Neutral or worse | $\text{Log}\left(\frac{(P1+P2+P3+P4)}{(P5)}\right)$ | A + 3D | B | 4 |

In output

| Text meaning | Formula | Value | Value_1 | Simple sequence |
|---|---|---|---|---|
| Very Dissatisfied | $\text{Log}\left(\frac{P1}{(P2+P3+P4+P5)}\right)$ | A | B-3x | 1 |
| Dissatisfied or worse | $\text{Log}\left(\frac{(P1+P2)}{(P3+P4+P5)}\right)$ | A + D | B-2x | 2 |
| Neutral or worse | $\text{Log}\left(\frac{(P1+P2+P3)}{(P4+P5)}\right)$ | A + 2D | B-X | 3 |
| | $\left(\frac{+P2+P3+P4)}{(P5)}\right)$ | A + 3D | B | 4 |

Analysis of Maximum Likelihood Esti

| Parameter | | DF | Estimate | |
|---|---|---|---|---|
| Intercept | 03_Very_Likely | 1 | -4.2983 | D |
| Intercept | 02_Somewhat_Likely | 1 | -2.2029 | D |
| At_Least_One_Parent_ | | 1 | 1.0478 | A |
| Undergraduate_Instit | | 1 | -0.0585 | A |
| GPA | | 1 | 0.6156 | A |

The left side kind of output, you can think that intercept is like D and Other part is like A

## Solution

- OLS not enough - The coefficients in the linear combination cannot be consistently estimated using ordinary least squares.
- MLE - They are usually estimated using maximum likelihood.
- Iterative process - The maximum-likelihood estimates are computed iteratively

$$P(Y=2) = \left(\frac{1}{1+e^{-(a_2+b_1x_1+b_2x_2+b_3x_3)}}\right)$$

Maximum Probability will define the class

$$P(Y=1) = \left(\frac{1}{1+e^{-(a_1+b_1x_1+b_2x_2+b_3x_3)}}\right) - P(Y=2)$$

$$P(Y=0) = 1 - P(Y=1) - P(Y=2)$$