STEVE SCHERRER

DEMYSTIFYING ANOVA

Linear Regression Review

Univariate Regression

$$y = mx + B$$

Univariate Regression

$$y = mx + B$$

slope

intercept

Univariate Regression

$$\overbrace{f(x)}^{\text{Predicted Values}} = \underbrace{\beta_1}_{\text{slope}}\overbrace{X}^{\text{x values}} + \underbrace{\beta_0}_{\text{intercept}} + \underbrace{\varepsilon}_{\text{error}}$$

Univariate Regression

Predicted values

Values - Feature

$$f(x) - \varepsilon = \beta_1 X + \beta_0$$

error

slope

intercept

Univariate Regression

$$\overbrace{f(x) - \varepsilon}^{\text{Values - Y (target)}} = \underbrace{\beta_1}_{\text{slope}}\overbrace{X}^{\text{Values - Feature}} + \underbrace{\beta_0}_{\text{intercept}}$$

Multivariate Regression

values - Feature 1 values - Feature 2

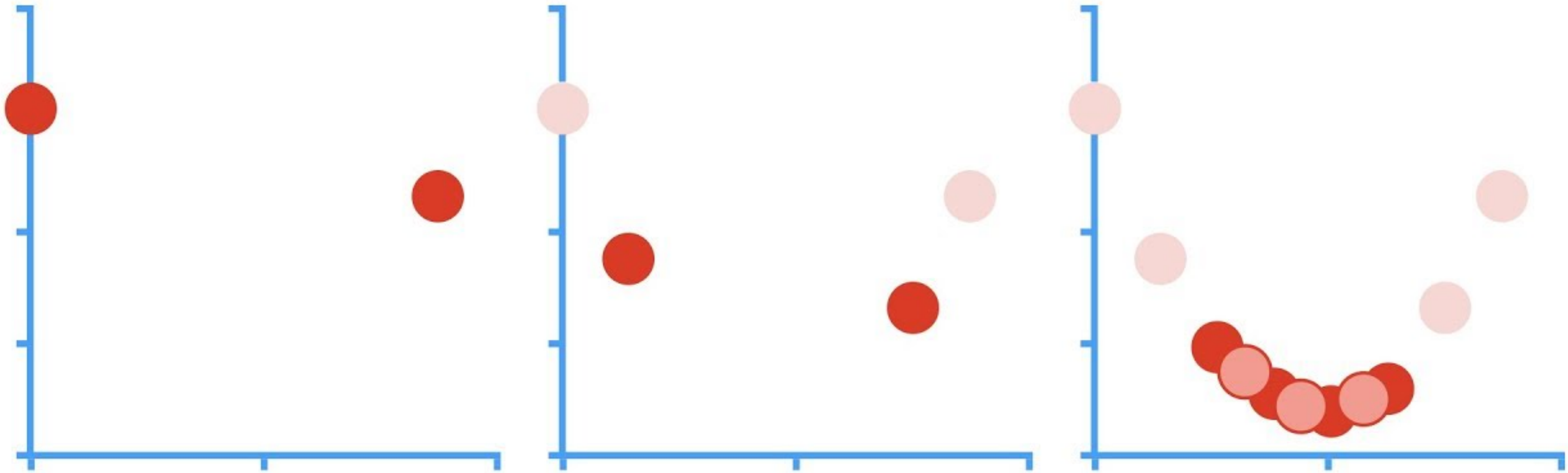
$$\overbrace{f(x) - \varepsilon}^{\text{values - y (target)}} = \beta_1 X_1 + \beta_2 X_2 + \beta_0$$

slope - Feature 1

intercept

slope - Feature 2

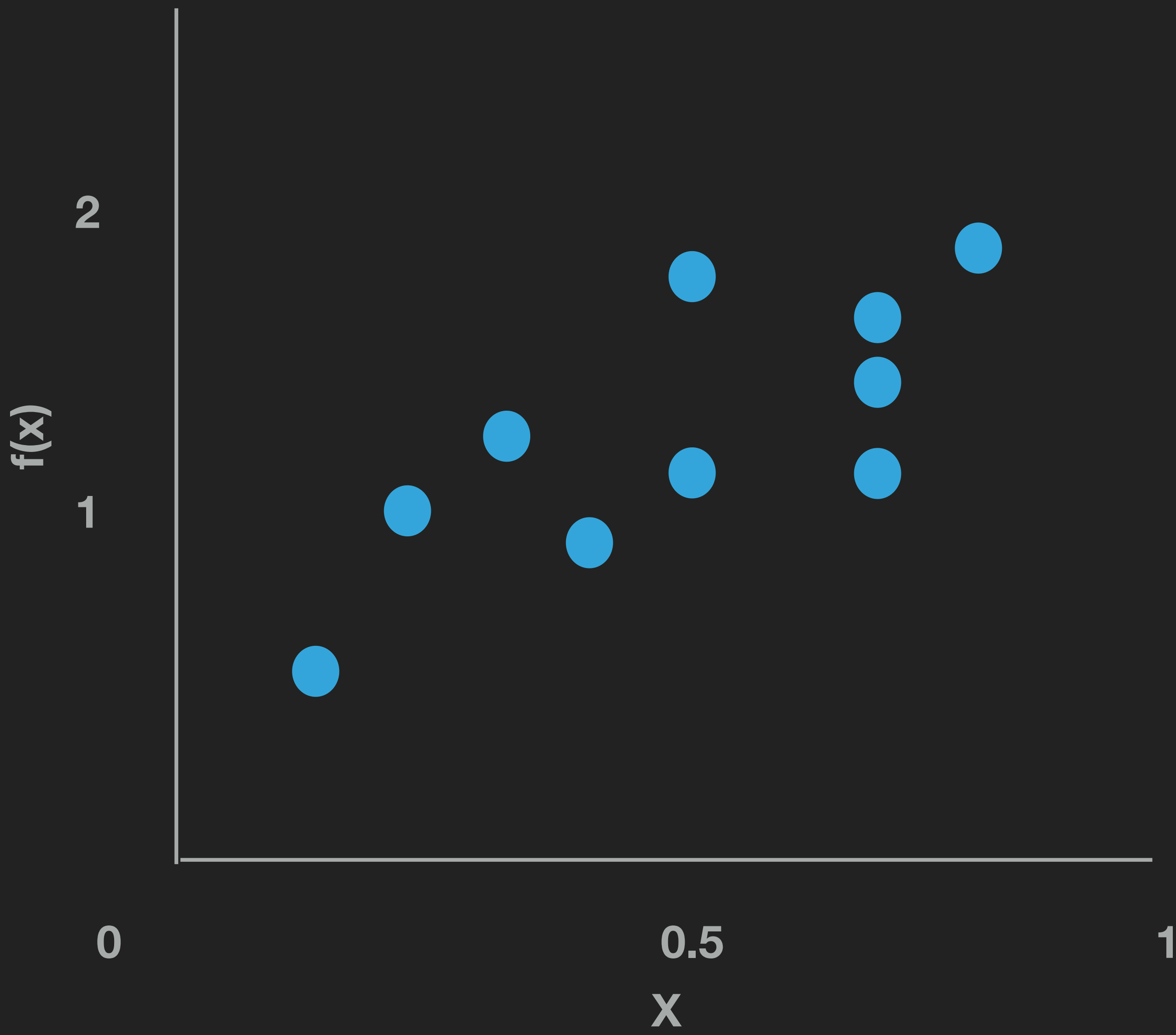
Gradient Descent....



...Step-by-Step!!!

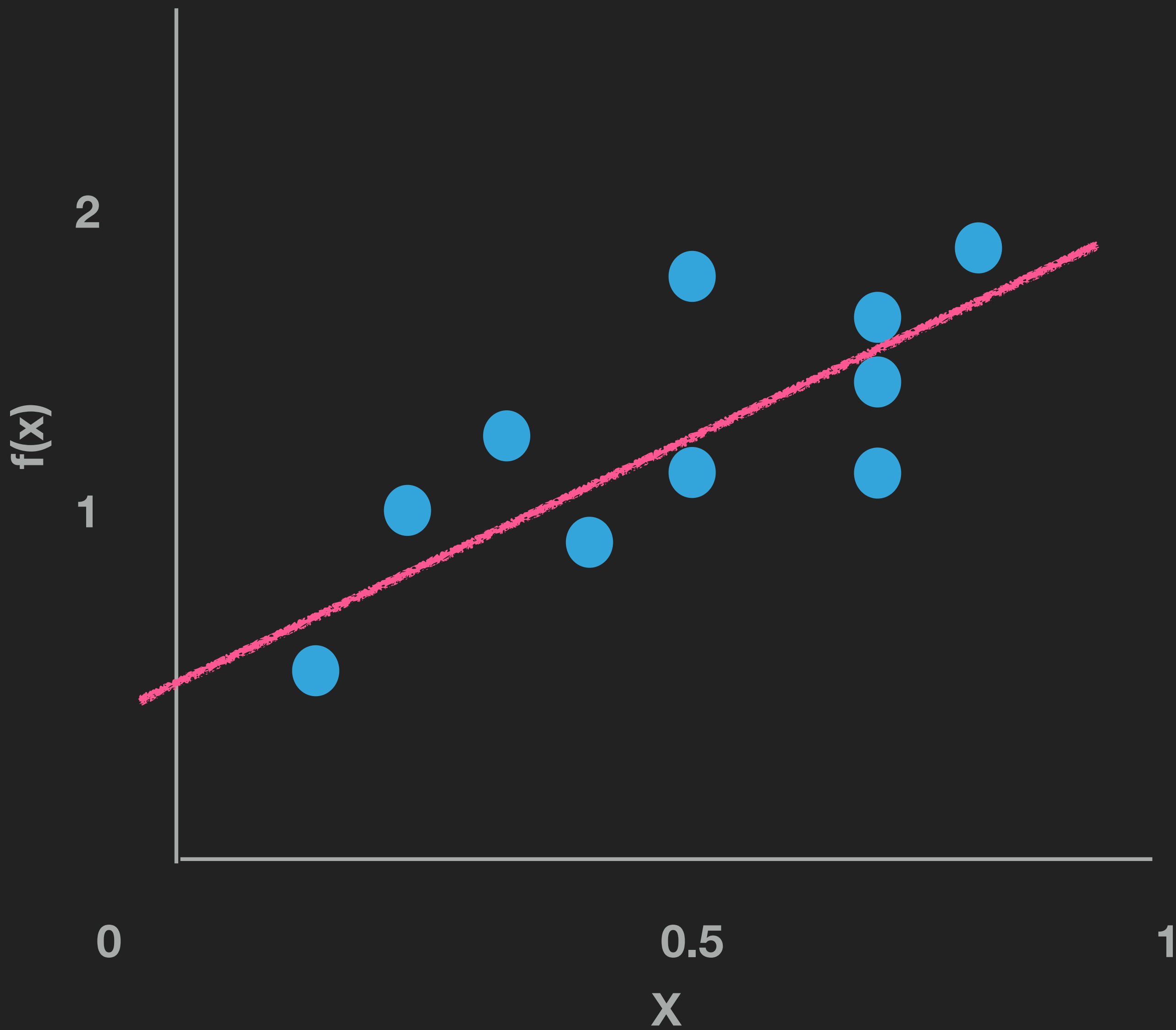
y	x
0.5	0.1
0.9	0.4
1.0	0.2
1.1	0.7
1.1	0.5
1.2	0.3
1.5	0.7
1.6	0.7
1.7	0.5
1.8	0.8

$$f(x) = \beta_1 X + \beta_0 + \varepsilon$$

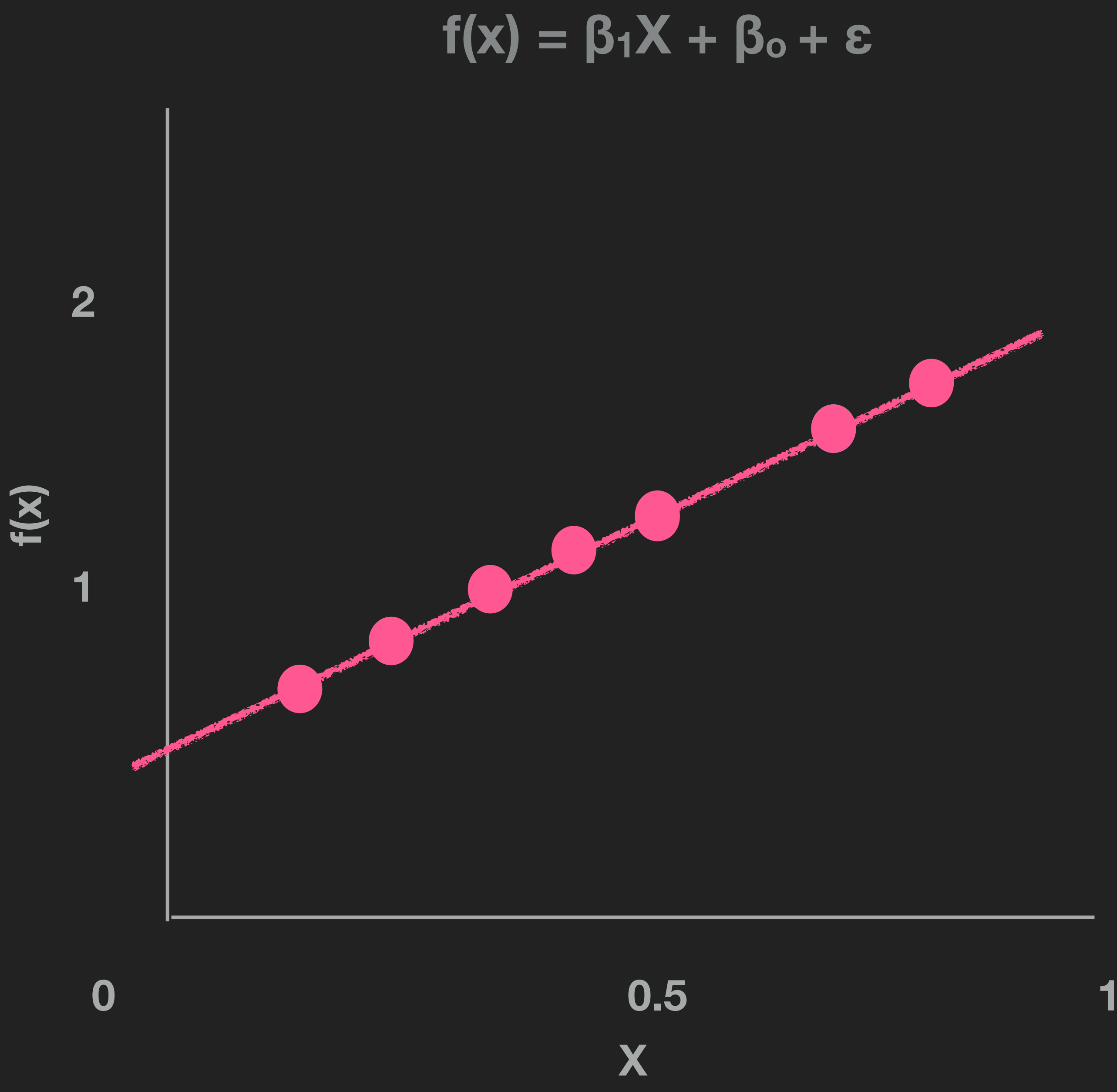


y	x
0.5	0.1
0.9	0.4
1.0	0.2
1.1	0.7
1.1	0.5
1.2	0.3
1.5	0.7
1.6	0.7
1.7	0.5
1.8	0.8

$$f(x) = \beta_1 X + \beta_0 + \varepsilon$$

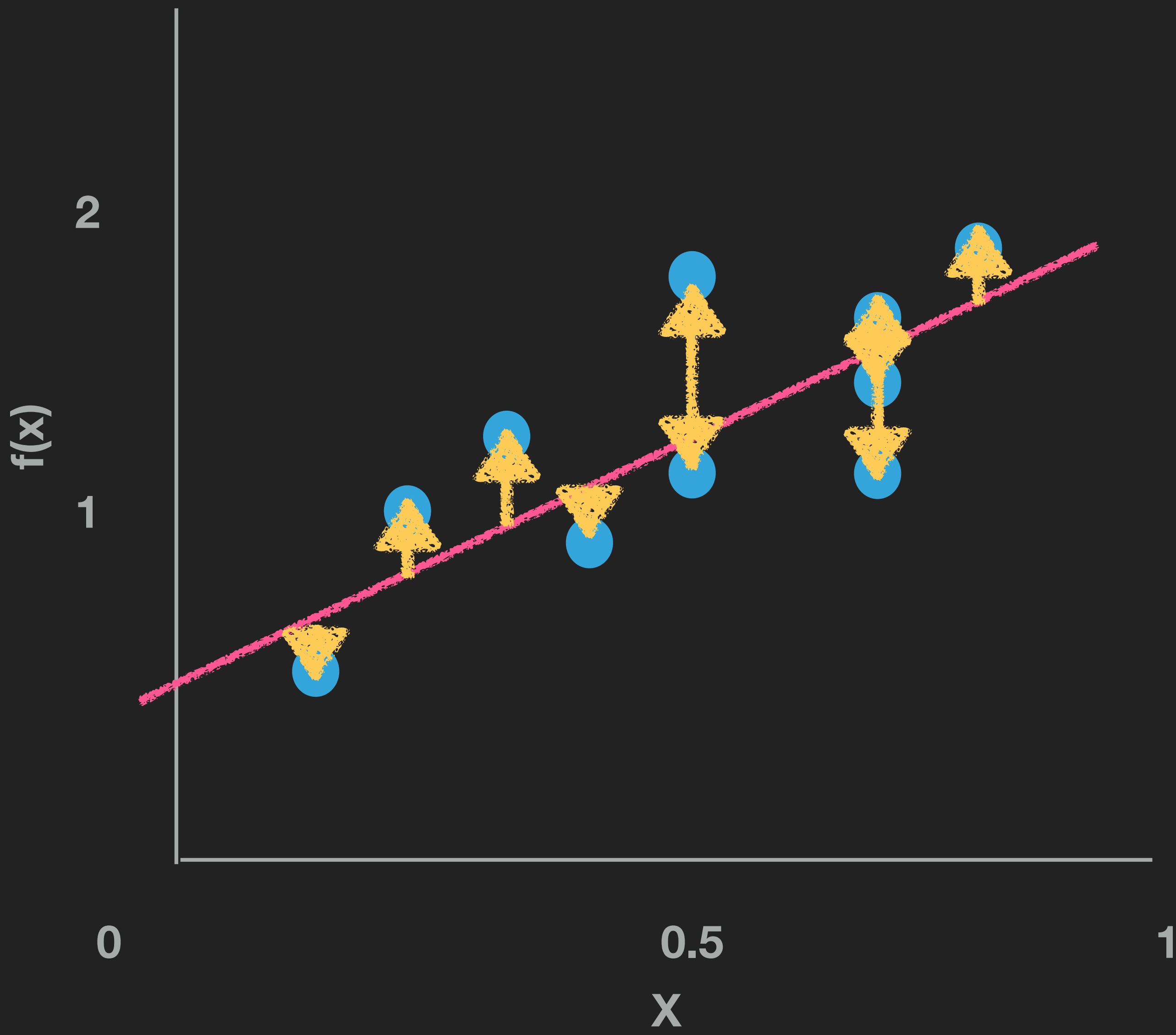


y	x
0.5	0.1
0.9	0.4
1.0	0.2
1.1	0.7
1.1	0.5
1.2	0.3
1.5	0.7
1.6	0.7
1.7	0.5
1.8	0.8



y	x	f(x)
0.5	0.1	0.73
0.9	0.4	1.1
1.0	0.2	0.86
1.1	0.7	1.50
1.1	0.5	1.24
1.2	0.3	0.99
1.5	0.7	1.50
1.6	0.7	1.50
1.7	0.5	1.24
1.8	0.8	1.62

$$f(x) = \beta_1 X + \beta_0 + \varepsilon$$



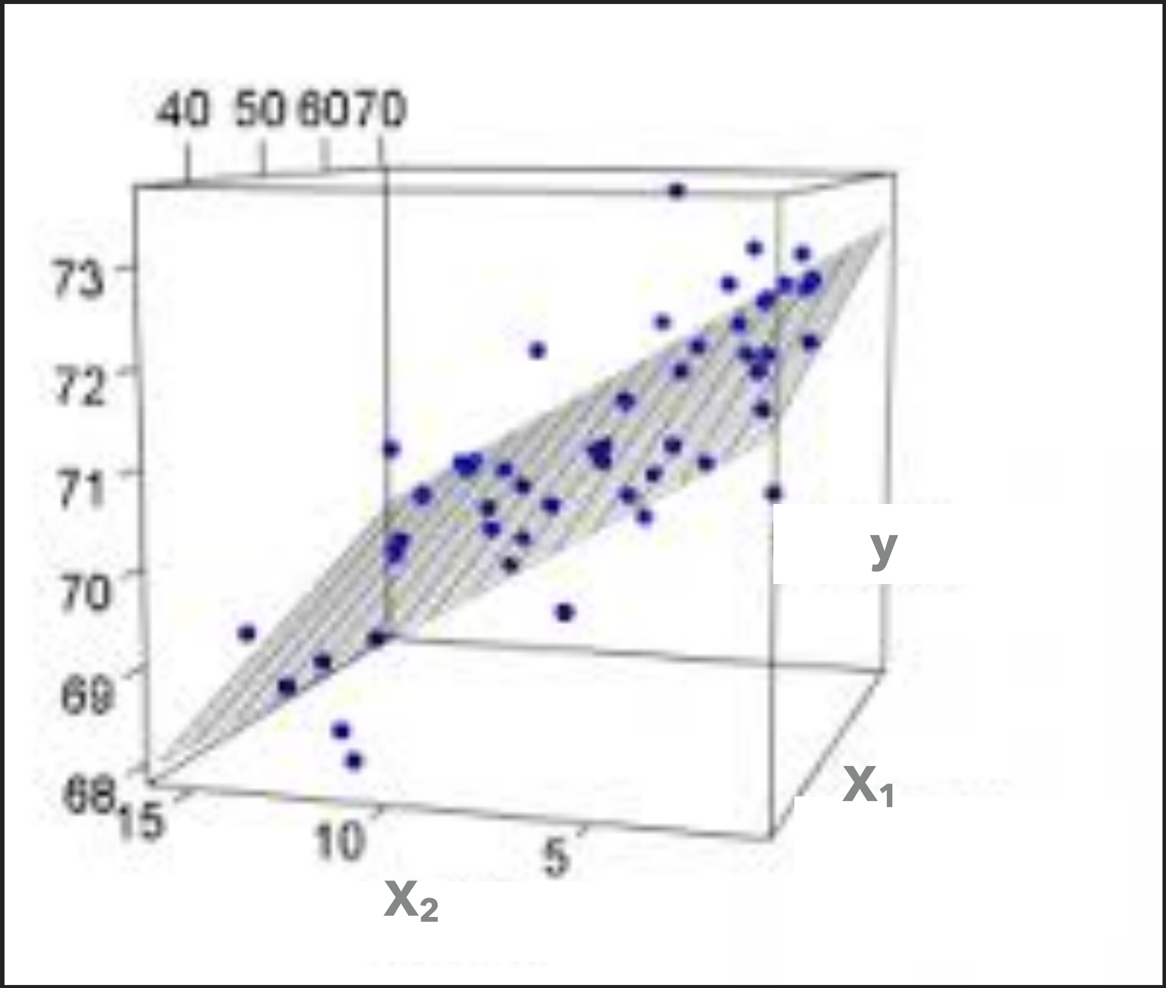
y	x	f(x)	ε
0.5	0.1	0.73	-0.23
0.9	0.4	1.1	-0.2
1.0	0.2	0.86	0.14
1.1	0.7	1.50	-0.4
1.1	0.5	1.24	-0.14
1.2	0.3	0.99	0.21
1.5	0.7	1.50	0
1.6	0.7	1.50	0.1
1.7	0.5	1.24	0.46
1.8	0.8	1.62	0.18

Assumptions of Linear Regression

1. Observations are independent
2. Residuals are normally distributed and centered around zero
    - Shapiro-Wilk's test
3. Residuals are homoskedastic (no underlying pattern)
    - - Breusch– Pagan test
4. If using multiple features (multivariate regression), features are not correlated

Multivariate Regression

$$f(x) = \beta_1 X_1 + \beta_2 X_2 + \beta_o + \varepsilon$$



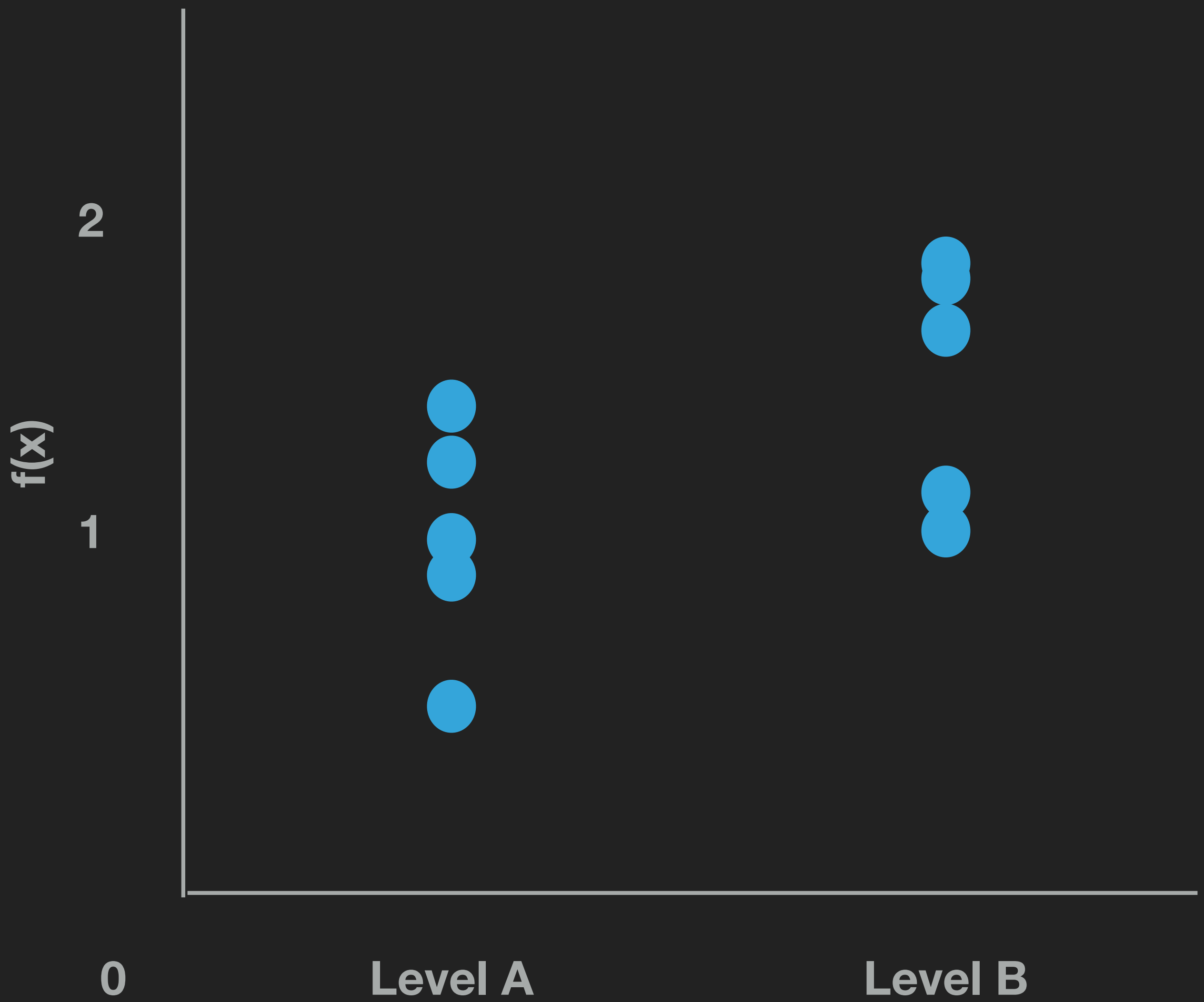
ANOVA is a Special Case of Multivariate Regression

y	x
0.5	A
0.9	A
1.0	A
1.1	B
1.1	A
1.2	B
1.5	A
1.6	B
1.7	B
1.8	B

One Hot Encoded

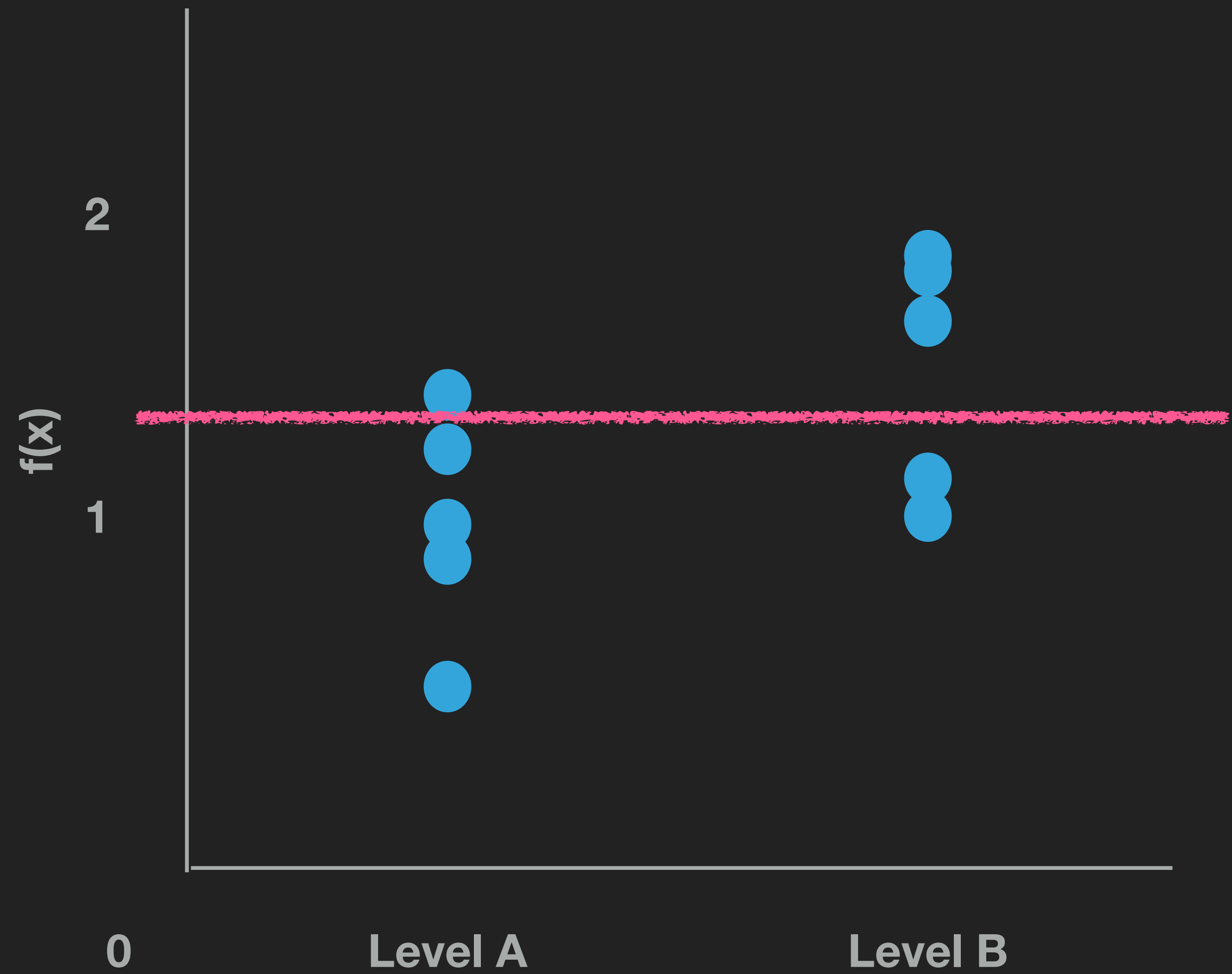
y	X_a	X_b
0.5	1	0
0.9	1	0
1.0	1	0
1.1	0	1
1.1	1	0
1.2	0	1
1.5	1	0
1.6	0	1
1.7	0	1
1.8	0	1

$$Y = \beta_a X_a + \beta_b X_b + \beta_0$$



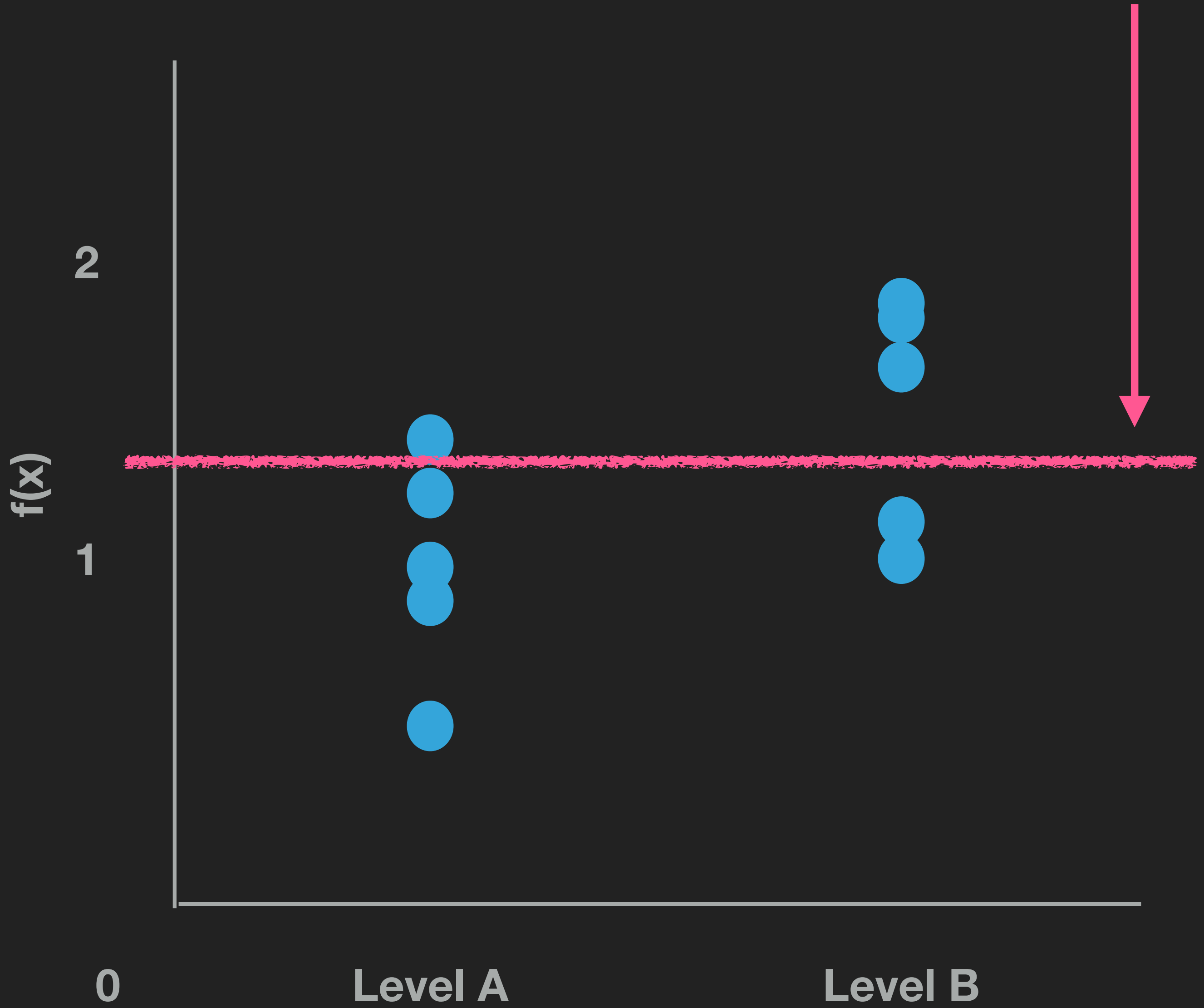
y	X_a	X_b
0.5	1	0
0.9	1	0
1.0	1	0
1.1	0	1
1.1	1	0
1.2	0	1
1.5	1	0
1.6	0	1
1.7	0	1
1.8	0	1

$$Y = \beta_a X_a + \beta_b X_b + \beta_o$$



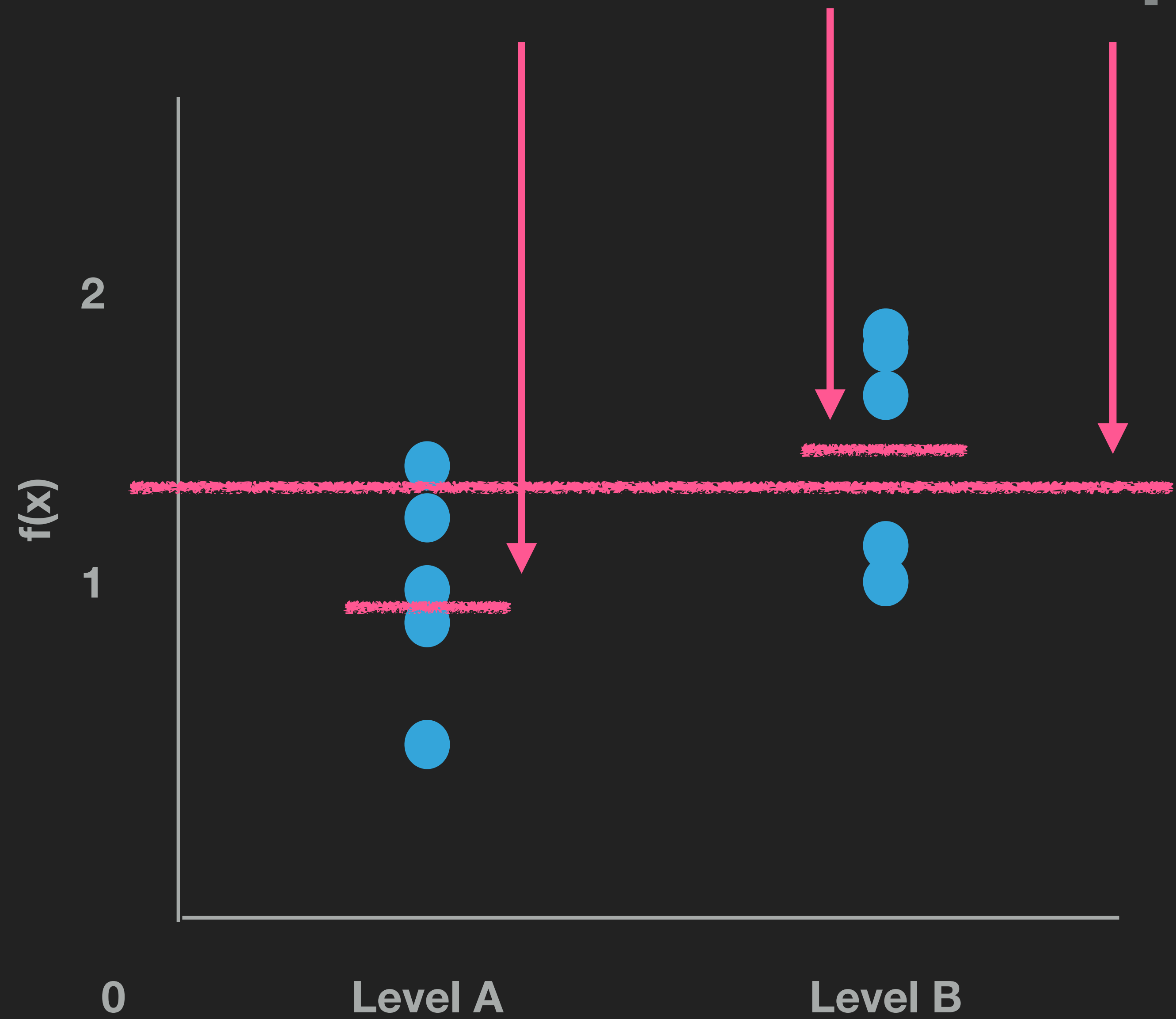
y	X_a	X_b
0.5	1	0
0.9	1	0
1.0	1	0
1.1	0	1
1.1	1	0
1.2	0	1
1.5	1	0
1.6	0	1
1.7	0	1
1.8	0	1

$$Y = \beta_a X_a + \beta_b X_b + \beta_o$$



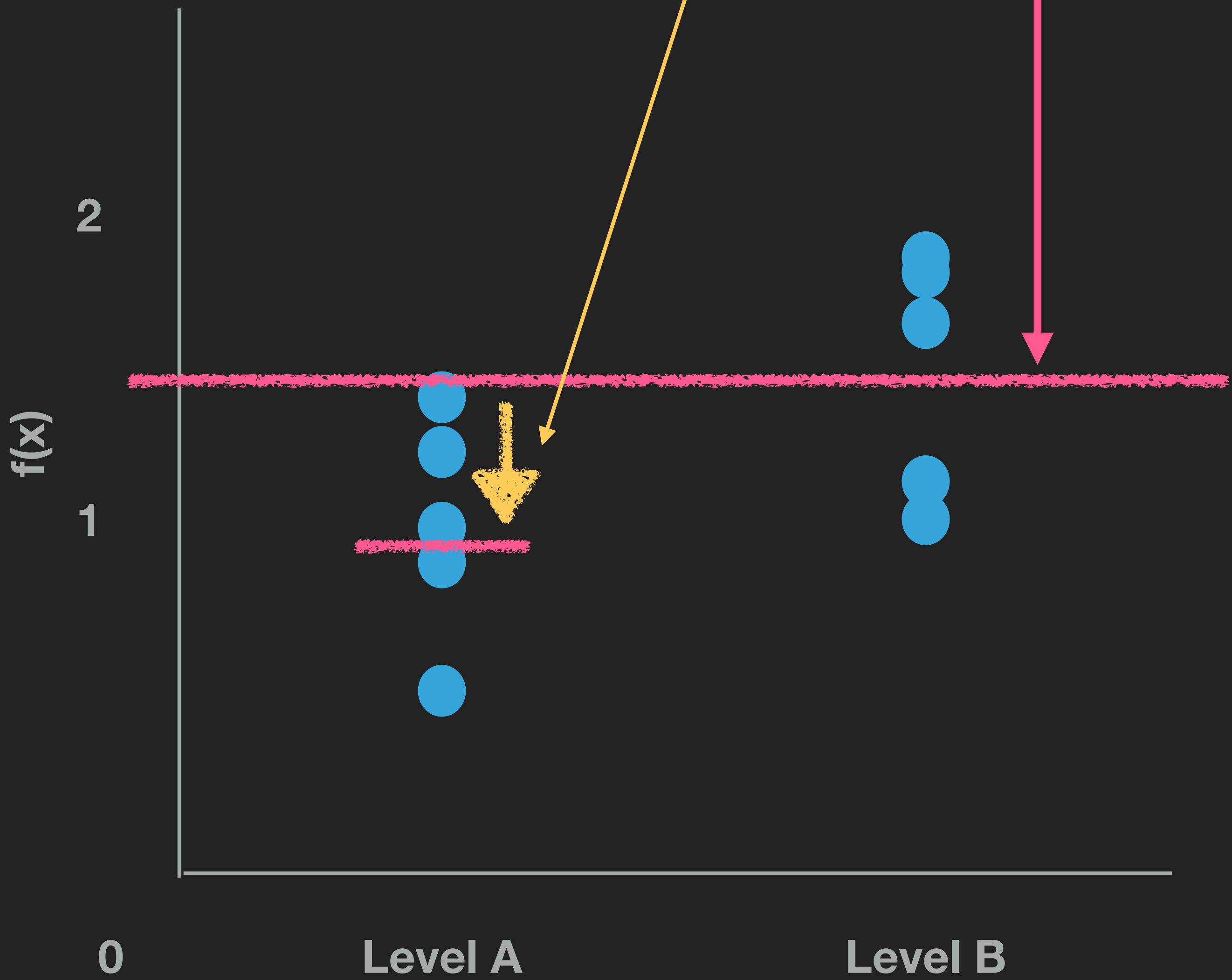
y	X_a	X_b
0.5	1	0
0.9	1	0
1.0	1	0
1.1	0	1
1.1	1	0
1.2	0	1
1.5	1	0
1.6	0	1
1.7	0	1
1.8	0	1

$$Y = 0.98X_a + 0.5X_b + \beta_0$$



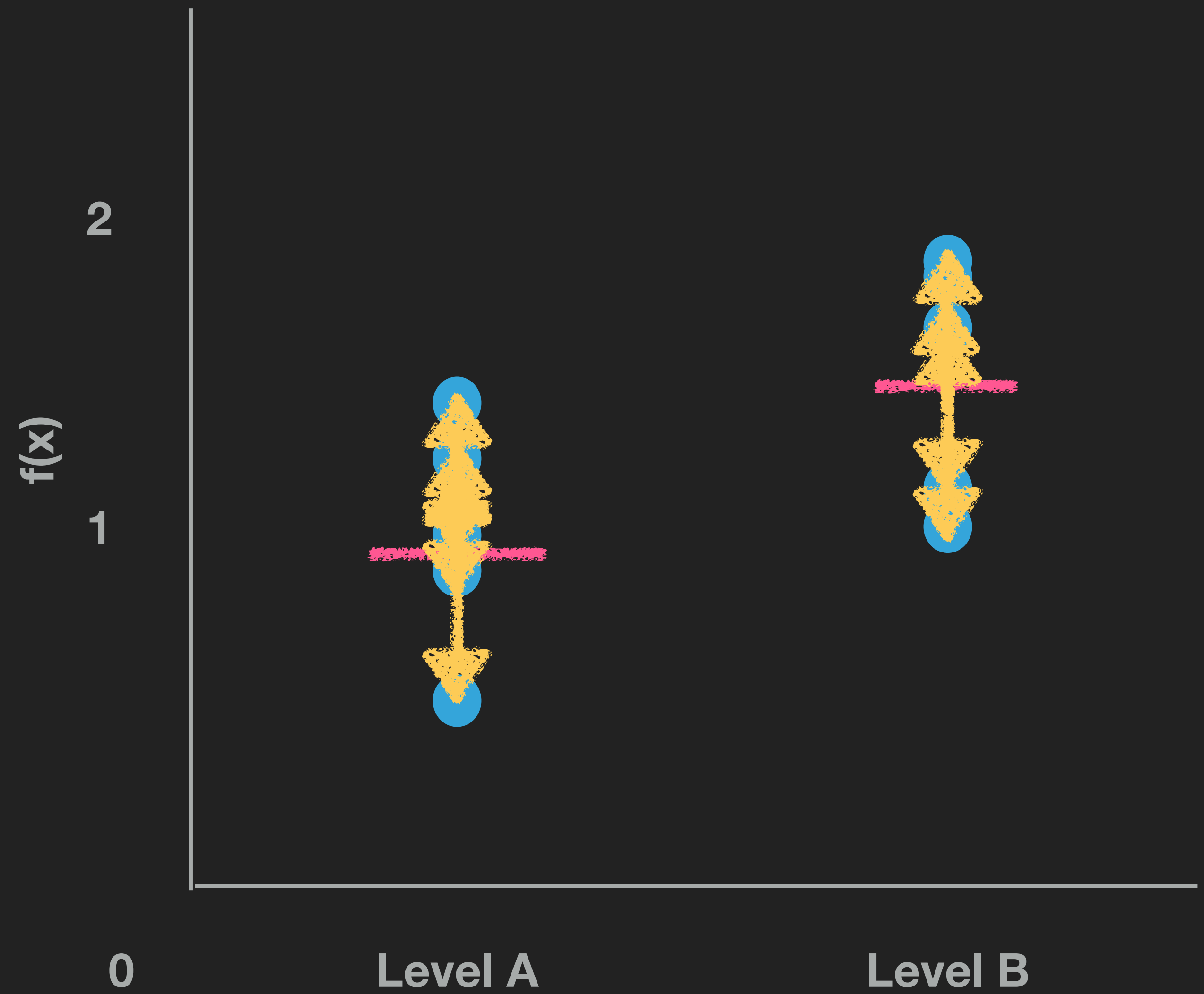
y	X_a	X_b
0.5	1	0
0.9	1	0
1.0	1	0
1.1	0	1
1.1	1	0
1.2	0	1
1.5	1	0
1.6	0	1
1.7	0	1
1.8	0	1

$$Y = 0.98 + 0.5\,X_b$$



y	X_a	f(x)
0.5	1	0.98
0.9	1	1.1
1.0	1	0.98
1.1	0	1.48
1.1	1	0.98
1.2	0	1.48
1.5	1	0.97
1.6	0	1.48
1.7	0	1.48
1.8	0	1.48

$$Y = -0.5\,X_a + 1.48$$



y	X_a	f(x)	ε
0.5	1	0.98	-0.48
0.9	1	1.1	-0.2
1.0	1	0.98	0.02
1.1	0	1.48	-0.38
1.1	1	0.98	0.12
1.2	0	1.48	-0.28
1.5	1	0.97	0.53
1.6	0	1.48	0.12
1.7	0	1.48	0.22
1.8	0	1.48	0.32

Assumptions of Linear Regression

1. Observations are independent and normally distributed

2. Residuals are normally distributed and centered around zero

    - Shapiro-Wilk's test

3. Residuals are homoskedastic (no underlying pattern)

    - - Breusch– Pagan test

4. If using multiple features (multivariate regression), features are not correlated

Assumptions of ANOVA

1. Observations are independent and normally distributed within groups
2. Residuals are normally distributed and centered around zero
    - Shapiro-Wilk's test
3. Variance between groups is similar (~ < 2x)
    - $| \max([\ \sigma_a^2 - \sigma_b^2\ ) / \min([\ \sigma_a^2 - \sigma_b^2\ ) | < 2$
4. If using multiple features (multivariate regression), features are not correlated

1. Observations are independent and normally distributed within groups

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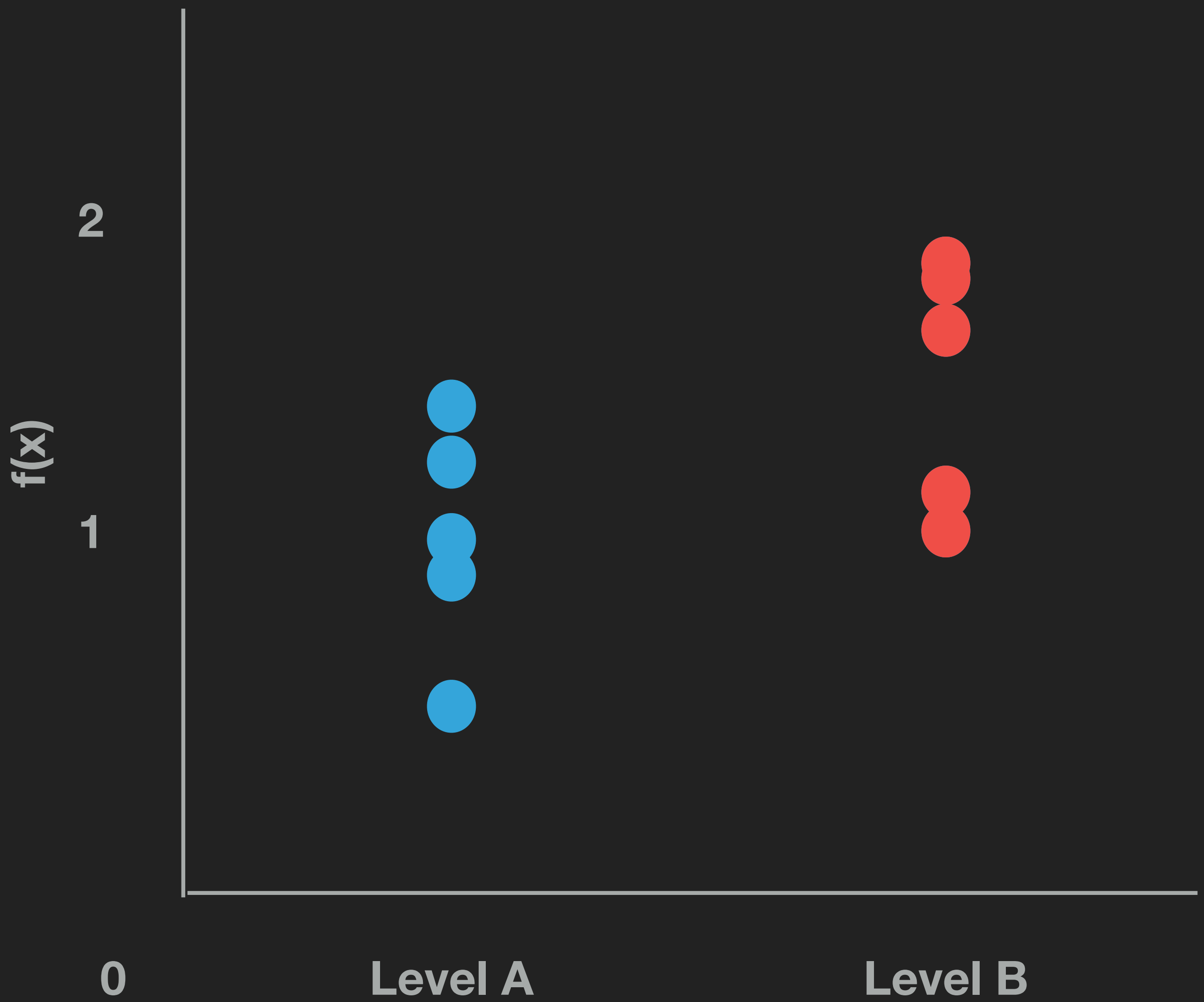
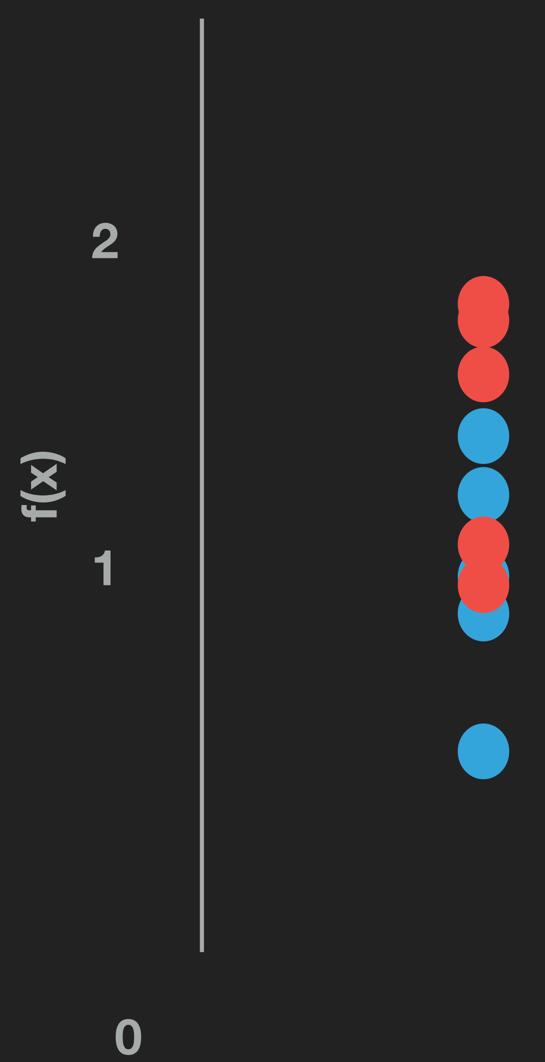
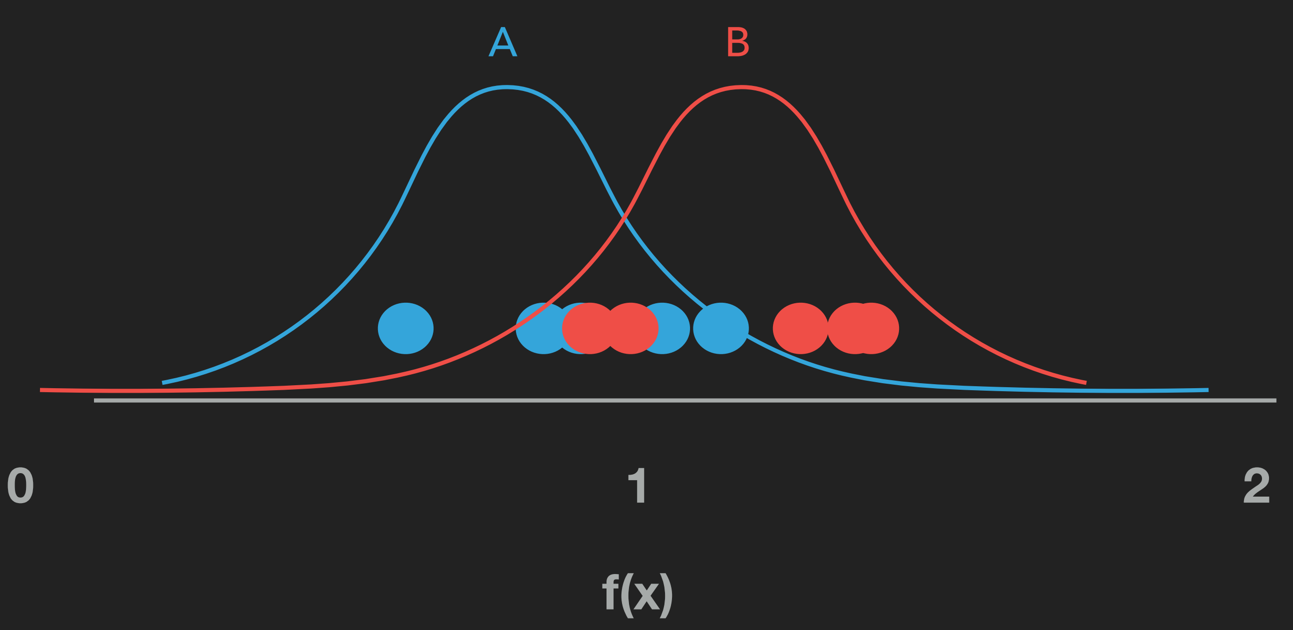


1. Observations are independent and normally distributed within groups



1. Observations are independent and normally distributed within groups



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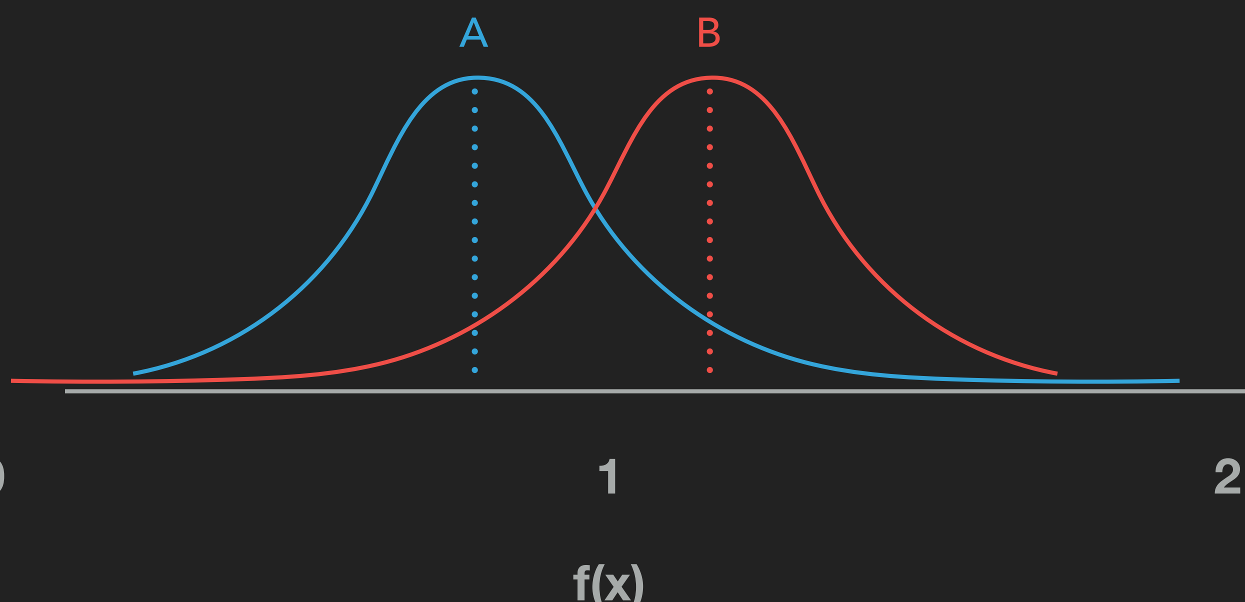

1. Observations are independent and normally distributed within groups

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.434
Model:                            OLS   Adj. R-squared:                  0.363
Method:                 Least Squares   F-statistic:                     6.127
Date:                Sun, 04 Oct 2020   Prob (F-statistic):             0.0384
Time:                        14:37:07   Log-Likelihood:                -1.6598
No. Observations:                  10   AIC:                             7.320
Df Residuals:                       8   BIC:                             7.925
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.9800      0.143      6.861      0.000       0.651       1.309
z[T.b]         0.5000      0.202      2.475      0.038
==============================================================================
Omnibus:                        0.887   Durbin-Watson:                   1.642
Prob(Omnibus):                  0.642   Jarque-Bera (JB):                0.670
Skew:                          -0.287   Prob(JB):                        0.715
Kurtosis:                       1.870   Cond. No.                         2.62
==============================================================================
```

click to scroll output; double click to hi

```
1  scipy.stats.ttest_ind(a = aov_data.y.loc[aov_data.z == 'a'], b = aov_data.y.loc[aov_data.z == 'b'])
```

executed in 6ms, finished 13:58:17 2020-10-04

```
Ttest_indResult(statistic=-2.4753688557441685, pvalue=0.03838779259171958)
```

1. Observations are independent and normally distributed within groups

```
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Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.9800      0.143      6.861      0.000       0.651       1.309
z[T.b]         0.5000      0.202      2.475      0.038 click to scroll output; double click to hi
==============================================================================
Omnibus:                        0.887   Durbin-Watson:                   1.642
Prob(Omnibus):                  0.642   Jarque-Bera (JB):                0.670
Skew:                          -0.287   Prob(JB):                        0.715
Kurtosis:                       1.870   Cond. No.                         2.62
==============================================================================
```

For more information, look into contrast coding

Setting your intercept as your “Control” will allow you to see how your different candidates (A, B, …) compete