H0: Men and women prefer cats and dogs equally. The preference is independent of gender. H1: The preference for cats and dogs is dependent on gender.

| | Cat | Dog |
|---|---|---|
| Men | 207 | 282 |
| Women | 231 | 242 |

H0: Men and women prefer cats and dogs equally. The preference is independent of gender. H1: The preference for cats and dogs is dependent on gender.

| | Cat | Dog |
|---|---|---|
| Men | 207 | 282 |
| Women | 231 | 242 |

With totals

| | Cats | Dogs | Total |
|---|---|---|---|
| Men | 207 | 282 | 489 |
| Women | 231 | 242 | 473 |
| Total | 438 | 524 | 962 |

H0: Men and women prefer cats and dogs equally. The preference is independent of gender. H1: The preference for cats and dogs is dependent on gender.

| | Cat | Dog |
|---|---|---|
| Men | 207 | 282 |
| Women | 231 | 242 |

With totals

| | Cats | Dogs | Total |
|---|---|---|---|
| Men | 207 | 282 | 489 |
| Women | 231 | 242 | 473 |
| Total | 438 | 524 | 962 |

Expected values

| | Cats | Dogs | |
|---|---|---|---|
| Men | $\frac{489x438}{962}$ | $\frac{489x524}{962}$ | 489 |
| Women | $\frac{473x438}{962}$ | $\frac{437x524}{962}$ | 473 |
| | 438 | 524 | 962 |

H0: Men and women prefer cats and dogs equally. The preference is independent of gender. H1: The preference for cats and dogs is dependent on gender.

| | Cat | Dog |
|---|---|---|
| Men | 207 | 282 |
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With totals

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| Men | 207 | 282 | 489 |
| Women | 231 | 242 | 473 |
| Total | 438 | 524 | 962 |

Expected values

| | Cats | Dogs | |
|---|---|---|---|
| Men | $\frac{489x438}{962}$ | $\frac{489x524}{962}$ | 489 |
| Women | $\frac{473x438}{962}$ | $\frac{437x524}{962}$ | 473 |
| | 438 | 524 | 962 |

Expected values - computed

| | Cats | Dogs | |
|---|---|---|---|
| Men | 222.64 | 266.36 | 489 |
| Women | 215.36 | 257.64 | 473 |
| | 438 | 524 | 962 |

H0: Men and women prefer cats and dogs equally. The preference is independent of gender. H1: The preference for cats and dogs is dependent on gender.

| | Cat | Dog |
|---|---|---|
| Men | 207 | 282 |
| Women | 231 | 242 |

With totals

| | Cats | Dogs | Total |
|---|---|---|---|
| Men | 207 | 282 | 489 |
| Women | 231 | 242 | 473 |
| Total | 438 | 524 | 962 |

Expected values

| | Cats | Dogs | |
|---|---|---|---|
| Men | $\frac{489x438}{962}$ | $\frac{489x524}{962}$ | 489 |
| Women | $\frac{473x438}{962}$ | $\frac{437x524}{962}$ | 473 |
| | 438 | 524 | 962 |

Expected values - computed

| | Cats | Dogs | |
|---|---|---|---|
| Men | 222.64 | 266.36 | 489 |
| Women | 215.36 | 257.64 | 473 |
| | 438 | 524 | 962 |

| | Cats | Dogs | |
|---|---|---|---|
| Men | $\frac{(207-226.4)^2}{226.4}$ | $\frac{(282-266.36)^2}{266.36}$ | 489 |
| Women | $\frac{(231-215.36)^2}{215.36}$ | $\frac{(242-257.64)^2}{257.64}$ | 473 |
| | 438 | 524 | 962 |

H0: Men and women prefer cats and dogs equally. The preference is independent of gender. H1: The preference for cats and dogs is dependent on gender.

| | Cats | Dogs | |
|---|---|---|---|
| Men | $\frac{(207-226.4)^2}{226.4}$ | $\frac{(282-266.36)^2}{266.36}$ | 489 |
| Women | $\frac{(231-215.36)^2}{215.36}$ | $\frac{(242-257.64)^2}{257.64}$ | 473 |
| | 438 | 524 | 962 |

| | Cat | Dog |
|---|---|---|
| Men | 1.099 | 0.918 |
| Women | 1.136 | 0.949 |

Add them up and that is the $X^2$ (Chi-squared or Chi-square) score:

$X^2$ = 1.099 + 0.918 + 1.136 + 0.949

$$X^2 = = 4.102$$

Now we take it to the table or to the chi-square distribution function in R, but first we have to know a new number:

# Degrees of Freedom

Degrees of freedom is a lot like what it sounds like. It's that maximum number of logically independent variables. It's essentially the "wiggle room" - how much do the variables allow for a good measurement?

In Chi Square, the degrees of freedom is:

$df = (rows - 1)x(columns - 1)$

In this case, (2-1) x (2 - 1) = 1

# Second Example

## UC Berkley Graduate Admissions, 1973, 6 largest programs

H0: Admissions are independent of gender.
H1: Admissions are dependent on gender.

(The "totals" are also referred to as *Marginal Frequency*.)

Table 1: Values

| | Male | Female | Marginal Freq. |
|---|---|---|---|
| Admit | 1198 | 597 | 1755 |
| Reject | 1493 | 1278 | 2771 |
| Marginal Freq. | 2691 | 1835 | 4526 |

Table 2: Expected values

| | Male | Female | Marginal Freq. |
|---|---|---|---|
| Admit | | | 1755 |
| Reject | | | 2771 |
| Marginal Freq. | 2691 | 1835 | 4526 |

Table 3: $Observed - Expected$

| | Male | Female | Marginal Freq. |
|---|---|---|---|
| Admit | | | 1755 |
| Reject | | | 2771 |
| Marginal Freq. | 2691 | 1835 | 4526 |

Table 4: $\frac{(Observed - Expected)^2}{Expected}$

| | Male | Female | Marginal Freq. |
|---|---|---|---|
| Admit | | | 1755 |
| Reject | | | 2771 |
| Marginal Freq. | 2691 | 1835 | 4526 |

## Add it up:

Degrees of freedom: (2x1)-(2x1) = 1

p-value: