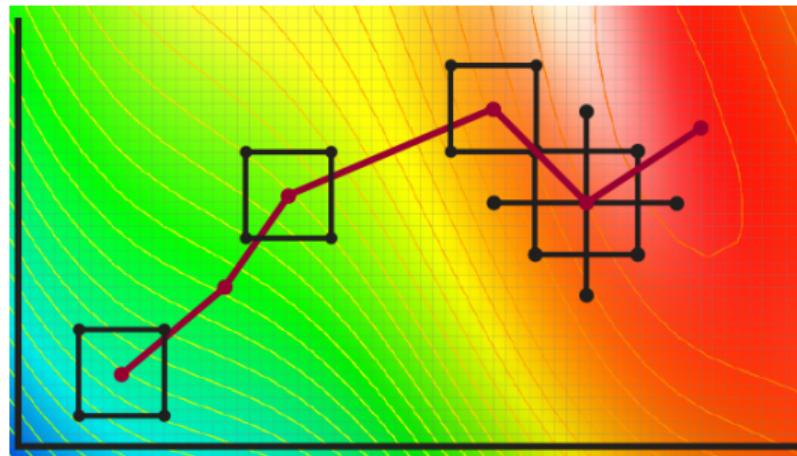


Experimentation for Improvement



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Design and Analysis of Experiments

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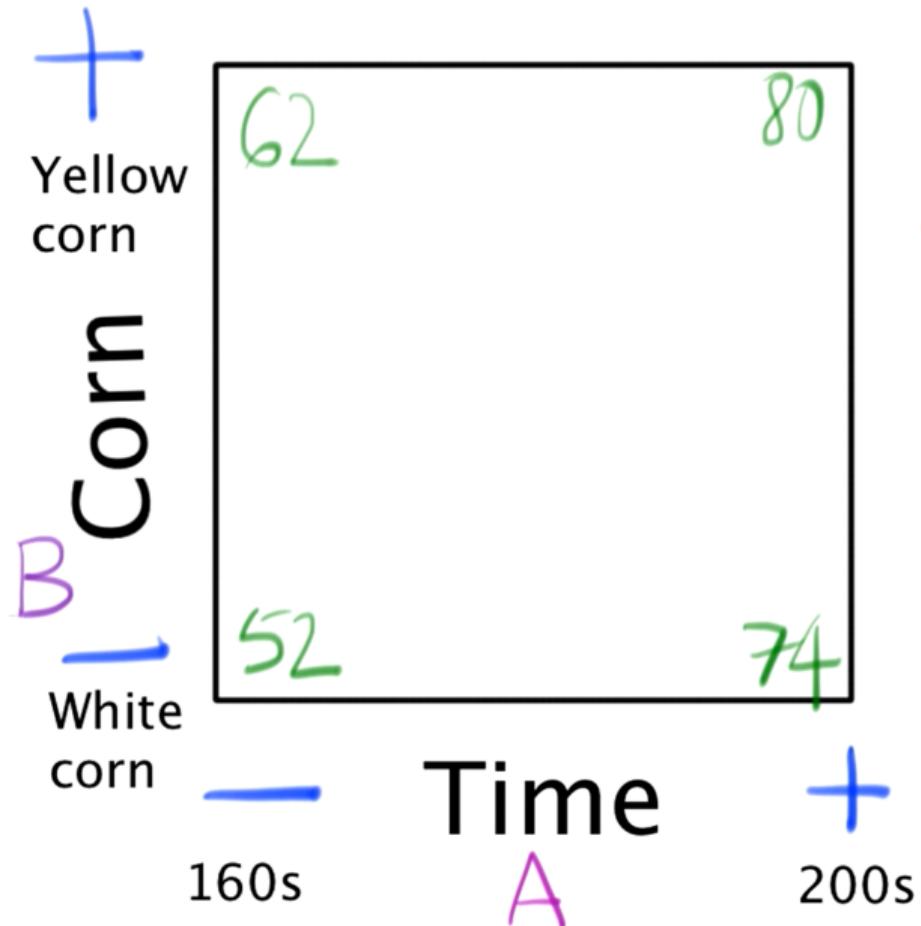
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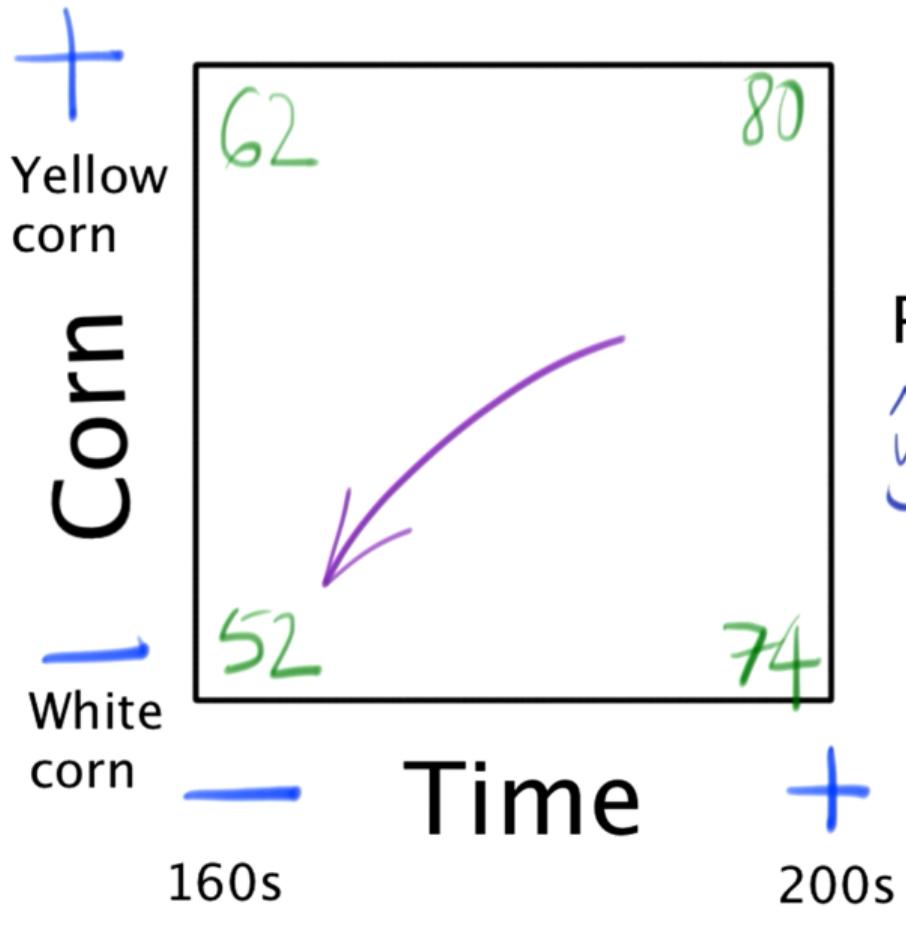
(when used without modification)



$$\hat{y} = \underline{67} + \underline{10}x_A + \underline{4}x_B$$

prediction

An orange arrow points from the term $\underline{10}x_A$ in the equation to the data point for White corn at Time A ≈ 160s.

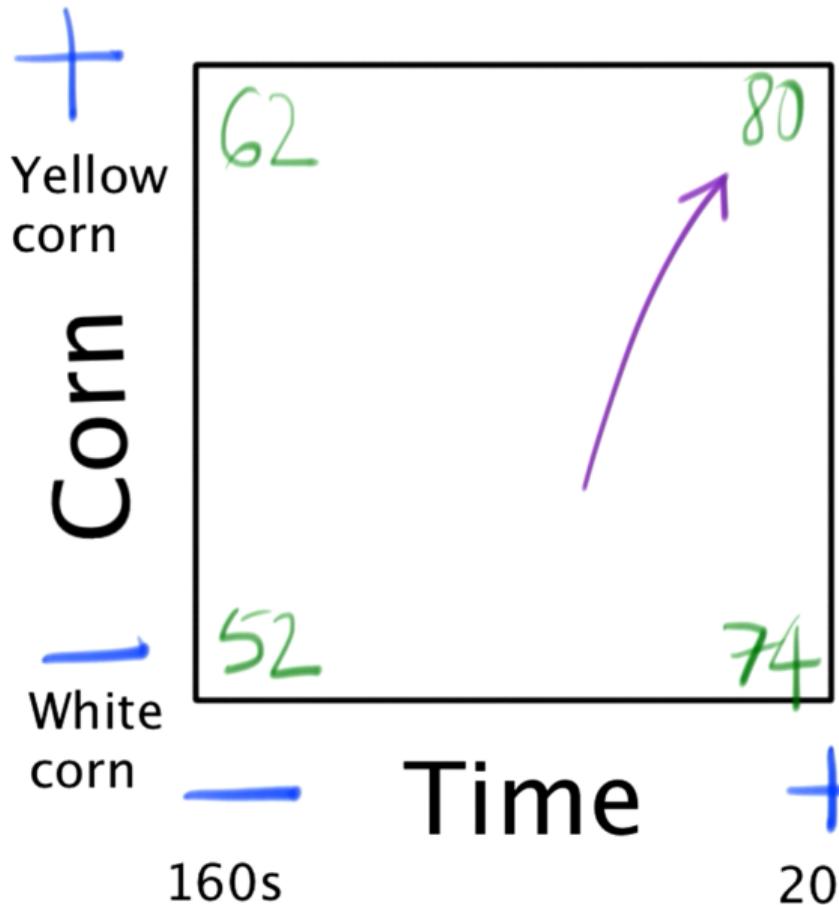


$$\hat{y} = \underline{67} + \underline{-10}x_A + \underline{4}x_B$$

Predicted popcorn = \hat{y}

$$\hat{y} = 67 + \underbrace{(10)(-1)}_{\text{the "time" [A] effect}} + \underbrace{(4)(-1)}_{\text{the "corn" [B] effect}}$$

$$\begin{aligned}\hat{y} &= 67 - 10 - 4 \\ &= 53 \text{ popped corns}\end{aligned}$$



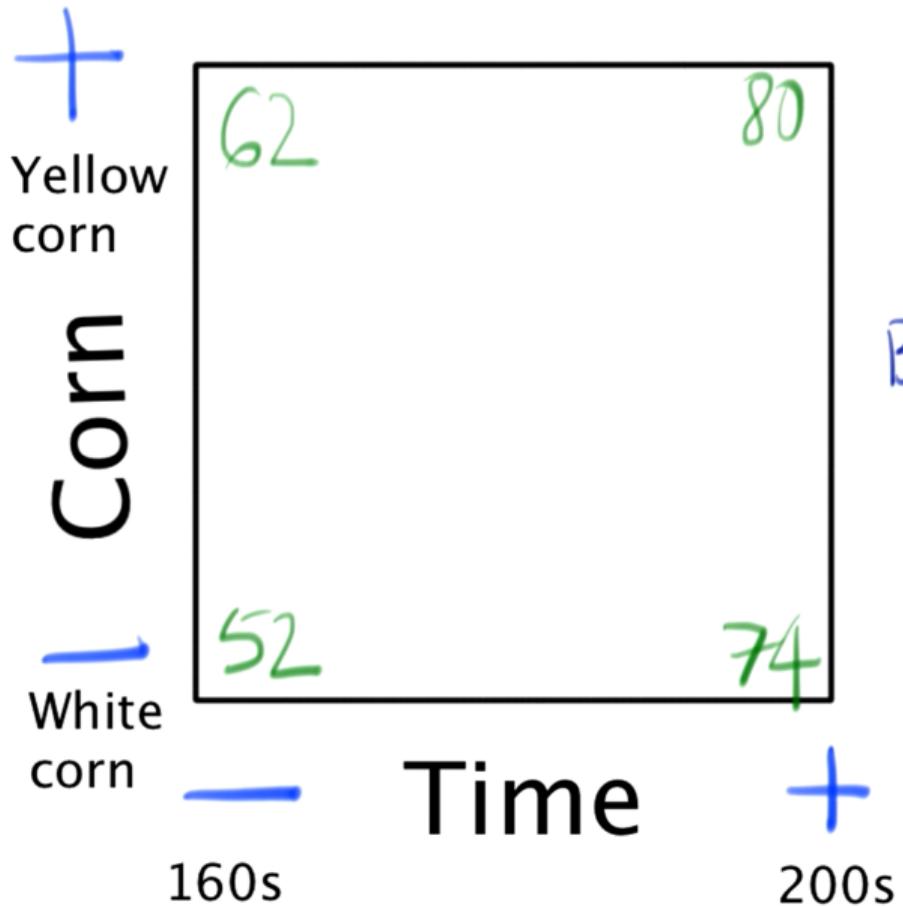
$$\hat{y} = \underline{67} + \underline{10}x_A + \underline{4}x_B$$

Predicted popcorn = \hat{y}

$$\hat{y} = 67 + \underbrace{(10)(+1)}_{A \text{ effect}} + \underbrace{(4)(+1)}_{B \text{ effect}}$$

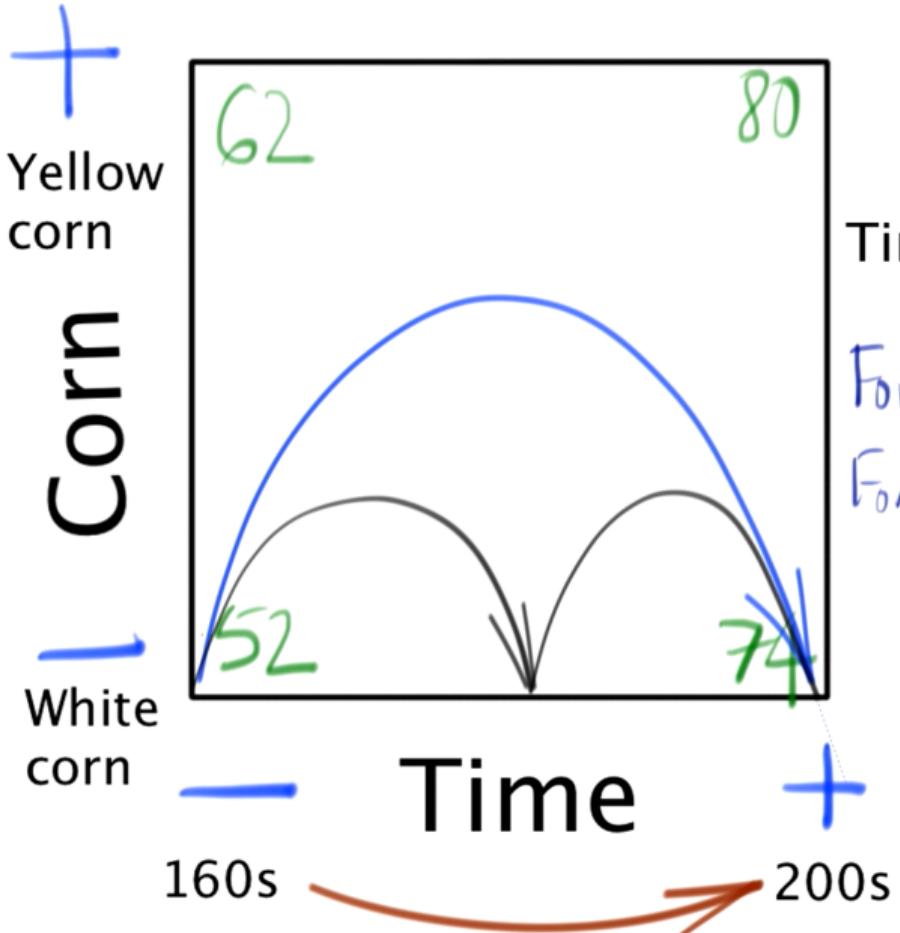
$$\hat{y} = 67 + 10 + 4$$

$$\hat{y} = 81 \text{ (close to 80)}$$



$$\hat{y} = \underline{67} + \underline{10}x_A + \underline{4}x_B$$

Baseline = $\frac{52 + 74 + 62 + 80}{4}$
 $= 67$



$$\hat{y} = \underline{67} + \underline{10}x_A + \underline{4}x_B$$

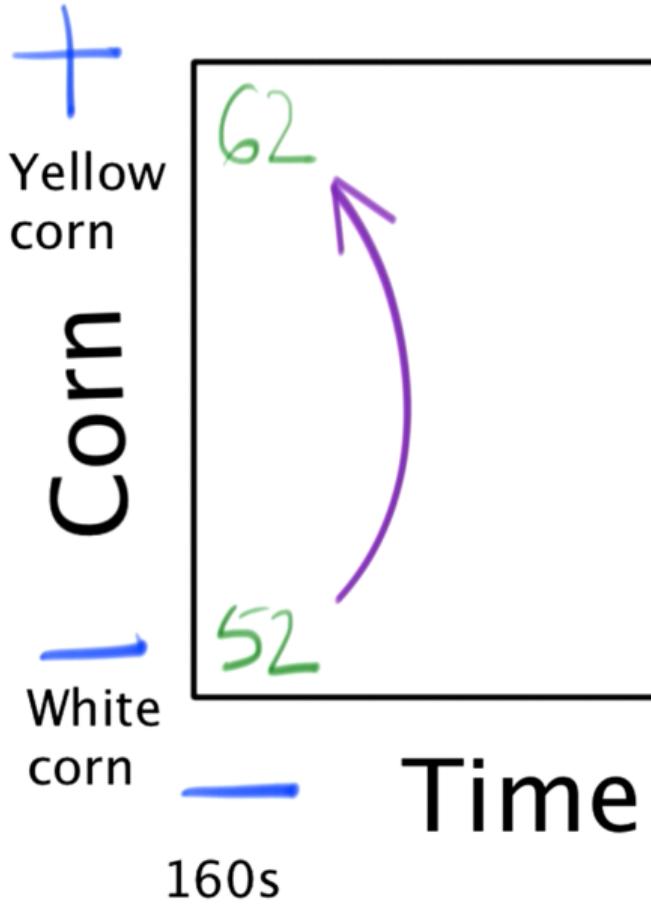
Time effect (A): from **high** to **low**

For yellow corn: $80 - 62 = 18$

For white corn: $74 - 52 = 22$

Average = 20

Report it as: 10 extra popped corns when cooking time is increased by 20 seconds.



$$\hat{y} = 67 + 10x_A + 4x_B$$

Corn effect (B): from **high** to **low**

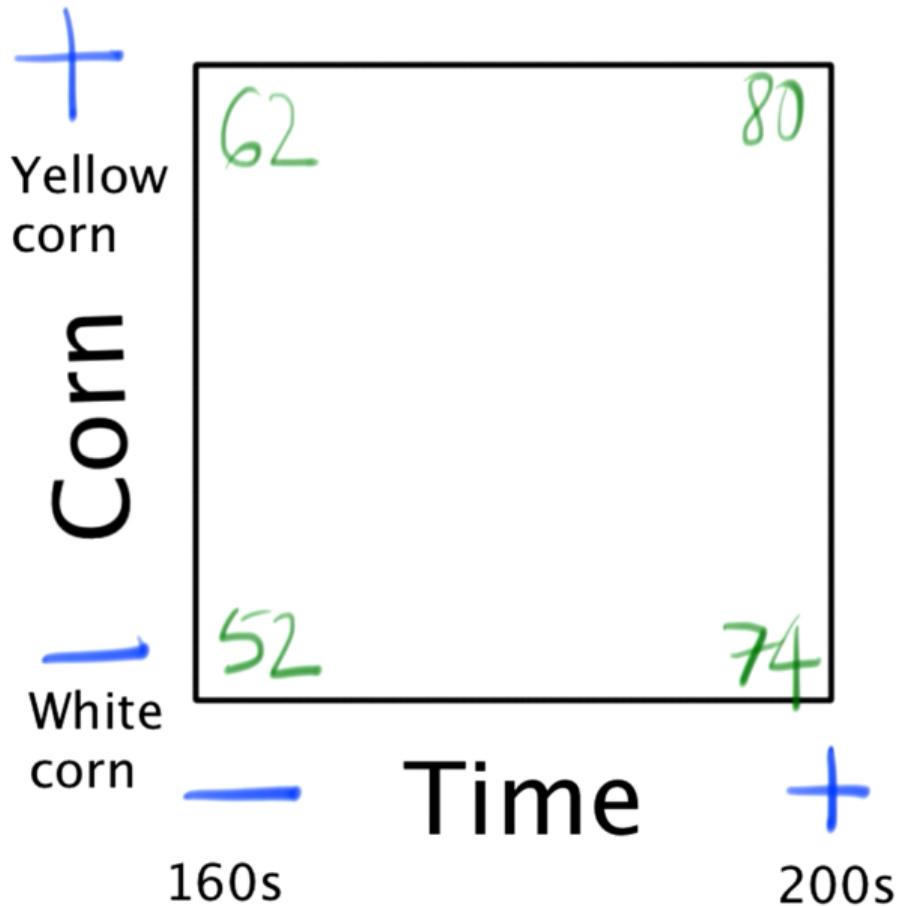
^(200s) Long cooking time: $80 - 74 = 6$

Short cooking time: $62 - 52 = 10$

Average = 8

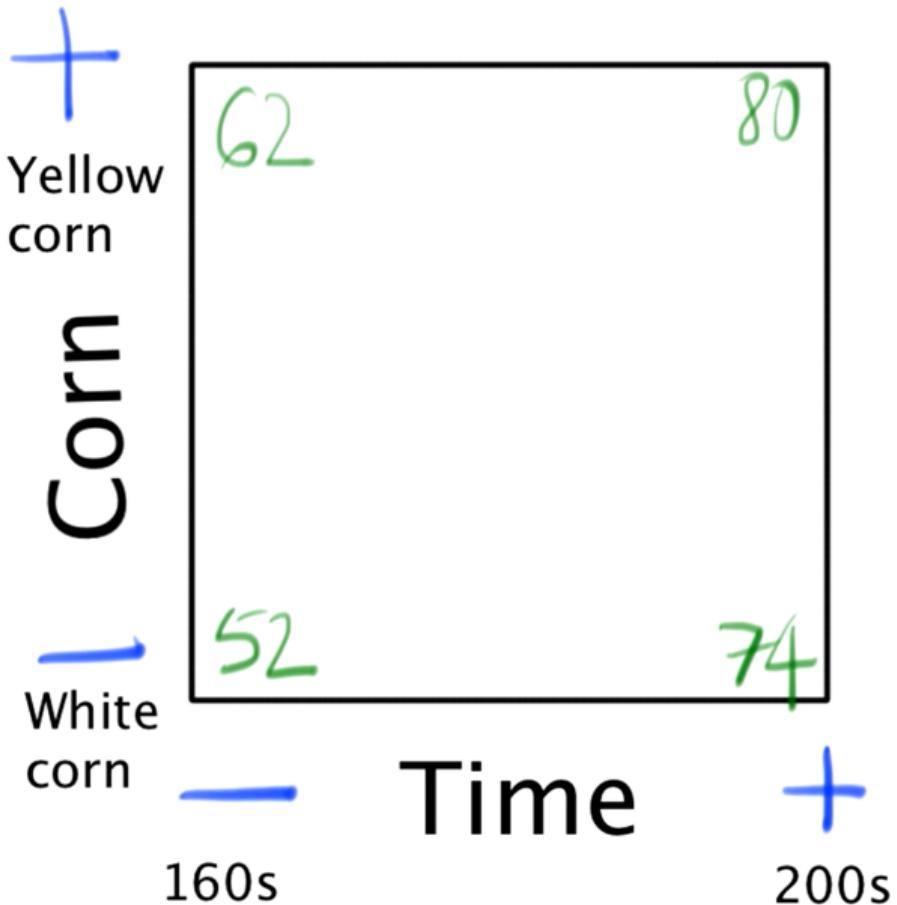
Report it as: 4 extra popped corns for the corn (B) effect.

But note that categorical factors have a messier interpretation.



$$\hat{y} = 67 + 10x_A + 4x_B$$

→
coded variables



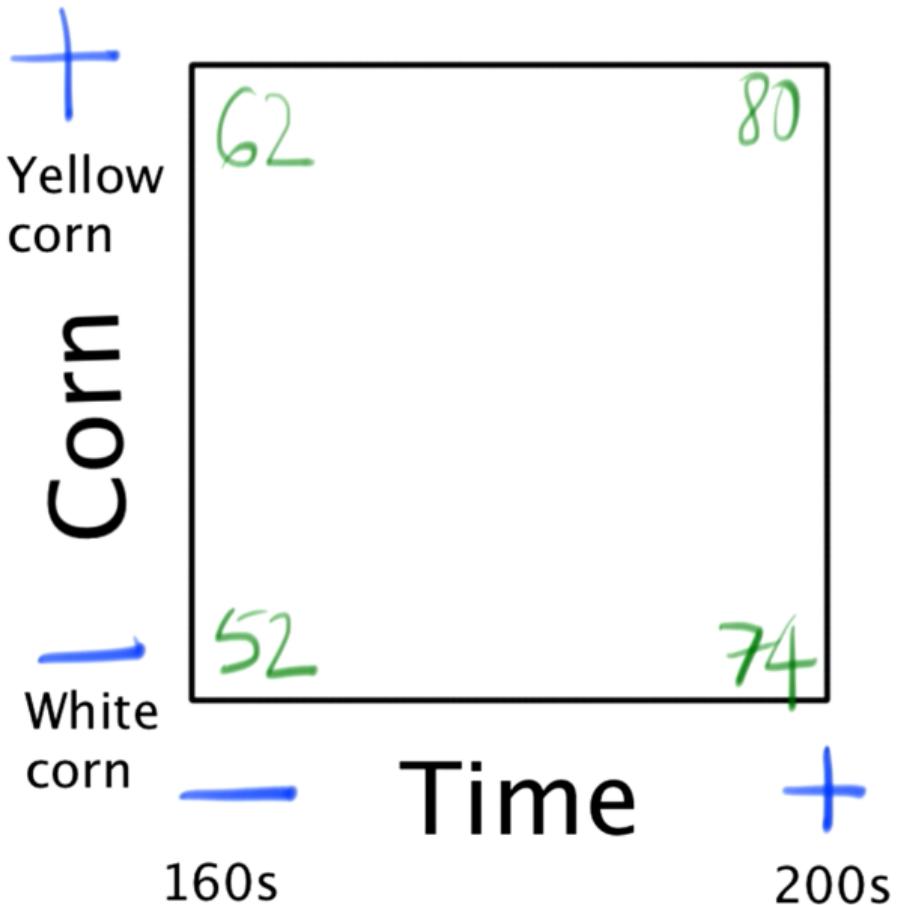
$$\hat{y} = 67 + 10x_A + 4x_B$$




 coded variables
 "to represent"

$x_B = -1$ represents "white corn"

$x_B = +1$ represents "yellow corn"

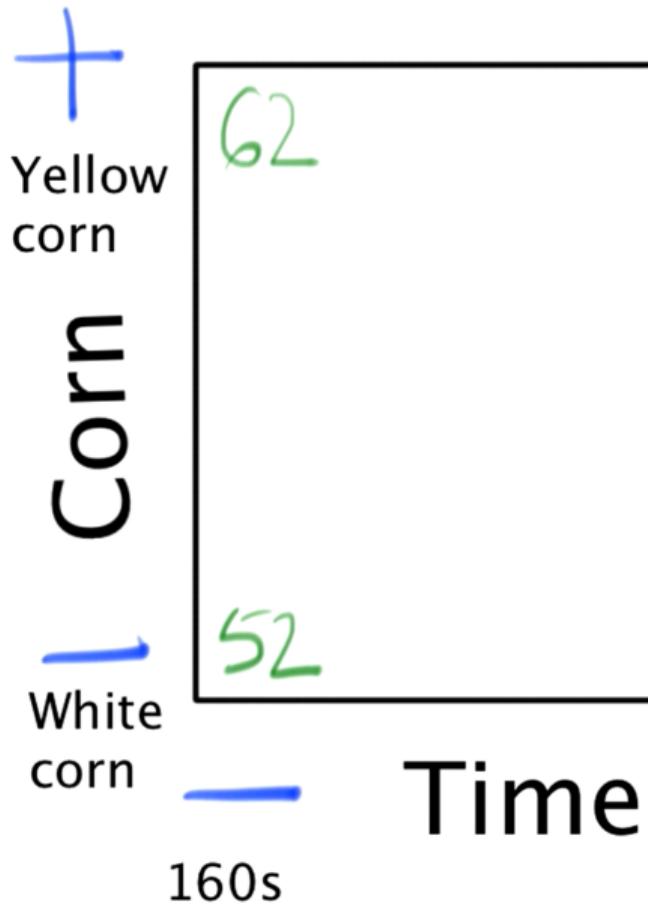


$$\hat{y} = 67 + 10x_A + 4x_B$$

coded variables
 "to represent"

$x_A = -1$ represents 160 seconds

$x_A = +1$ represents 200 seconds



$$\hat{y} = 67 + 10x_A + 4x_B$$

→ coded variables
 "to represent"

$$x_A = \underline{\hspace{2cm}}$$

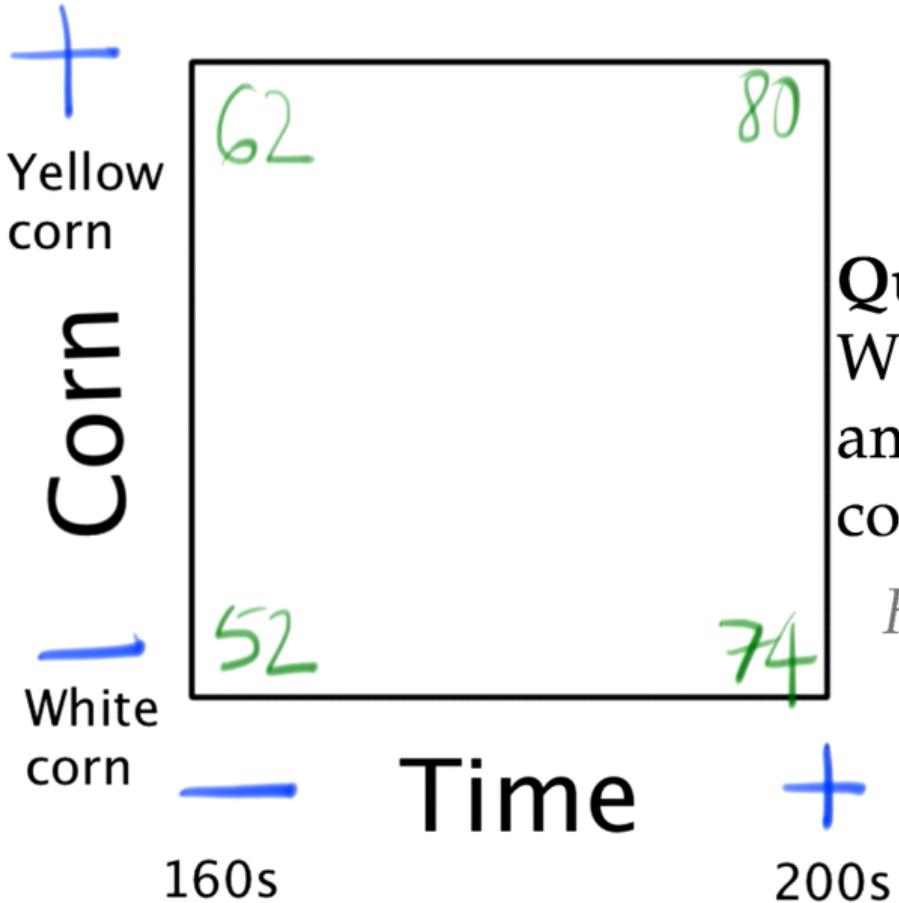
represents 180 seconds

$$x_A = \underline{\hspace{2cm}} 0.5$$

represents 190 seconds

coded
 units

real-world
 values

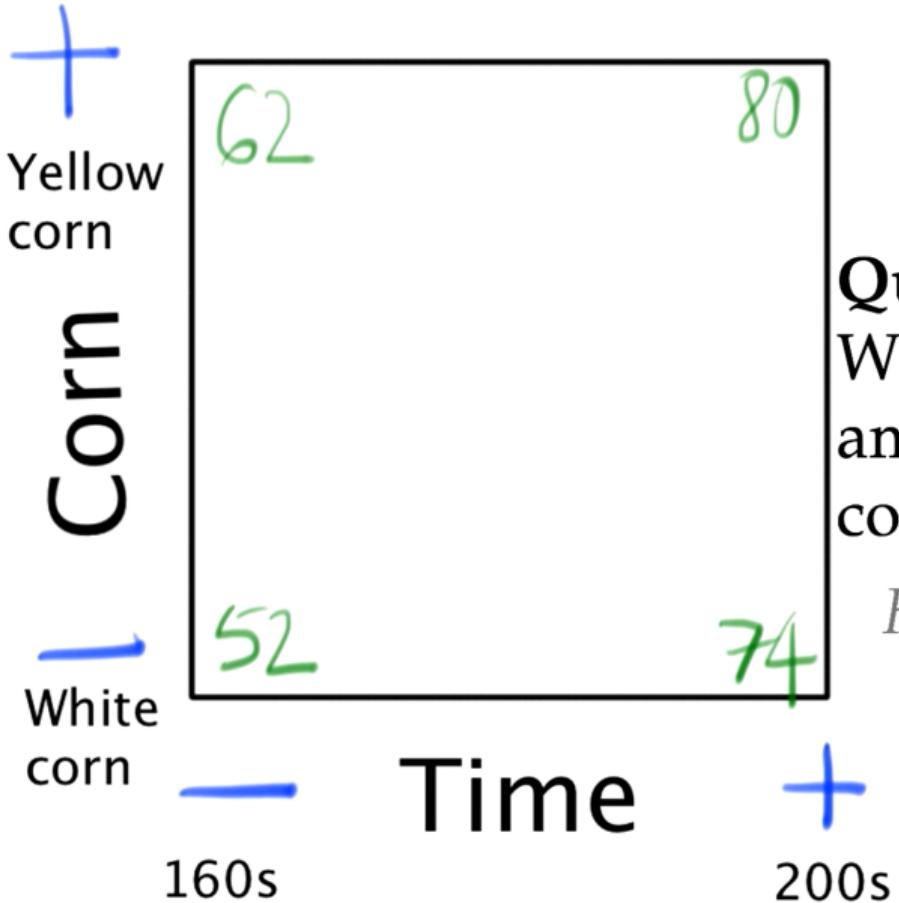


$$\hat{y} = 67 + 10x_A + 4x_B$$

Question

What is the predicted popcorn amount for white corn and a cooking time of 200 seconds?

Hint: $x_A = +1$ and $x_B = -1$



$$\hat{y} = 67 + 10x_A + 4x_B$$

Question

What is the predicted popcorn amount for white corn and a cooking time of 200 seconds?

Hint: $x_A = +1$ and $x_B = -1$

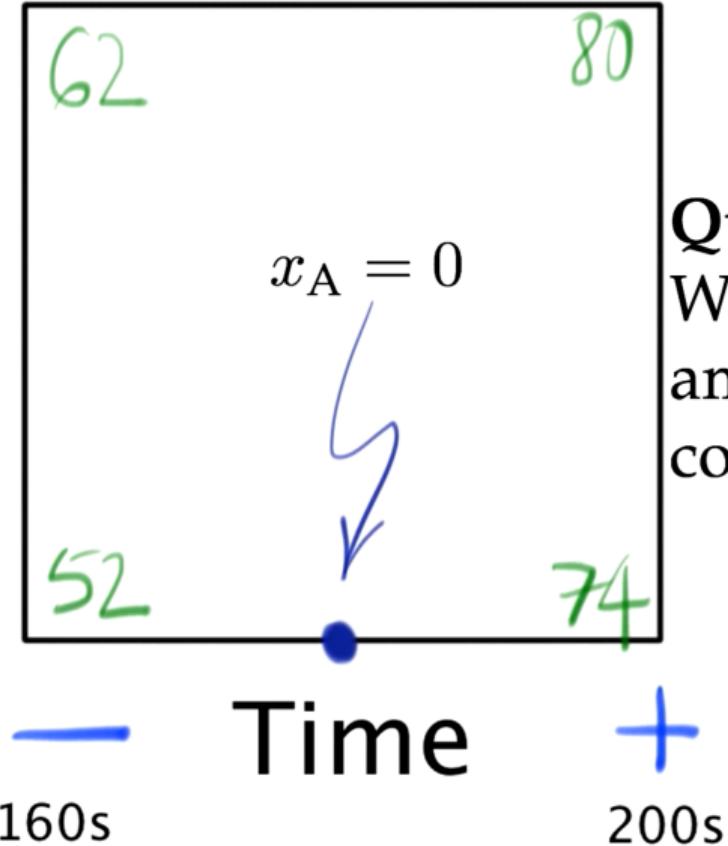
$$\begin{aligned}
 \hat{y} &= 67 + (10)(+1) + (4)(-1) \\
 &= 67 + 10 - 4 = 73
 \end{aligned}$$

+

Yellow
corn

Corn

White
corn

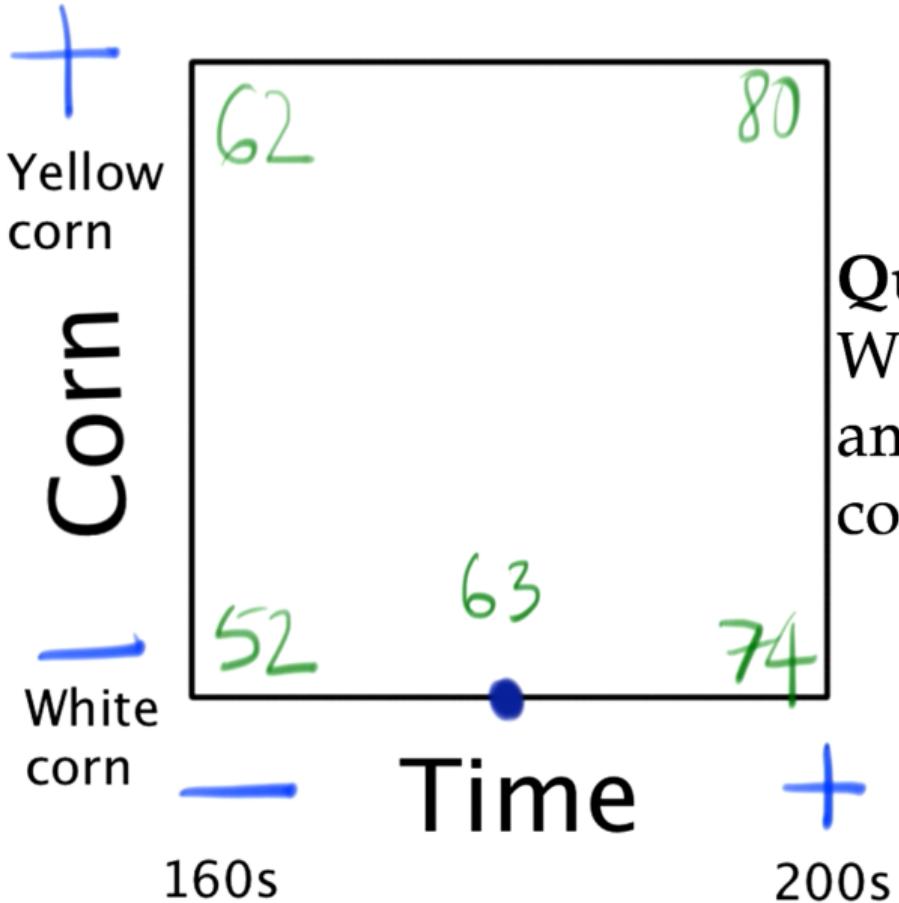


$$\hat{y} = 67 + 10x_A + 4x_B$$

Question

What is the predicted popcorn amount for white corn and a cooking time of **180 seconds**?

Hint: Visualize this point on the cube plot



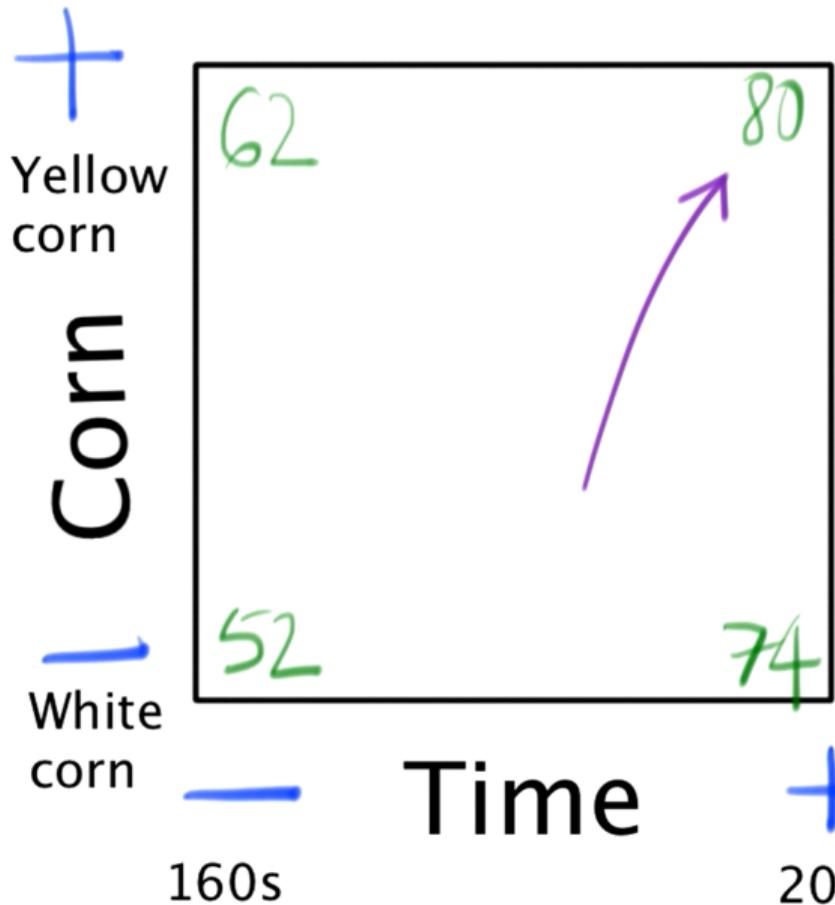
$$\hat{y} = 67 + 10x_A + 4x_B$$

Question

What is the predicted popcorn amount for white corn and a cooking time of **180 seconds**?

$$\hat{y} = 67 + (10)(0) + (4)(-1)$$

$$\hat{y} = 67 + 0 - 4 = \underline{\underline{63}}$$



$$\hat{y} = \underline{67} + \underline{10}x_A + \underline{4}x_B$$

Predicted popcorn = \hat{y}

$$\hat{y} = 67 + \underbrace{(10)(+1)}_{A \text{ effect}} + \underbrace{(4)(+1)}_{B \text{ effect}}$$

$$\hat{y} = 67 + 10 + 4$$

$$\hat{y} = 81 \text{ (close to 80)}$$