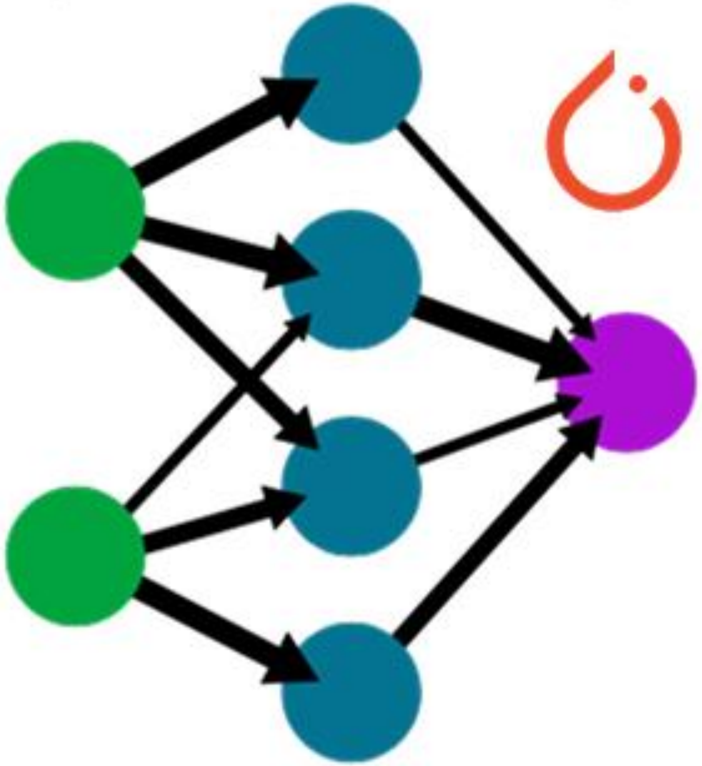
# Introducción a la IA & ML III: Redes Neuronales



Hugo Centeno Sanz
4to Ingeniería de Datos y Teleco

IA

IA

IA

**IA**

IA

IA

**Sreekanth Kumbha** • 3rd+ 1w •••
Consultant- Technology Management ,SeMT i...

I can suggest an equation that has the potential to impact the future:

$E = mc^2 + AI$

This equation combines Einstein's famous equation $E=mc^2$, which relates energy (E) to mass (m) and the speed of light (c), with the addition of AI (Artificial Intelligence). By including AI in the equation, it symbolizes the increasing role of artificial intelligence in shaping and transforming our future. This equation highlights the potential for AI to unlock new forms of energy, enhance scientific discoveries, and revolutionize various fields such as healthcare, transportation, and technology.

Like • 3 | Reply • 3 replies

**Taosif Ahsan** (He/Him) • 3rd+ 4d •••
Physics, MIT PhD| Physics/CS, Princeton...

What

Like • 5 | Reply

# Introducción y Objetivos

- Conceptos fundamentales
- Optimización único parámetro con backpropagation
- Optimización mútliples parámetros con backpropagation

# Dinámica

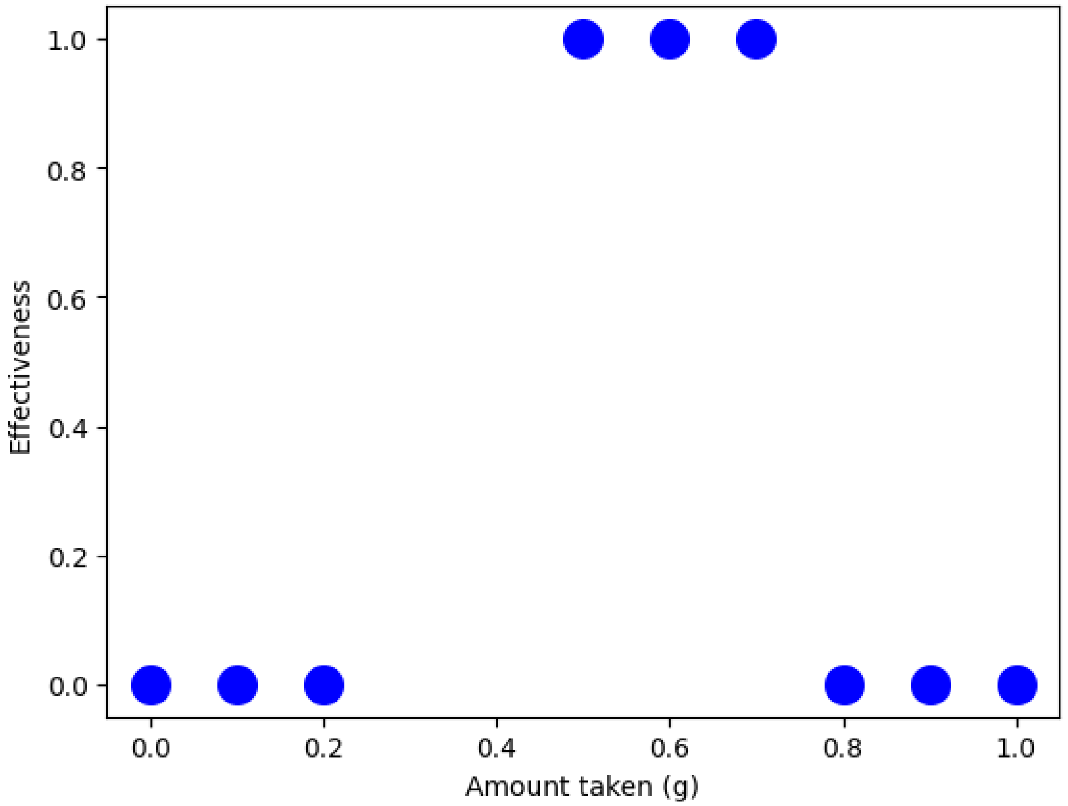
http://www.aiscmadrid.com/events/evento.php?id=12

# Conceptos fundamentales

## Datos

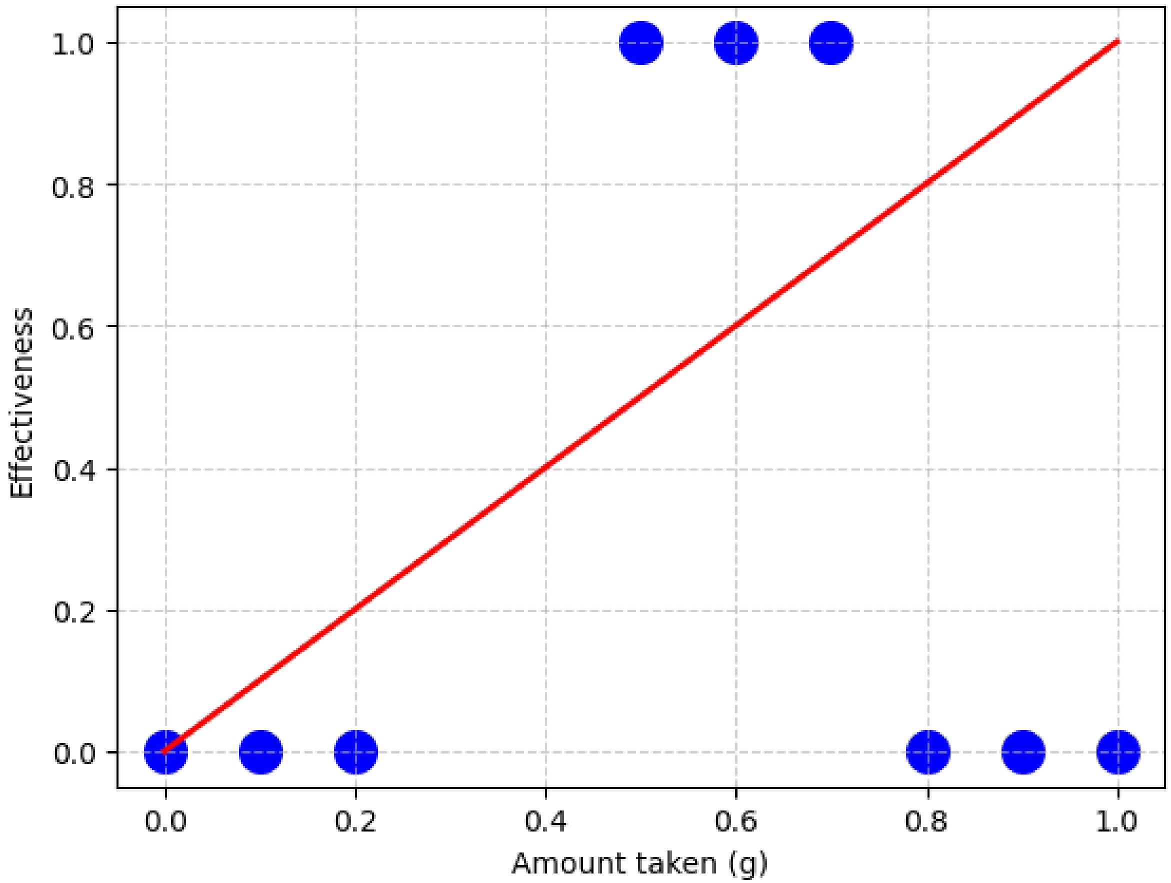
| | Amount taken (g) | % Effectiveness |
|---|---|---|
| 0 | 0.0 | 0.0 |
| 1 | 0.1 | 0.0 |
| 2 | 0.2 | 0.0 |
| 3 | 0.5 | 1.0 |
| 4 | 0.6 | 1.0 |
| 5 | 0.7 | 1.0 |
| 6 | 0.8 | 0.0 |
| 7 | 0.9 | 0.0 |
| 8 | 1.0 | 0.0 |

## Modelarlos



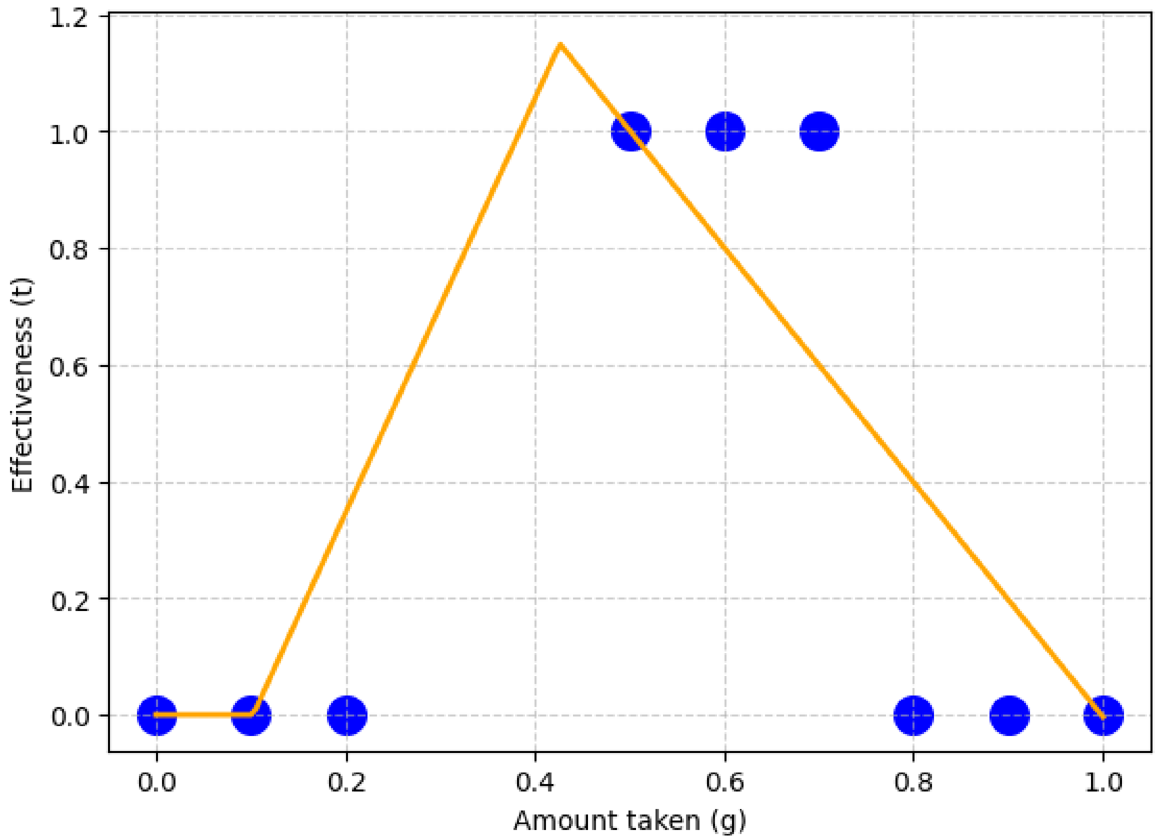
# Conceptos fundamentales

## Mala predicción



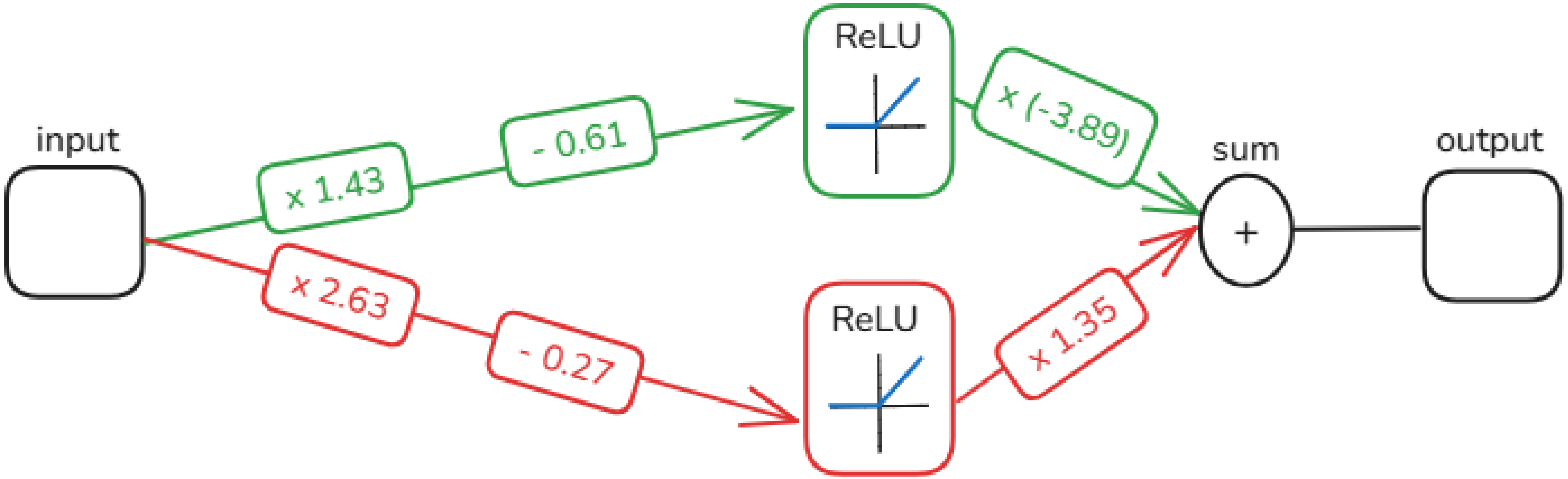
# Conceptos fundamentales

## Predicción de una NN (Neural Network)



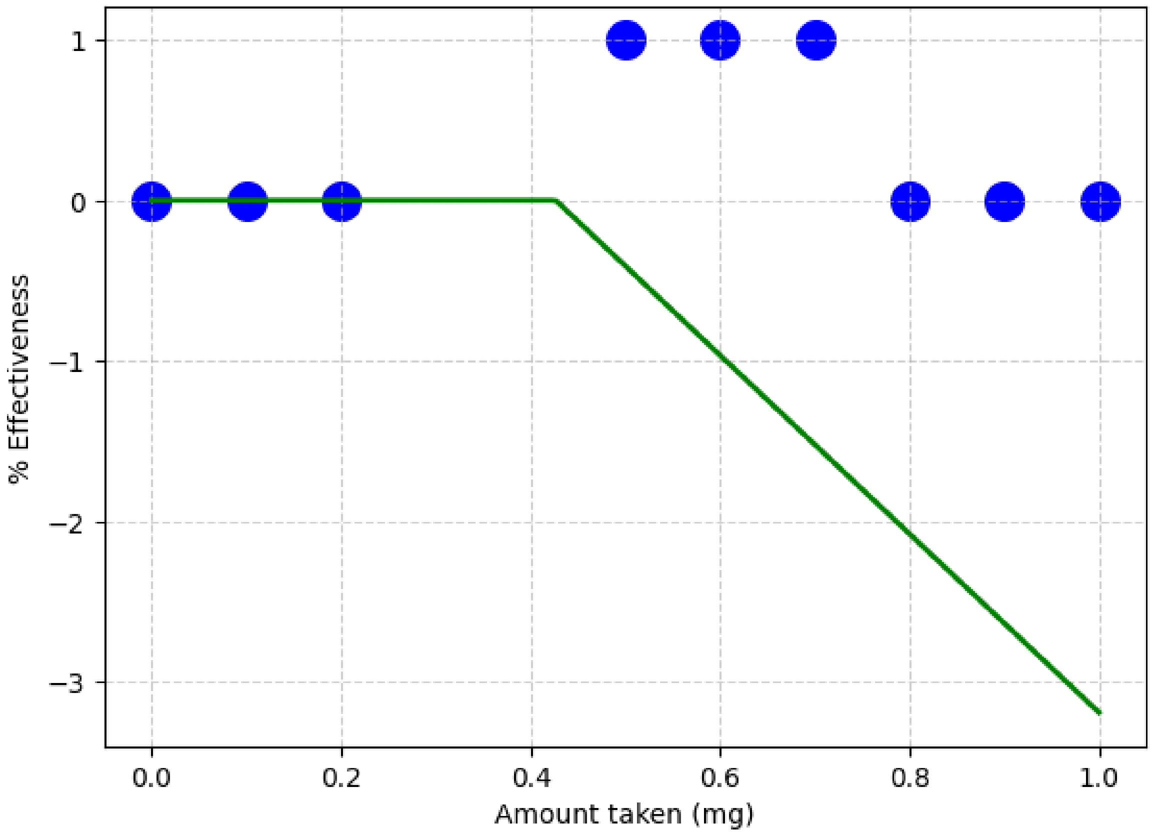
# Conceptos fundamentales

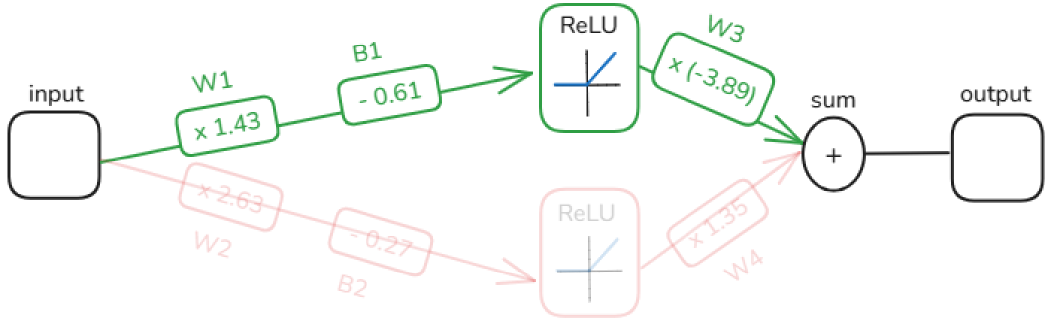
## Predicción de una NN (Neural Network)



# Conceptos fundamentales

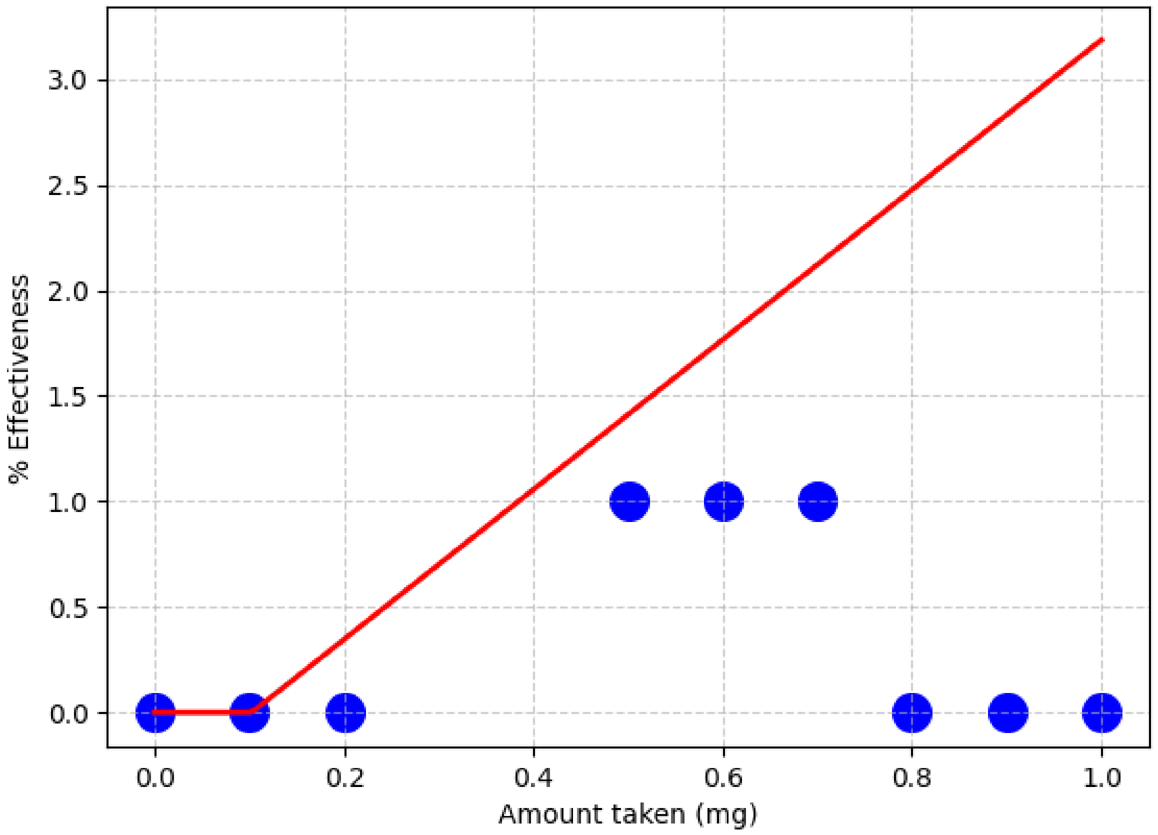
## Predicción de una NN (Neural Network)

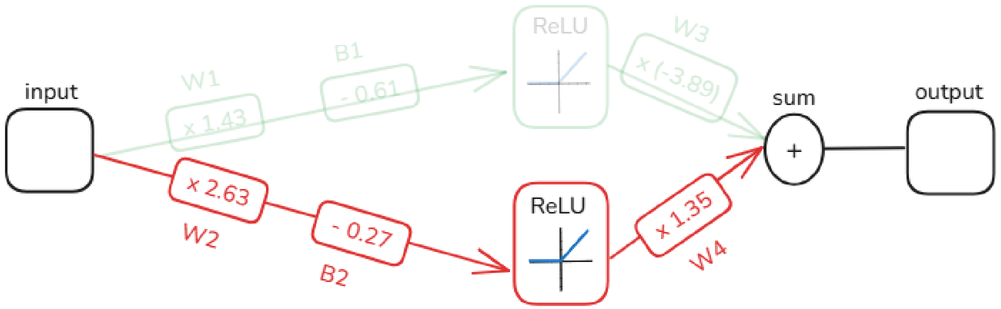


# Conceptos fundamentales

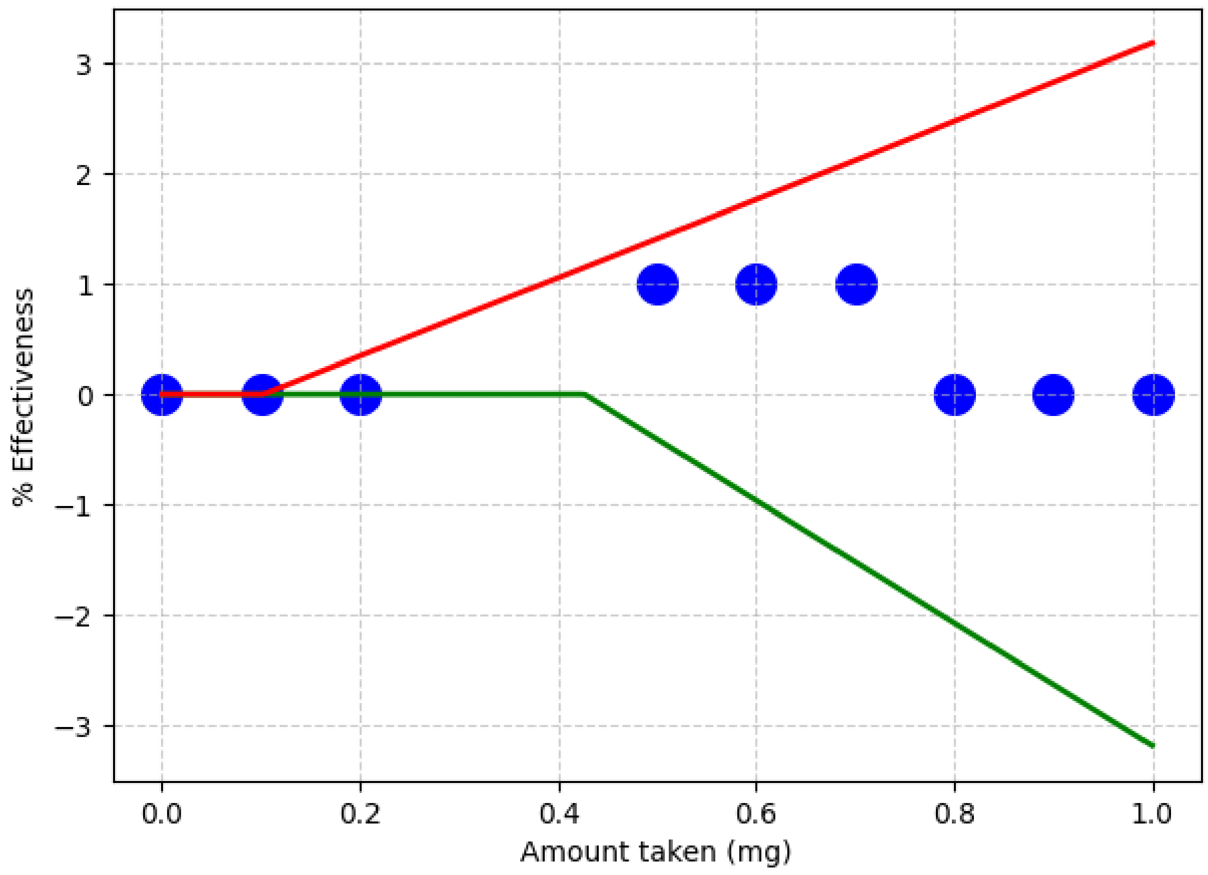
## Predicción de una NN (Neural Network)



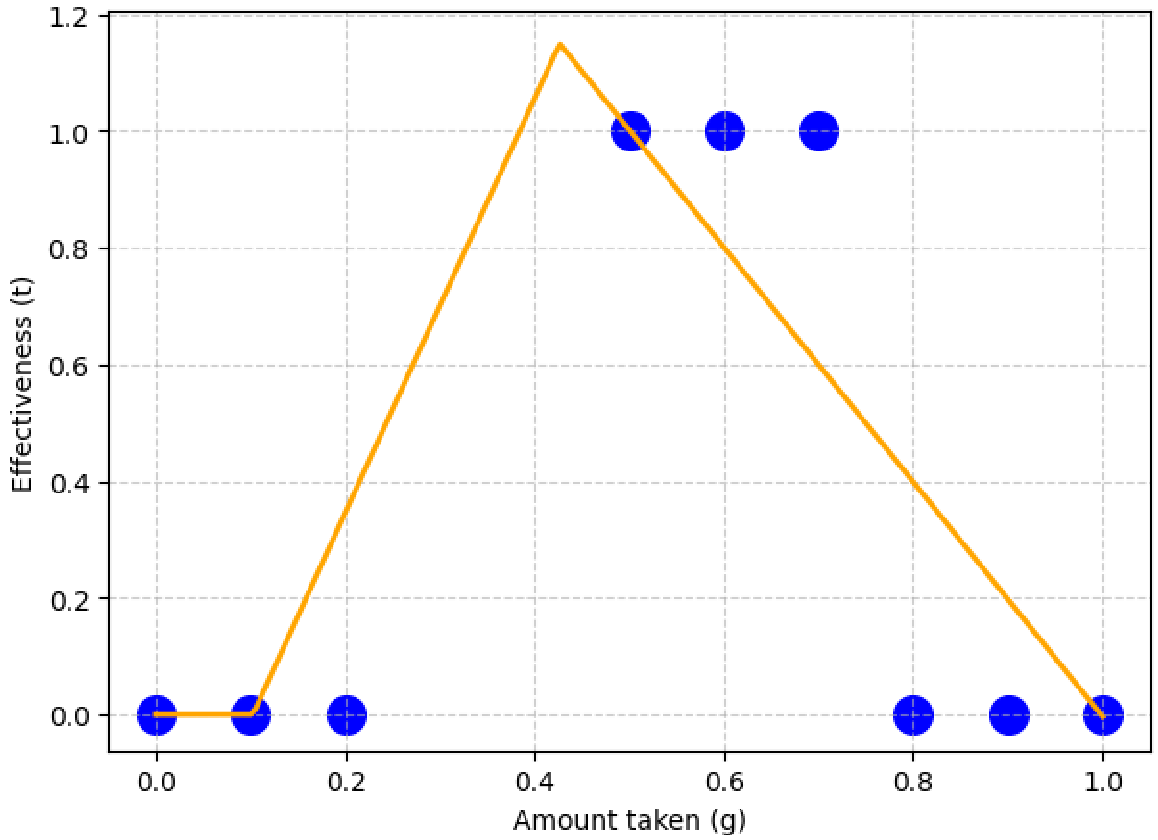
# Conceptos fundamentales

## Predicción de una NN (Neural Network)



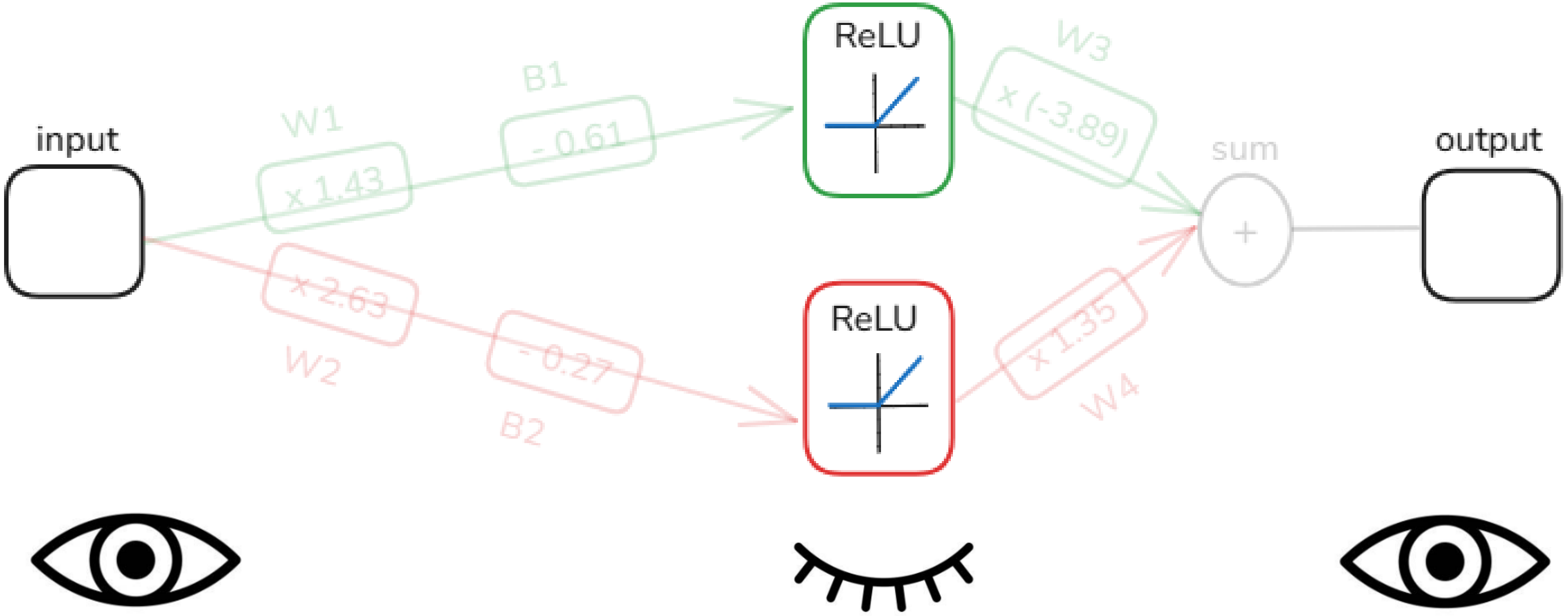
# Conceptos fundamentales

## Predicción de una NN (Neural Network)



# Conceptos fundamentales

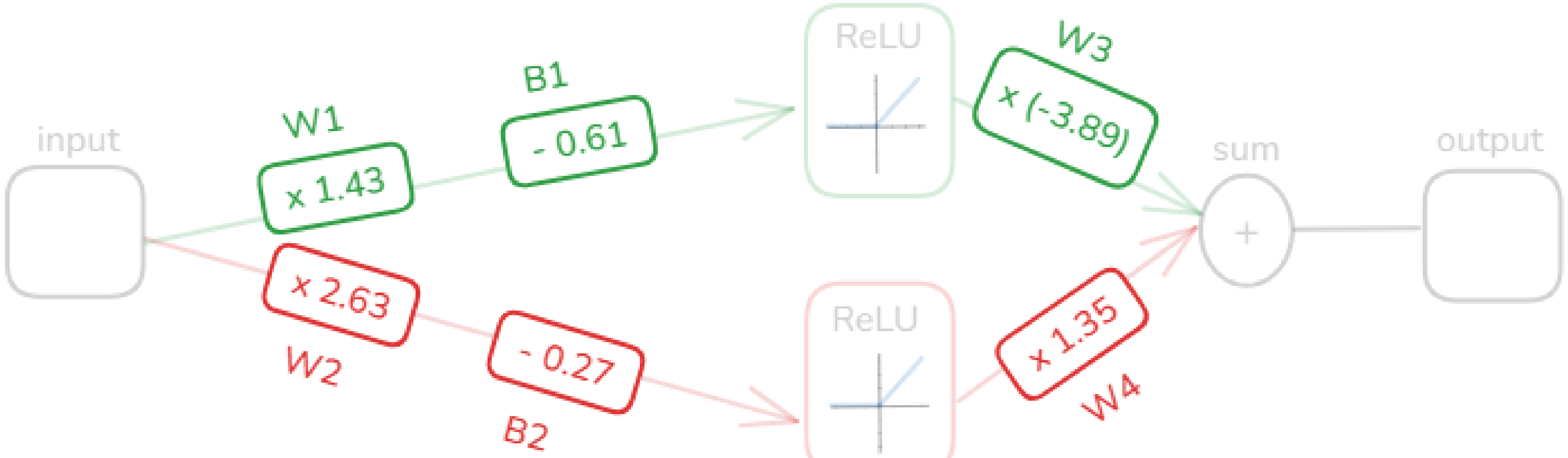
## Nodos



# Conceptos fundamentales

Weights W1, W2, W3, W4(pesos)
Biases B1, B2 (sesgos)

$\left.\begin{array}{l} \\ \\ \end{array}\right\}$ Parameters



# Conceptos fundamentales

Entrenar un modelo = Modificar el valor de los parámetros

# Conceptos fundamentales

¿Cuántos parámetros?

“We are releasing two model sizes: gpt-oss-**120b**, which consists of **36 layers**…”[1]

[1] gpt-oss-120b & gpt-oss-20b Model Card. OpenAI. https://arxiv.org/pdf/2508.10925

# Conceptos fundamentales

Activation functions (funciones de activación)

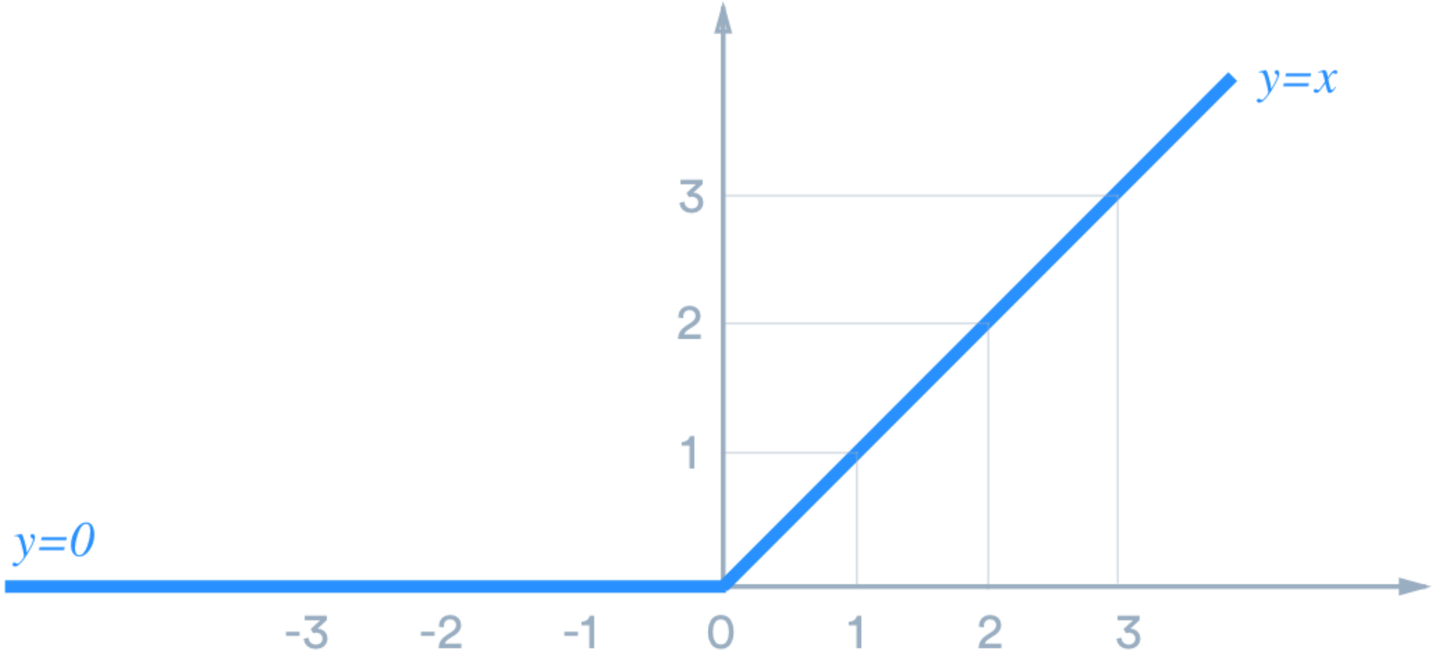
**ReLU** (Rectified Linear Unit)

$$f(x) = max\ (0, x)$$

# Conceptos fundamentales

Activation functions (funciones de activación)

**ReLU** (Rectified Linear Unit)



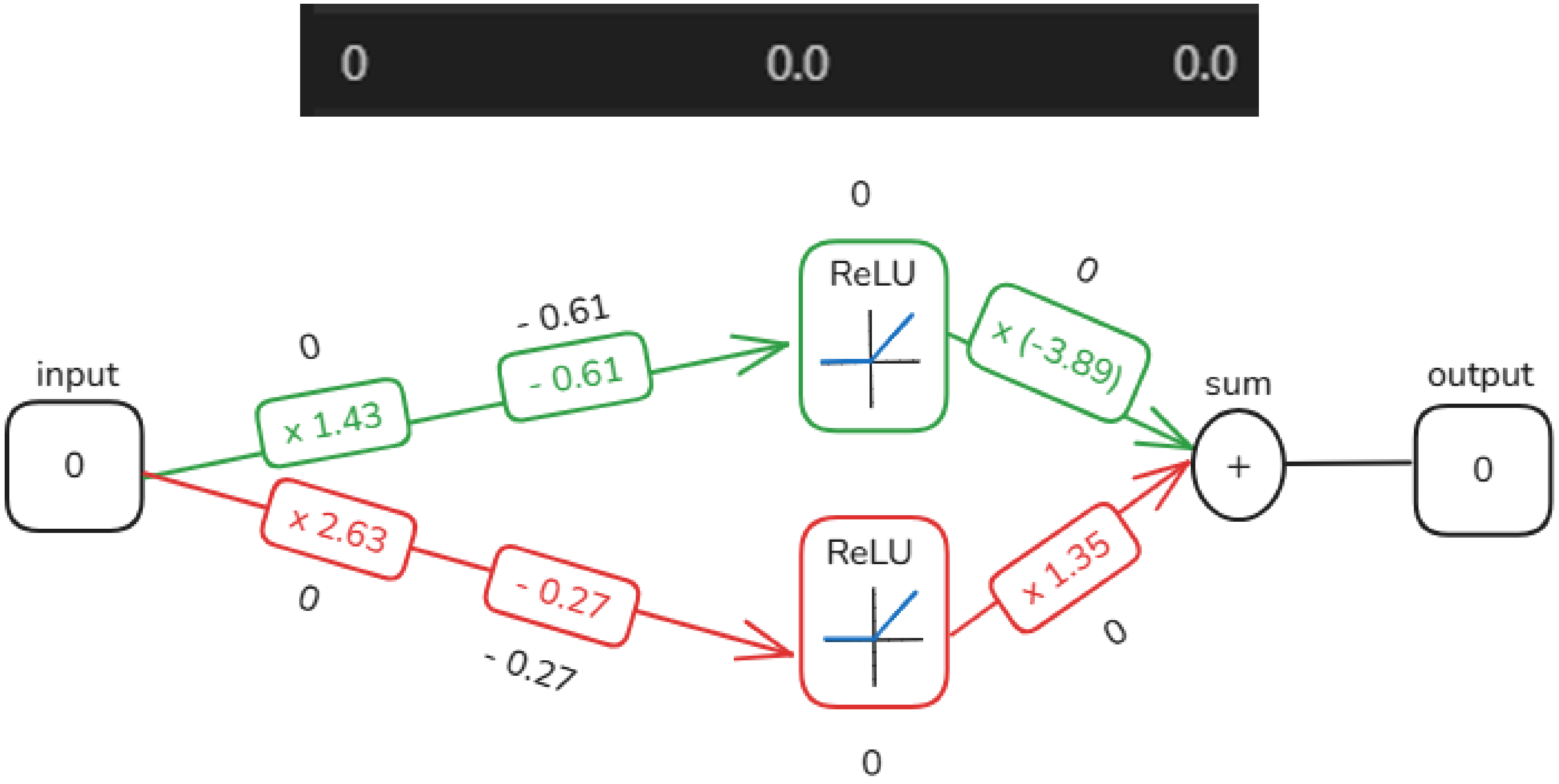
# Conceptos fundamentales

Pass Forward (propagación hacia delante)

| | Amount taken (g) | % Effectiveness |
|---|---|---|
| 0 | 0.0 | 0.0 |
| 1 | 0.1 | 0.0 |
| 2 | 0.2 | 0.0 |
| 3 | 0.5 | 1.0 |
| 4 | 0.6 | 1.0 |
| 5 | 0.7 | 1.0 |
| 6 | 0.8 | 0.0 |
| 7 | 0.9 | 0.0 |
| 8 | 1.0 | 0.0 |

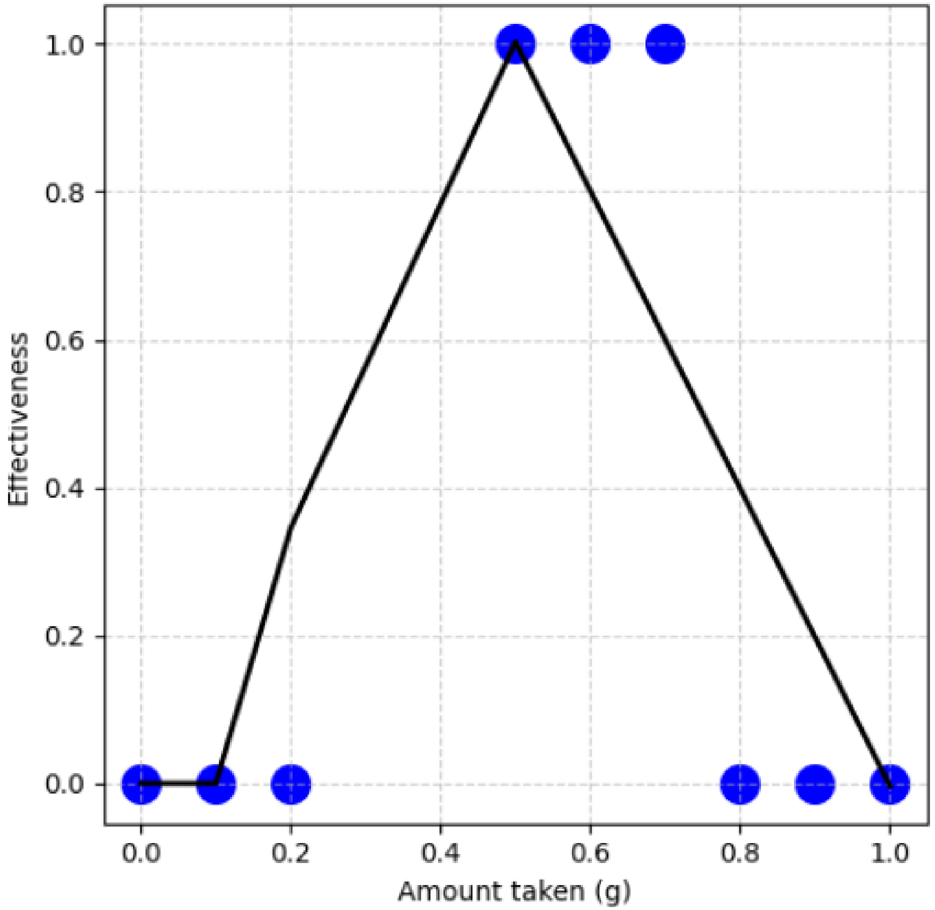
# Conceptos fundamentales

## Pass Forward (propagación hacia delante)



# Conceptos fundamentales

## Pass Forward (propagación hacia delante)



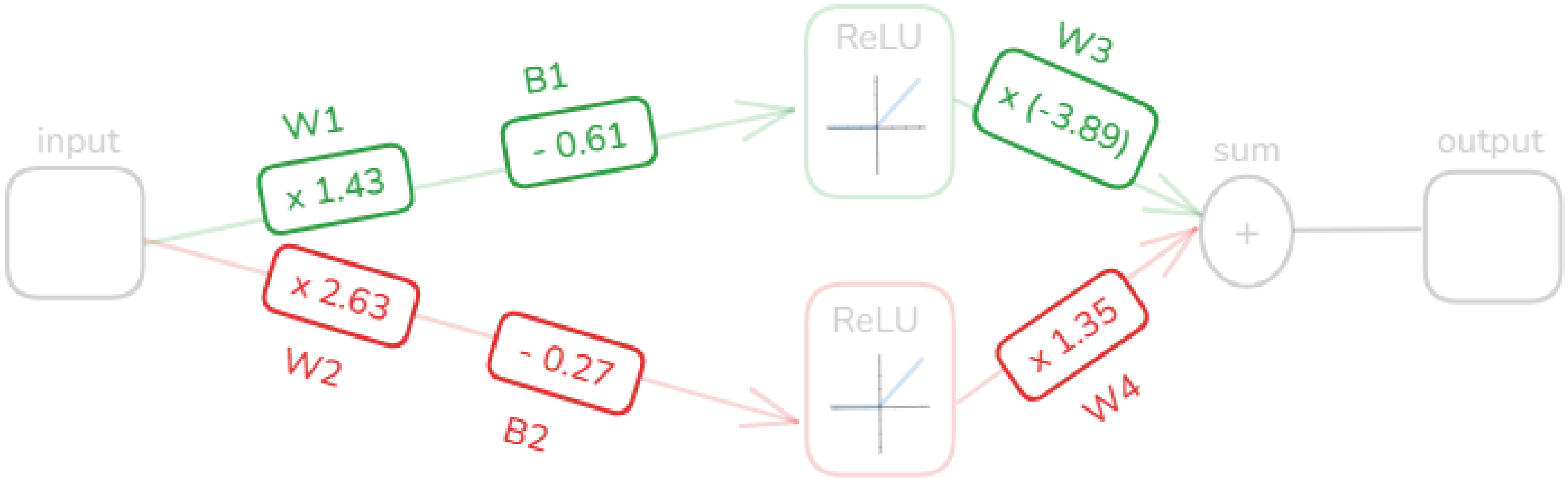
# Conceptos fundamentales

¡Práctica!

# Optimización único parámetro con backpropagation

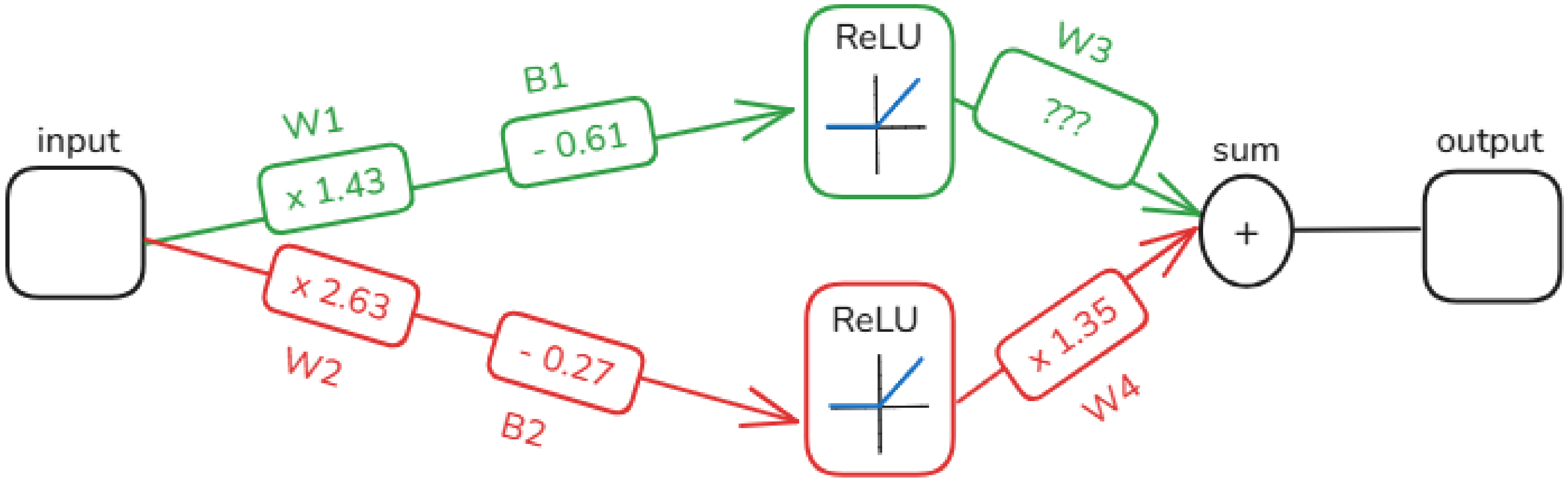
Weights W1, W2, W3, W4

Biases B1, B2



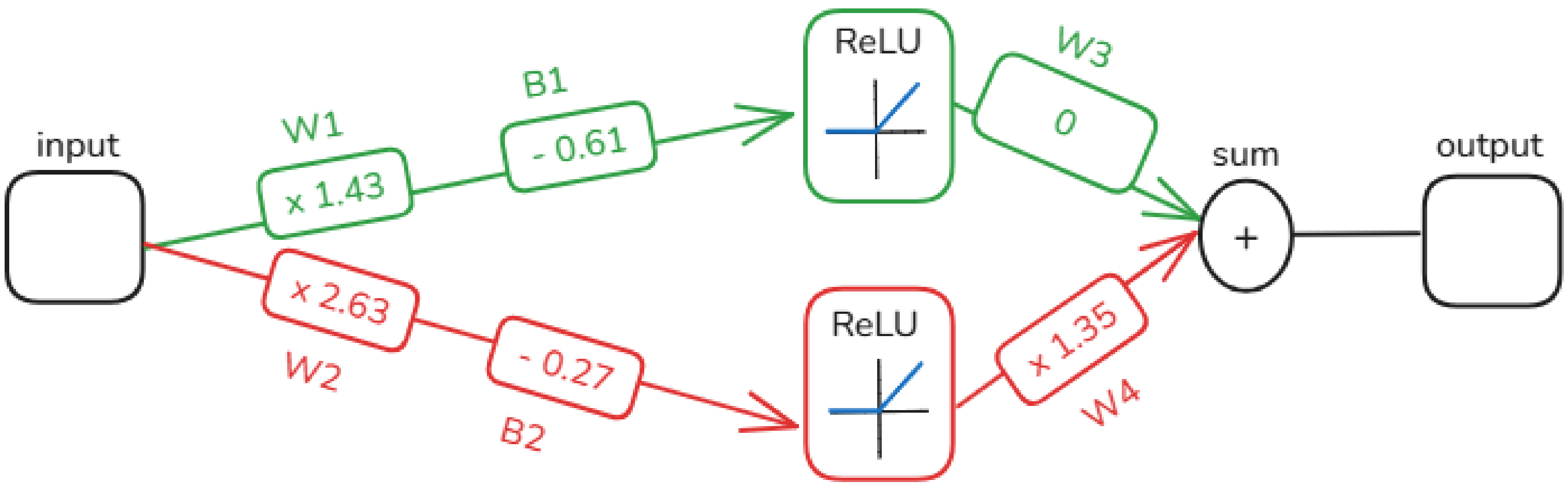
# Optimización único parámetro con backpropagation

W3 única desconocida

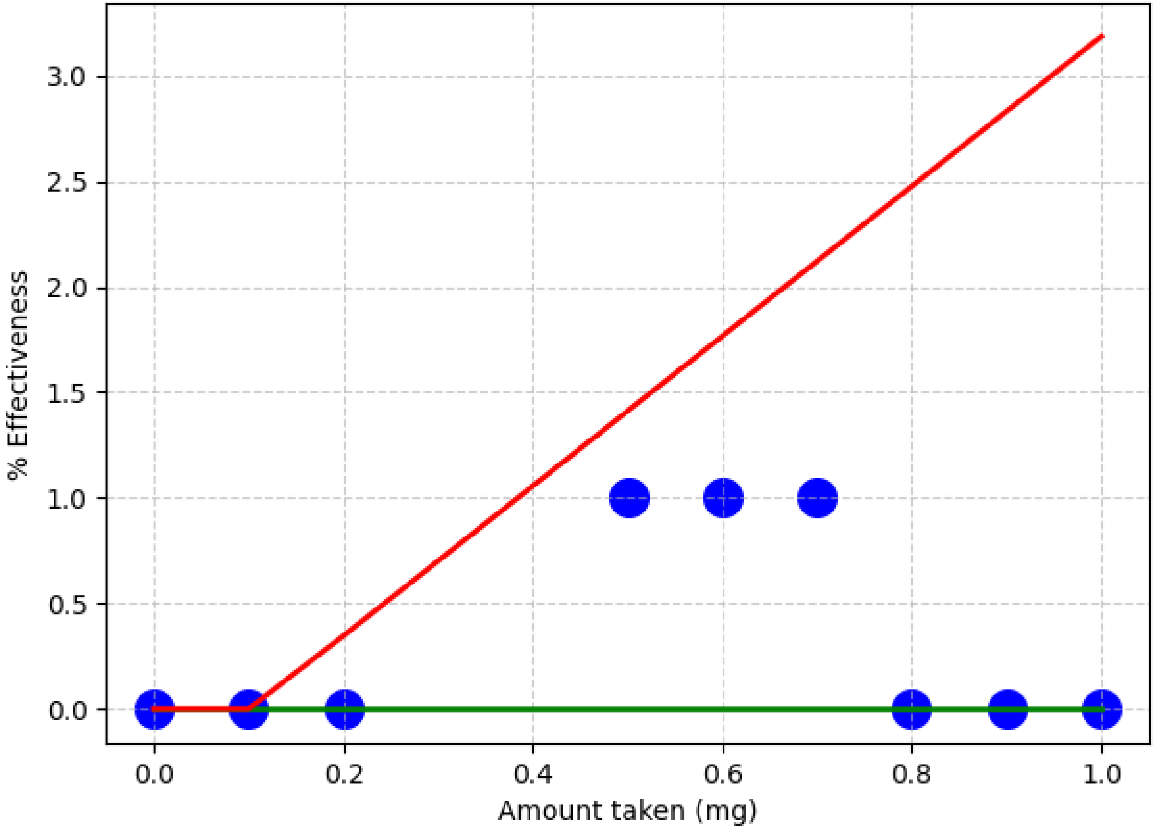


# Optimización único parámetro con backpropagation

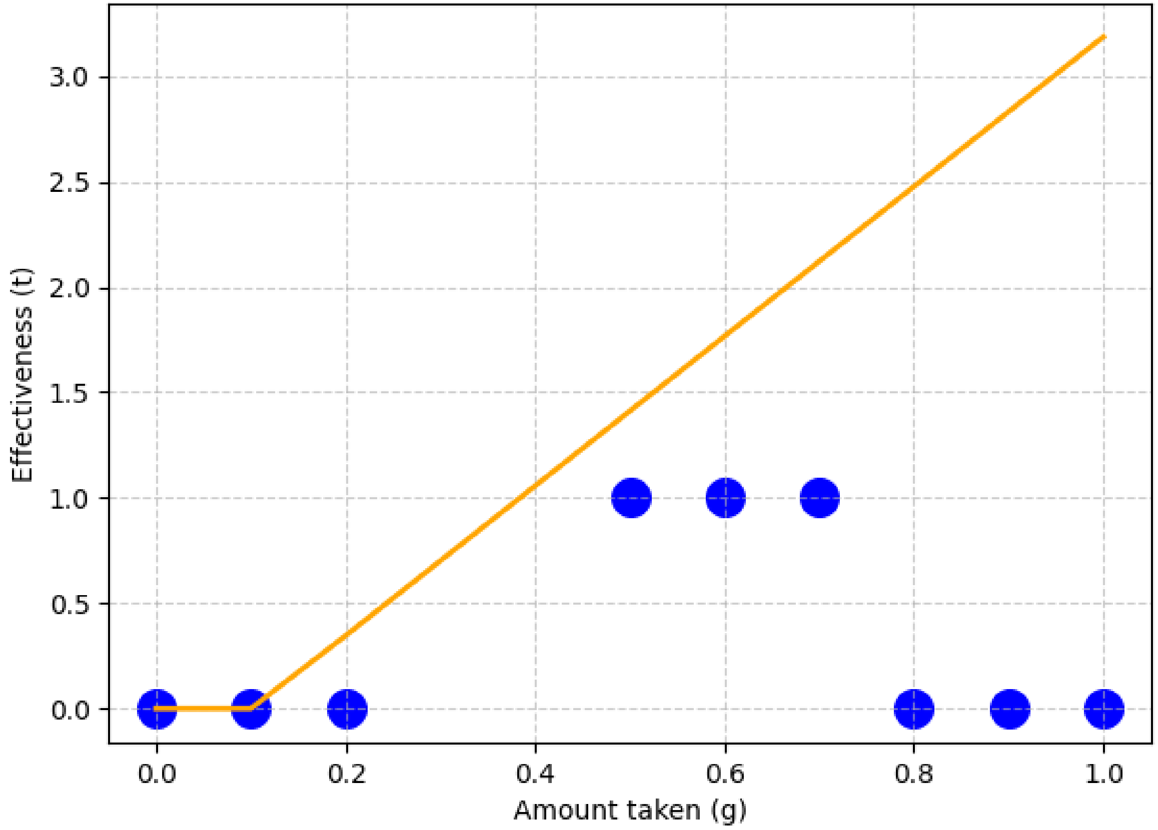
Suponemos W3 = 0



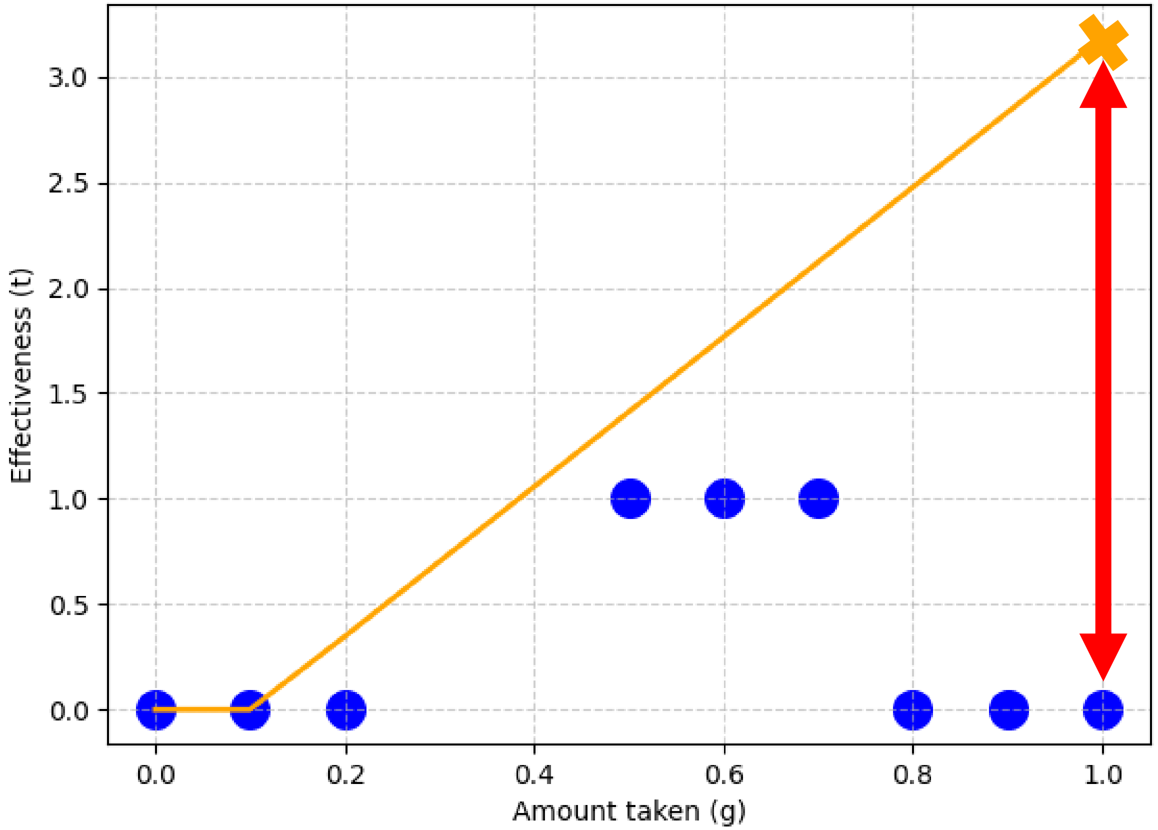
# Optimización único parámetro con backpropagation



# Optimización único parámetro con backpropagation



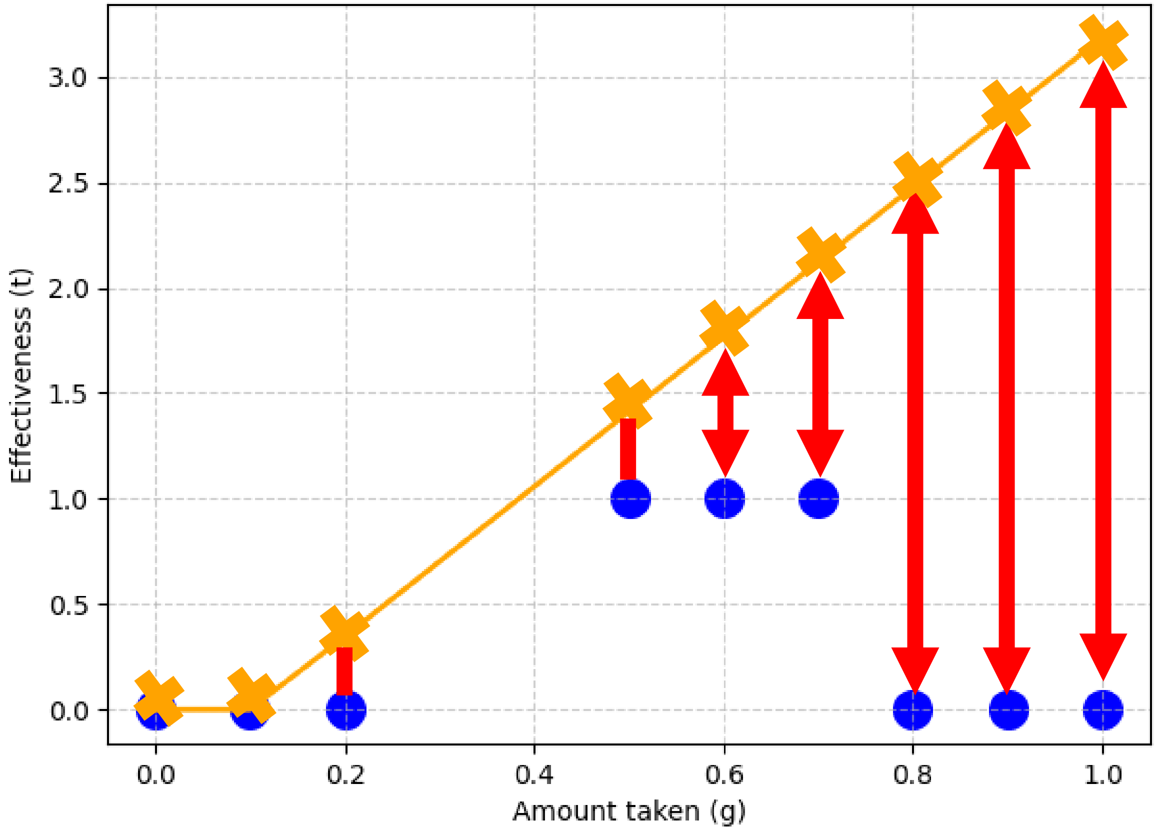
# Optimización único parámetro con backpropagation




Cuantificar cómo de mala es **una única predicción**: Residual

Residual = Observed - Predicted

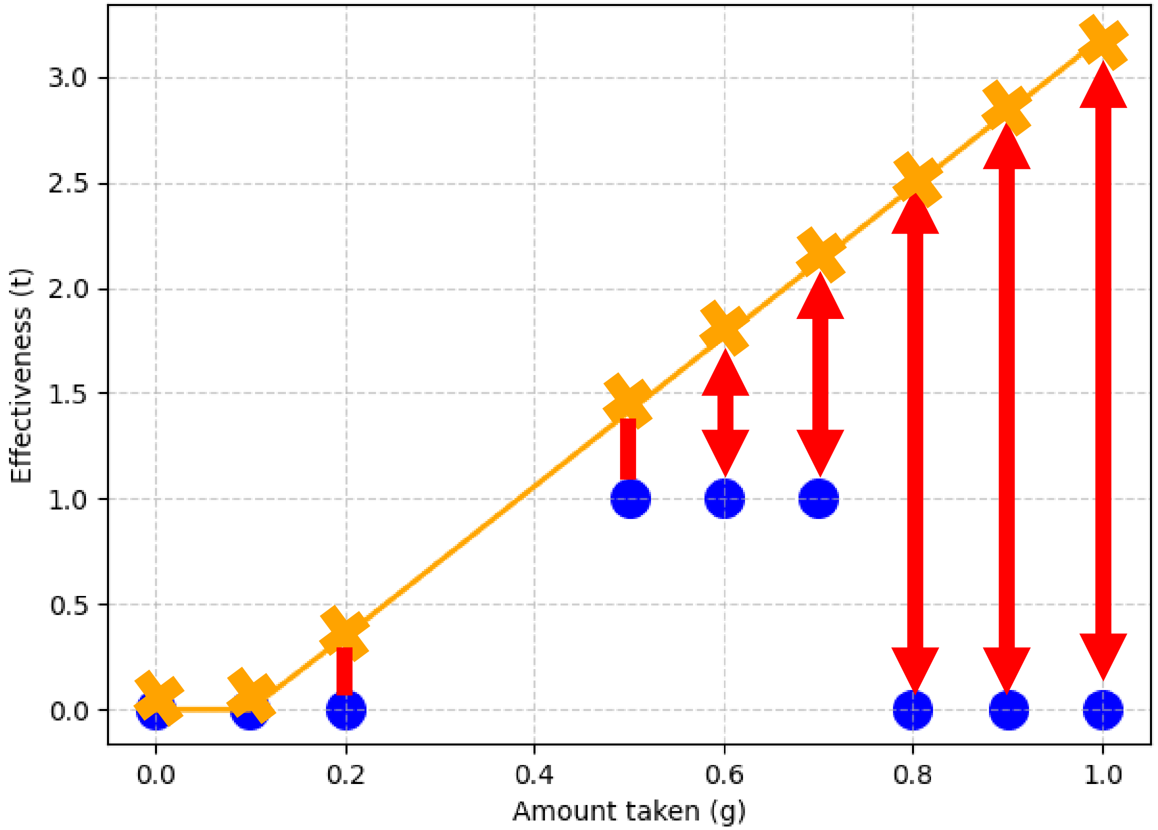
# Optimización único parámetro con backpropagation




Cuantificar cómo de malo es un modelo (**conjunto de predicciones**): Sum Square of Residuals

SSR $=\sum_i^n Residual_i^2$

# Optimización único parámetro con backpropagation




## Residuals

| | |
|---|---|
| 0 | 0.00000 |
| 1 | 0.00000 |
| 2 | -0.34560 |
| 3 | -0.41075 |
| 4 | -0.76580 |
| 5 | -1.12085 |
| 6 | -2.47590 |
| 7 | -2.83095 |
| 8 | -3.18600 |

## Residuals^2

| | |
|---|---|
| 0 | 0.000000 |
| 1 | 0.000000 |
| 2 | 0.119439 |
| 3 | 0.168716 |
| 4 | 0.586450 |
| 5 | 1.256305 |
| 6 | 6.130081 |
| 7 | 8.014278 |
| 8 | 10.150596 |

# Optimización único parámetro con backpropagation

If w3 = 0 ->SSR $=\sum_i^n Residual_i^2 = 26.42$

Residuals^2

| | |
|---|---|
| 0 | 0.000000 |
| 1 | 0.000000 |
| 2 | 0.119439 |
| 3 | 0.168716 |
| 4 | 0.586450 |
| 5 | 1.256305 |
| 6 | 6.130081 |
| 7 | 8.014278 |
| 8 | 10.150596 |

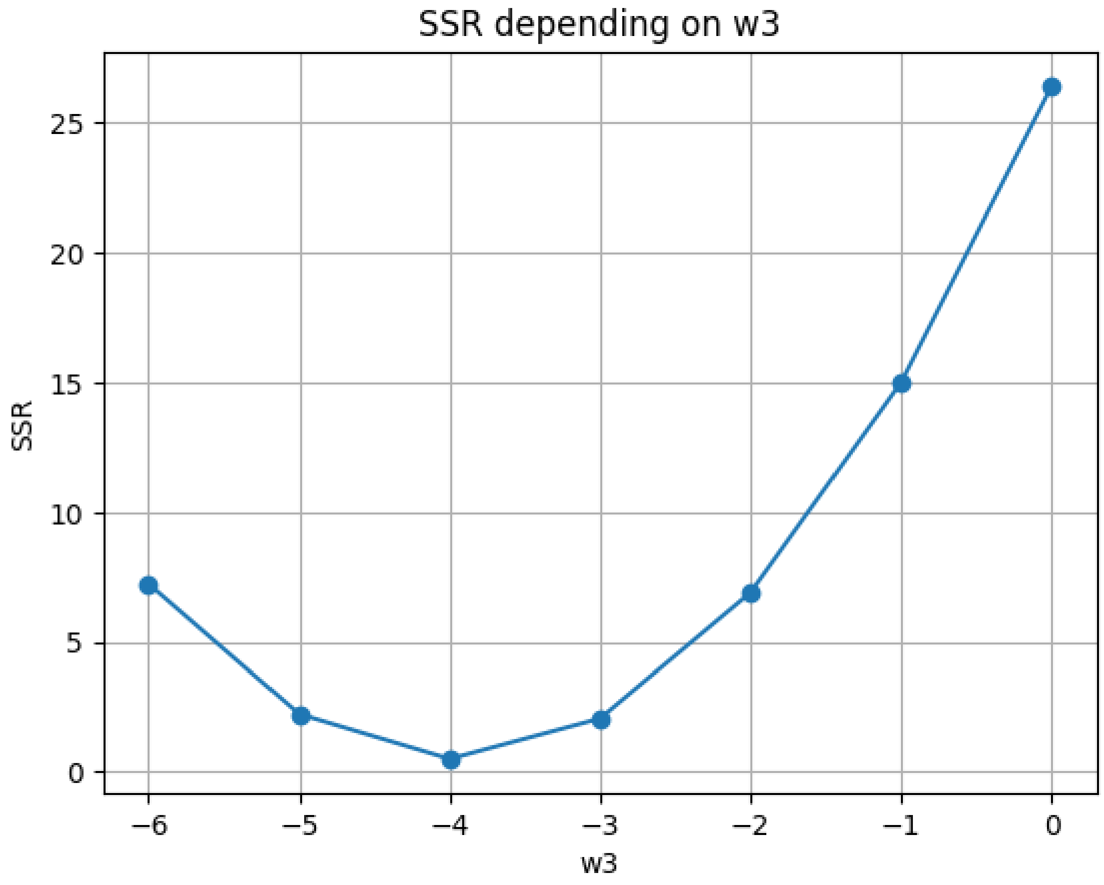
# Optimización único parámetro con backpropagation

If w3 = 0 ->SSR =$\sum_i^n Residual_i^2 = 26.42$

| | |
|---|---|
| -6 | 7.24 |
| -5 | 2.23 |
| -4 | 0.5 |
| -3 | 2.06 |
| -2 | 6.9 |
| -1 | 15.02 |

| w3 | SSR |
|---|---|
| -6 | 7.242445 |
| -5 | 2.233206 |
| -4 | 0.506558 |
| -3 | 2.062499 |
| -2 | 6.901031 |
| -1 | 15.022152 |
| 0 | 26.425864 |

# Optimización único parámetro con backpropagation

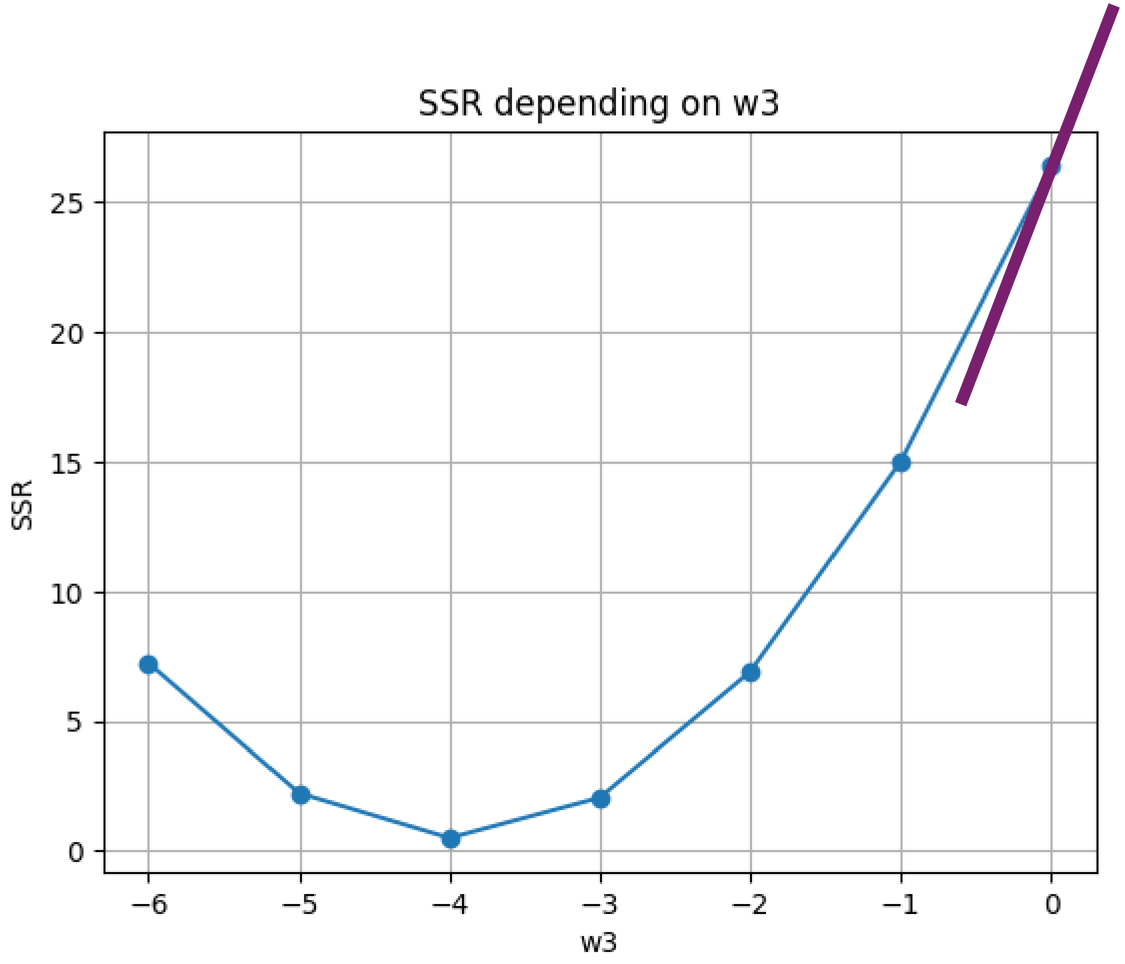


# Optimización único parámetro con backpropagation

Objetivo: optimizar SSR ($\sum_{i}^{n} Residual_{i}^{2}$)

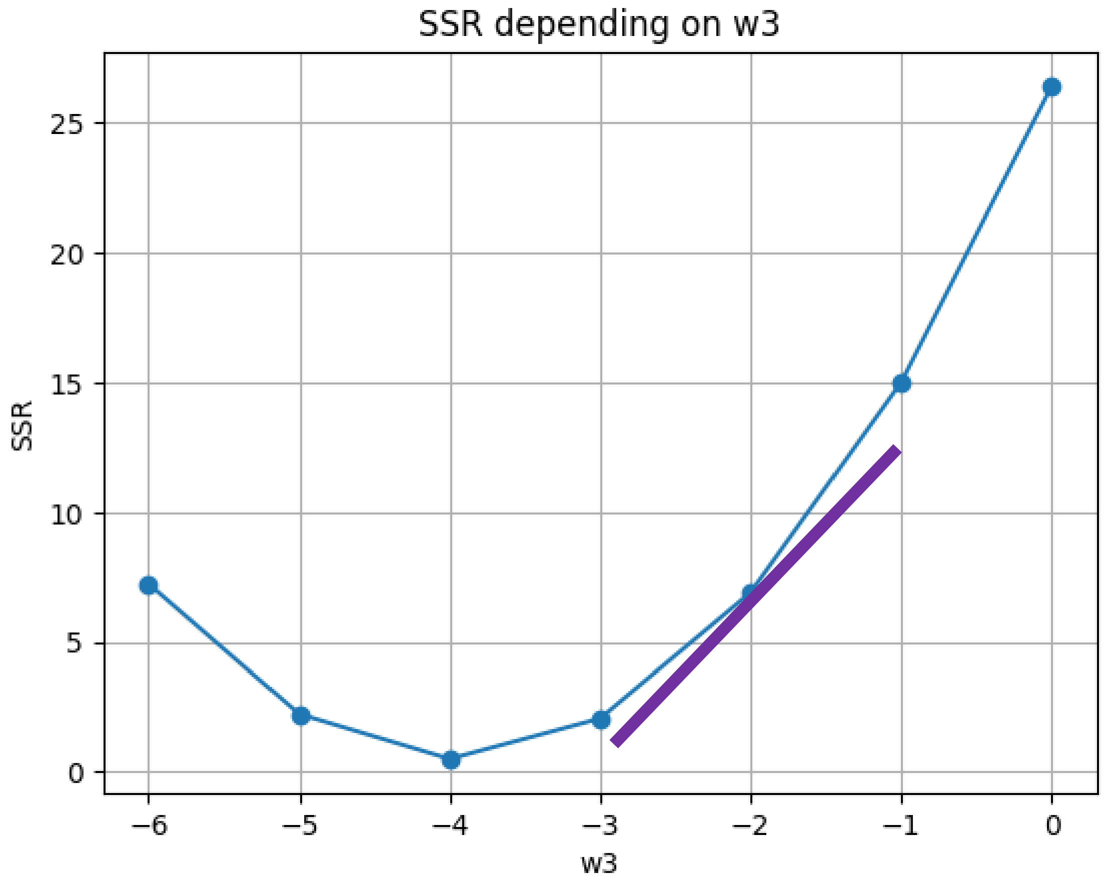
Objetivo: optimizar **Loss Function** (función de pérdida)

# Optimización único parámetro con backpropagation



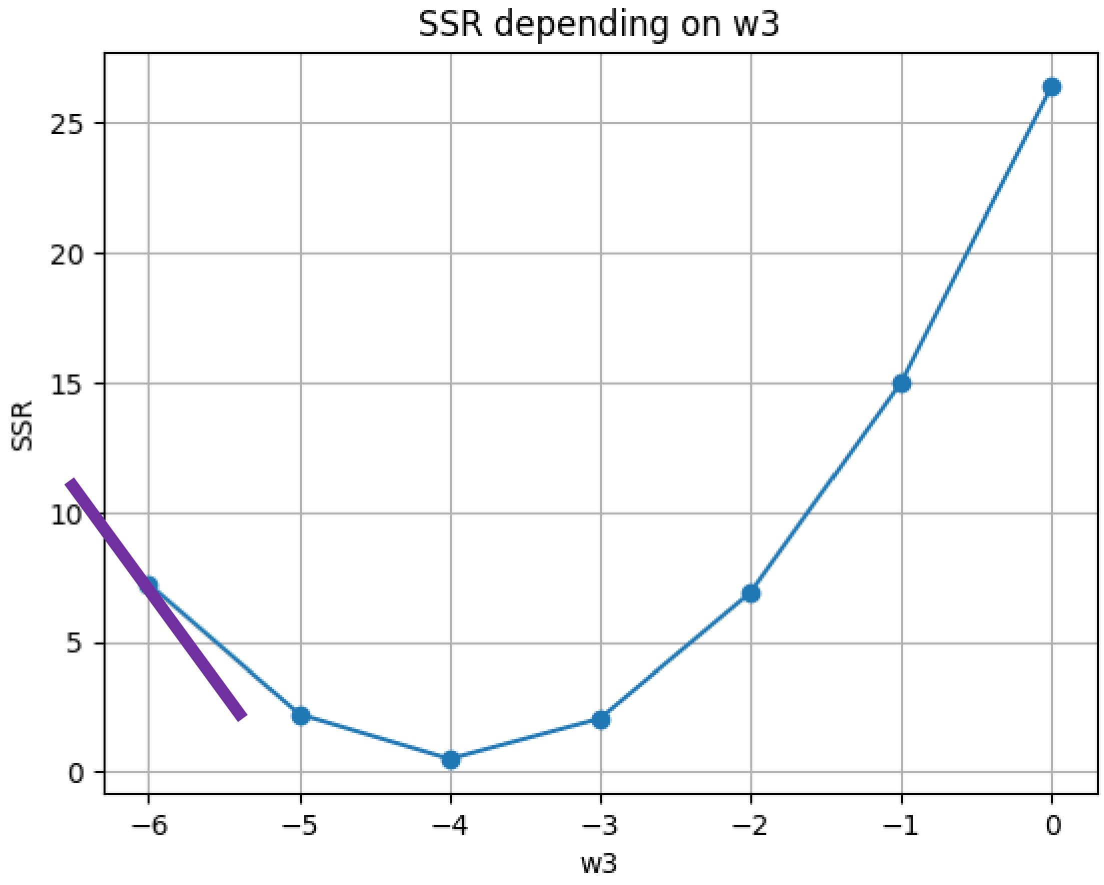

$$\frac{\partial SSR}{\partial w3} > 0$$

# Optimización único parámetro con backpropagation




$$\frac{\partial SSR}{\partial w3} > 0$$

# Optimización único parámetro con backpropagation




$$\frac{\partial SSR}{\partial w3} < 0$$

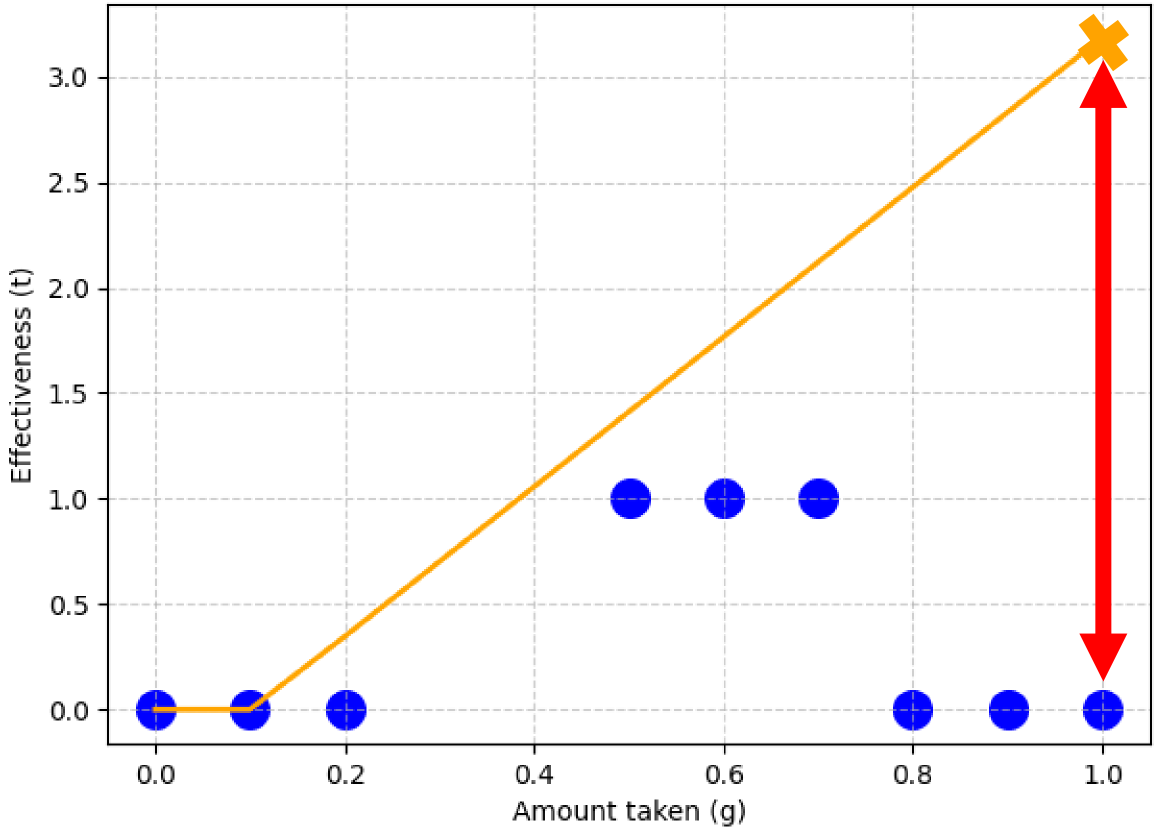
# Optimización único parámetro con backpropagation

$$\frac{dSSR}{dW3}$$

Signo -> en qué dirección moverse

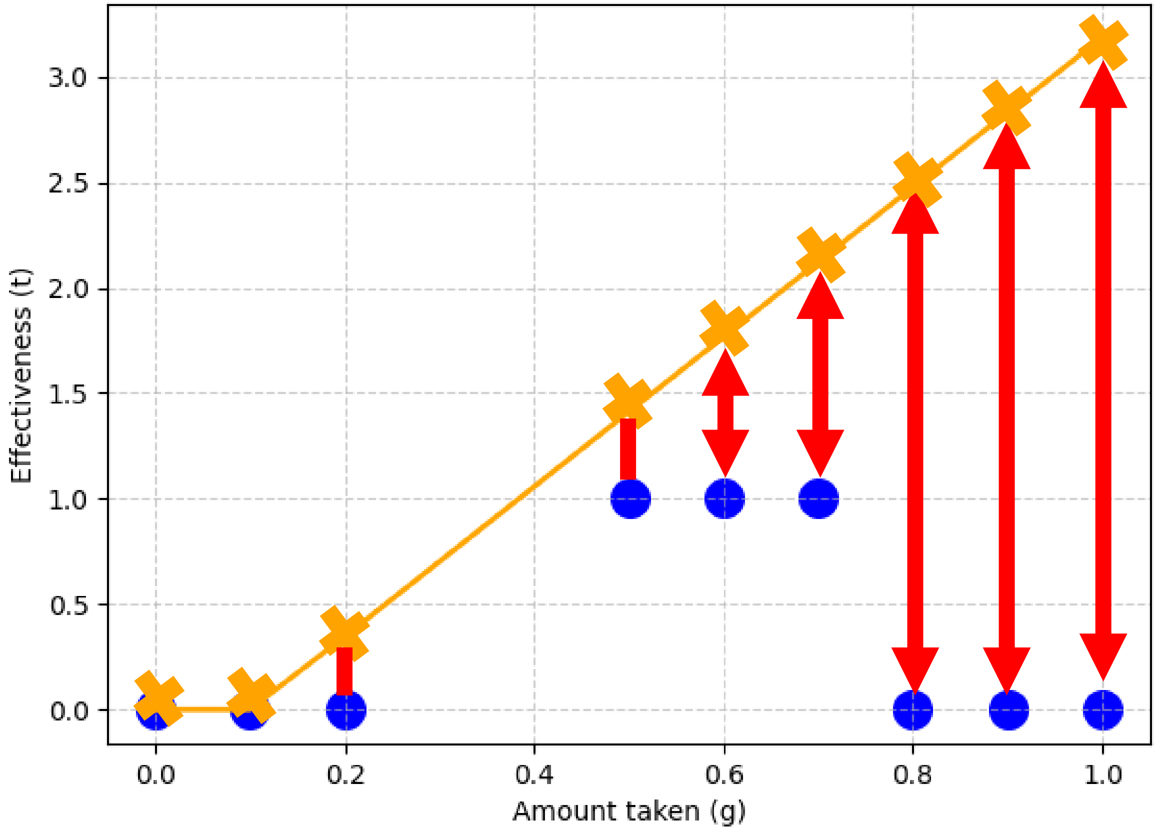
Magnitud -> cómo de lejos estamos

# Optimización único parámetro con backpropagation




Residual = Observed - Predicted

# Optimización único parámetro con backpropagation




Residual = Observed - Predicted

$$\text{SSR} = \sum_{i=0}^{n} (\text{Residual}_i)^2$$

$$\text{SSR} = \sum_{i=0}^{n} (\text{Observed}_i - \text{Predicted}_i)^2$$

# Optimización único parámetro con backpropagation

SSR = $\sum_{i=0}^{n}(\text{Observed}_i - \text{Predicted}_i)^2$

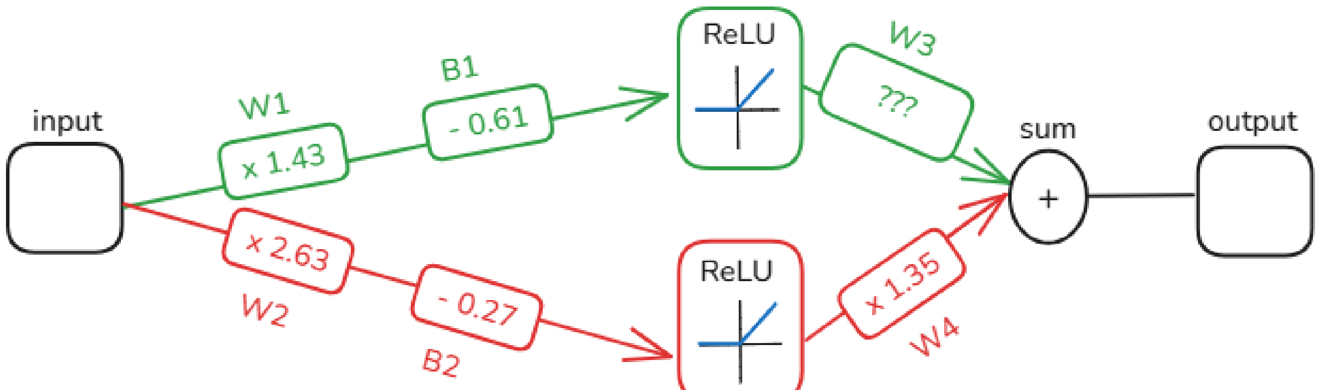
Observed -> valores tabulados

| Amount taken (g) |
|---|
| 0.0 |
| 0.1 |
| 0.2 |
| 0.5 |
| 0.6 |
| 0.7 |
| 0.8 |
| 0.9 |
| 1.0 |

# Optimización único parámetro con backpropagation

SSR = $\sum_{i=0}^{n}(\text{Observed}_i - \text{Predicted}_i)^2$

Predicted = upper + lower = (y x W3) + lower



# Optimización único parámetro con backpropagation

Chain Rule (Regla de la cadena)[2]

$$\frac{dSSR}{dW3} = \frac{dSSR}{dPredicted} \times \frac{dPredicted}{dW3}$$

[2] More about the Chain Rule: https://blog.quantinsti.com/understanding-chain-rule/

# Optimización único parámetro con backpropagation

$$\frac{dSSR}{dW3} = \frac{dSSR}{dPredicted} \text{ x } \frac{dPredicted}{dW3}$$

$$\frac{dSSR}{dPredicted} = \frac{\sum_{i=0}^{n}(Observed_i - Predicted_i)^2}{dPredicted} = \sum_{i=0}^{n} -2(Observed_i - Predicted_i)$$

# Optimización único parámetro con backpropagation

$$\frac{dSSR}{dW3} = \frac{dSSR}{dPredicted} \times \frac{dPredicted}{dW3}$$

$$\frac{dPredicted}{dW3} = \frac{(y \times W3) + lower}{dW3} = y$$

# Optimización único parámetro con backpropagation

$$\frac{dSSR}{dW3} = \frac{dSSR}{dPredicted} \times \frac{dPredicted}{dW3}$$

$$\frac{dSSR}{dW3} = \sum_{i=0}^{n} -2(Observed_i - Predicted_i) * y_i$$

# Optimización único parámetro con backpropagation

$$\frac{dSSR}{dW3} = \sum_{i=0}^{n} -2(Observed_i - Predicted_i) \quad * y_i$$

| Amount taken (g) | Predicted | y |
|---|---|---|
| 0.0 | 0.00000 | 0.000 |
| 0.1 | 0.00000 | 0.000 |
| 0.2 | 0.34560 | 0.000 |
| 0.5 | 1.41075 | 0.105 |
| 0.6 | 1.76580 | 0.248 |
| 0.7 | 2.12085 | 0.391 |
| 0.8 | 2.47590 | 0.534 |
| 0.9 | 2.83095 | 0.677 |
| 1.0 | 3.18600 | 0.820 |

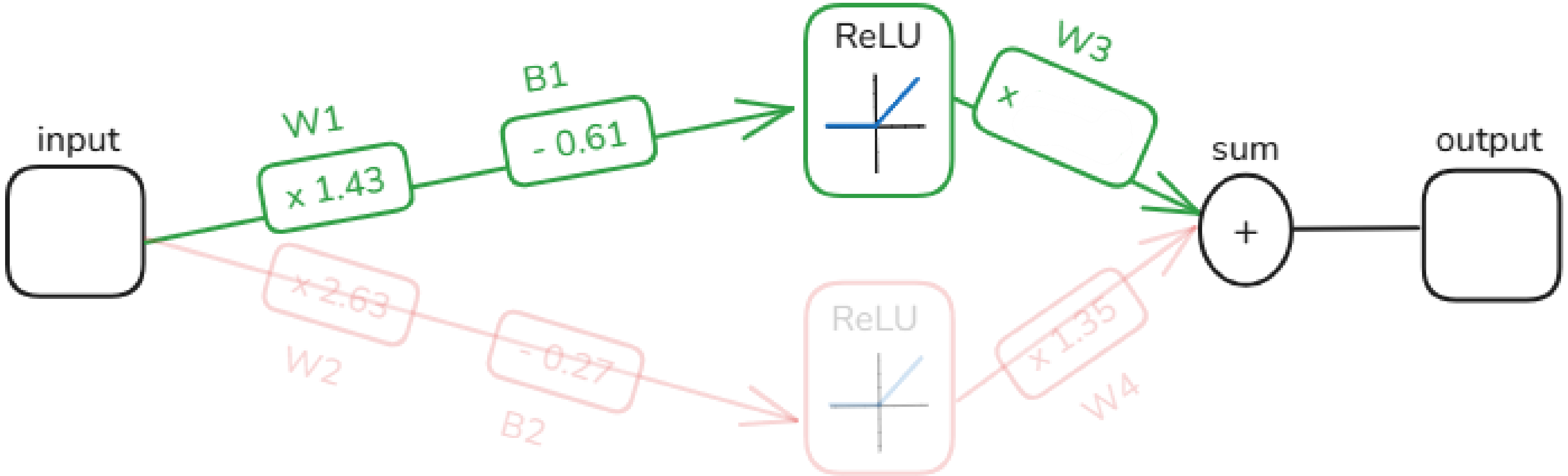
Observed-> valores tabulados (Amount taken (g))

Predicted-> salida Red Neuronal

$y$-> $\frac{dPredicted}{dW3} = \frac{(y \times W3) + lower}{dW3} = y$

# Optimización único parámetro con backpropagation

$$y\text{->}\frac{\text{dPredicted}}{\text{dW3}} = \frac{(\text{y x W3}) + \text{lower}}{\text{dW3}} = \text{y}$$



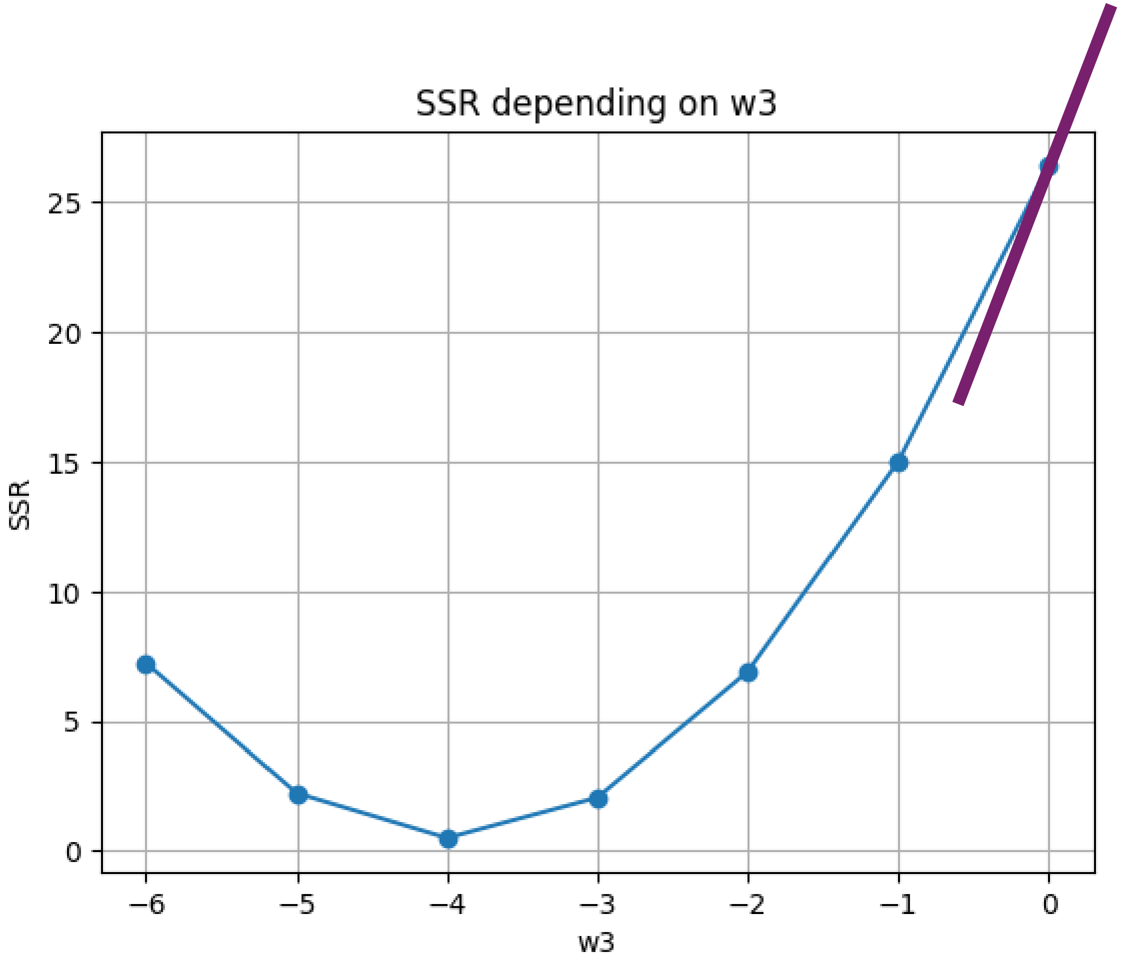
# Optimización único parámetro con backpropagation

$$\frac{dSSR}{dW3} = \sum_{i=0}^{n} -2(\text{Observed}_i - \text{Predicted}_i) \quad * \, y_i$$

| Amount taken (g) | Predicted | y | Result |
|---|---|---|---|
| 0.0 | 0.00000 | 0.000 | -0.000000 |
| 0.1 | 0.00000 | 0.000 | -0.000000 |
| 0.2 | 0.34560 | 0.000 | 0.000000 |
| 0.5 | 1.41075 | 0.105 | 0.191257 |
| 0.6 | 1.76580 | 0.248 | 0.578237 |
| 0.7 | 2.12085 | 0.391 | 1.111105 |
| 0.8 | 2.47590 | 0.534 | 1.789861 |
| 0.9 | 2.83095 | 0.677 | 2.614506 |
| 1.0 | 3.18600 | 0.820 | 3.585040 |

Si sumamos todo Result = 9.87

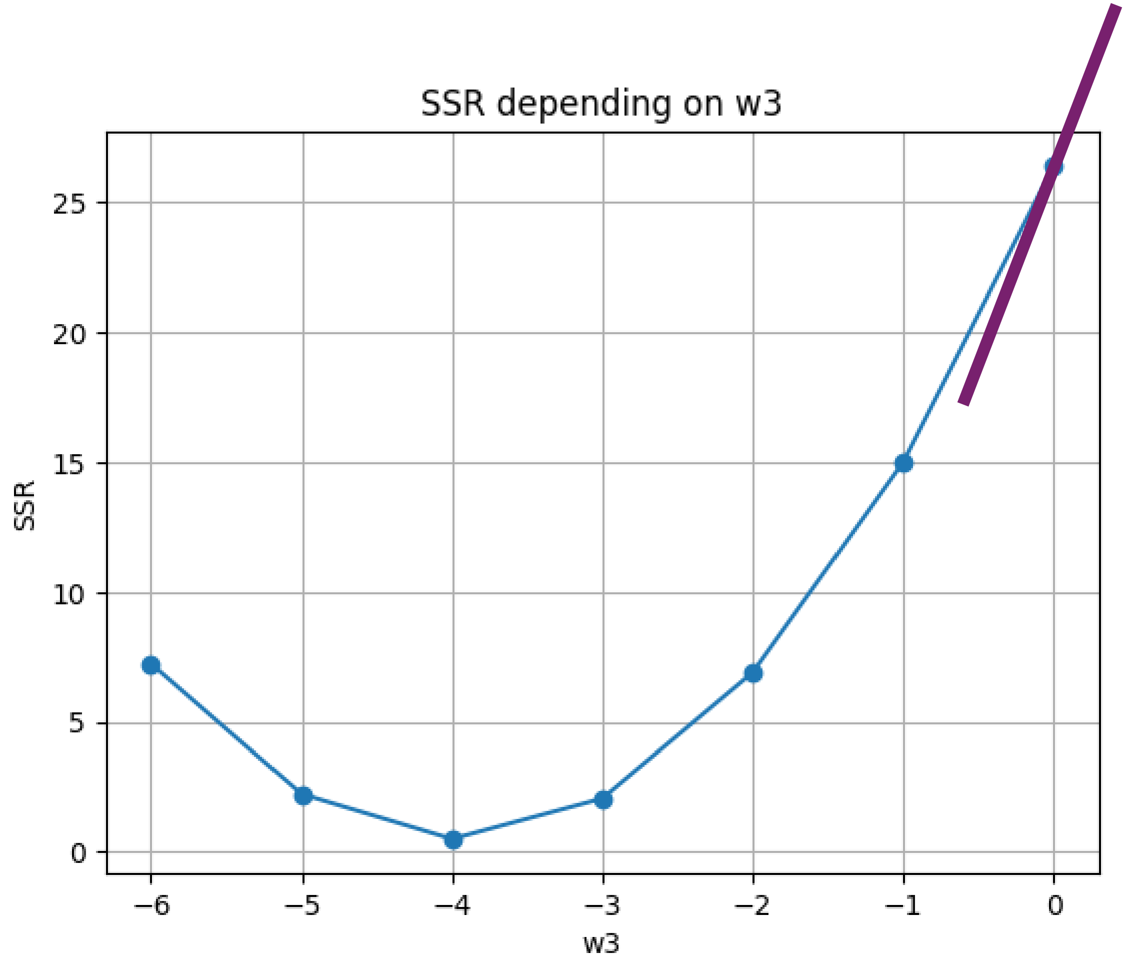
# Optimización único parámetro con backpropagation




$$\frac{\partial SSR}{\partial w3} > 0$$

Pendiente = **9.87**

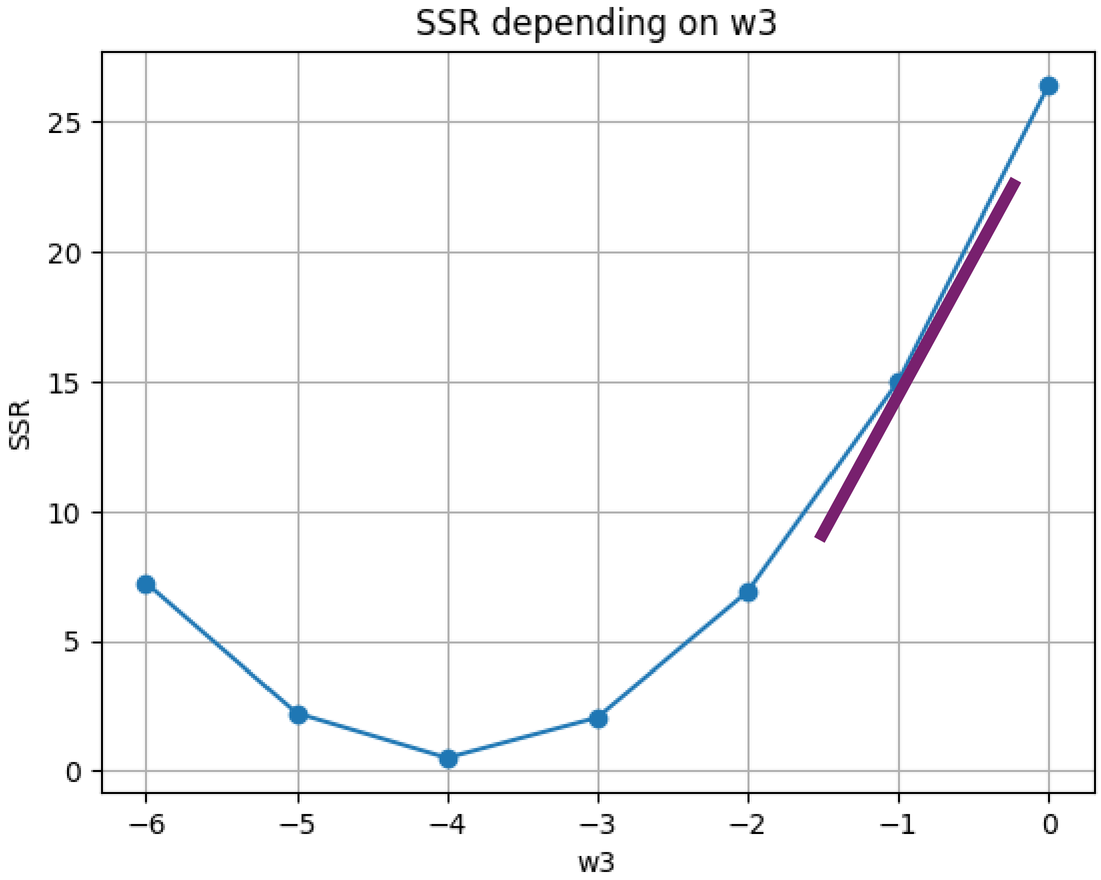
# Optimización único parámetro con backpropagation




Moverse hacia la izquierda

**¿Cuánto?**

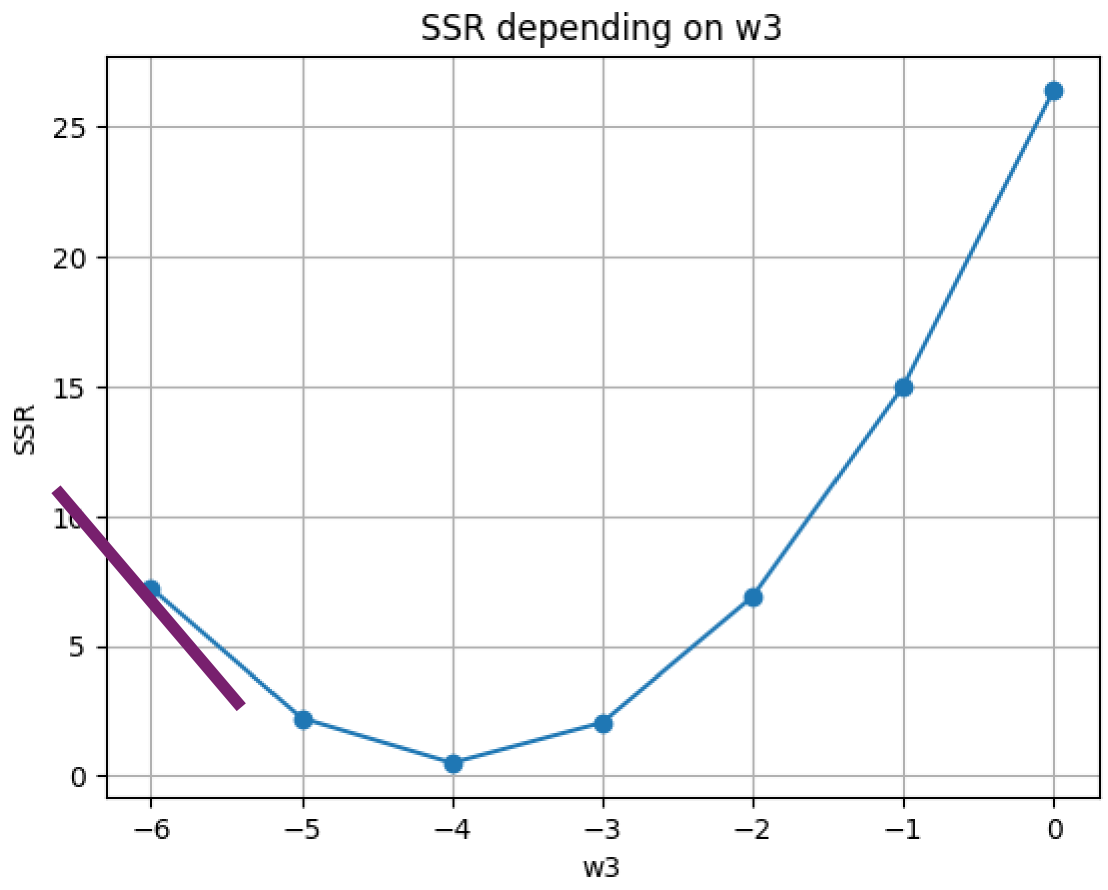
# Optimización único parámetro con backpropagation




Moverse hacia la izquierda

**¿Cuánto?**

# Optimización único parámetro con backpropagation




Moverse hacia la izquierda

**¿Cuánto?**

# Optimización único parámetro con backpropagation

**Learning Rate** (Ratio de aprendizaje)

Step Size = Derivative x Learning Rate

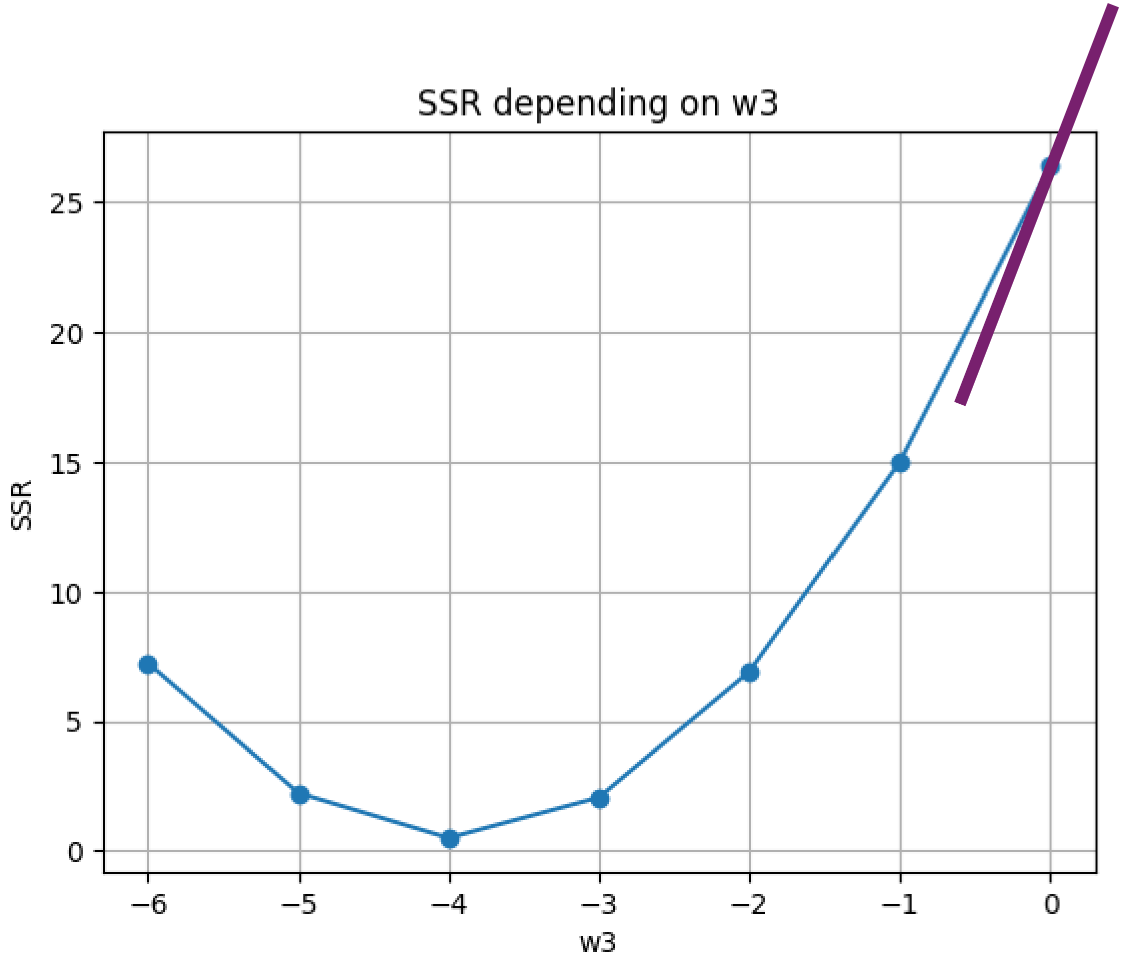
# Optimización único parámetro con backpropagation

**Learning Rate** (Ratio de aprendizaje)

Step Size = Derivative x Learning Rate

New W3 = Old W3 - Step Size

# Optimización único parámetro con backpropagation



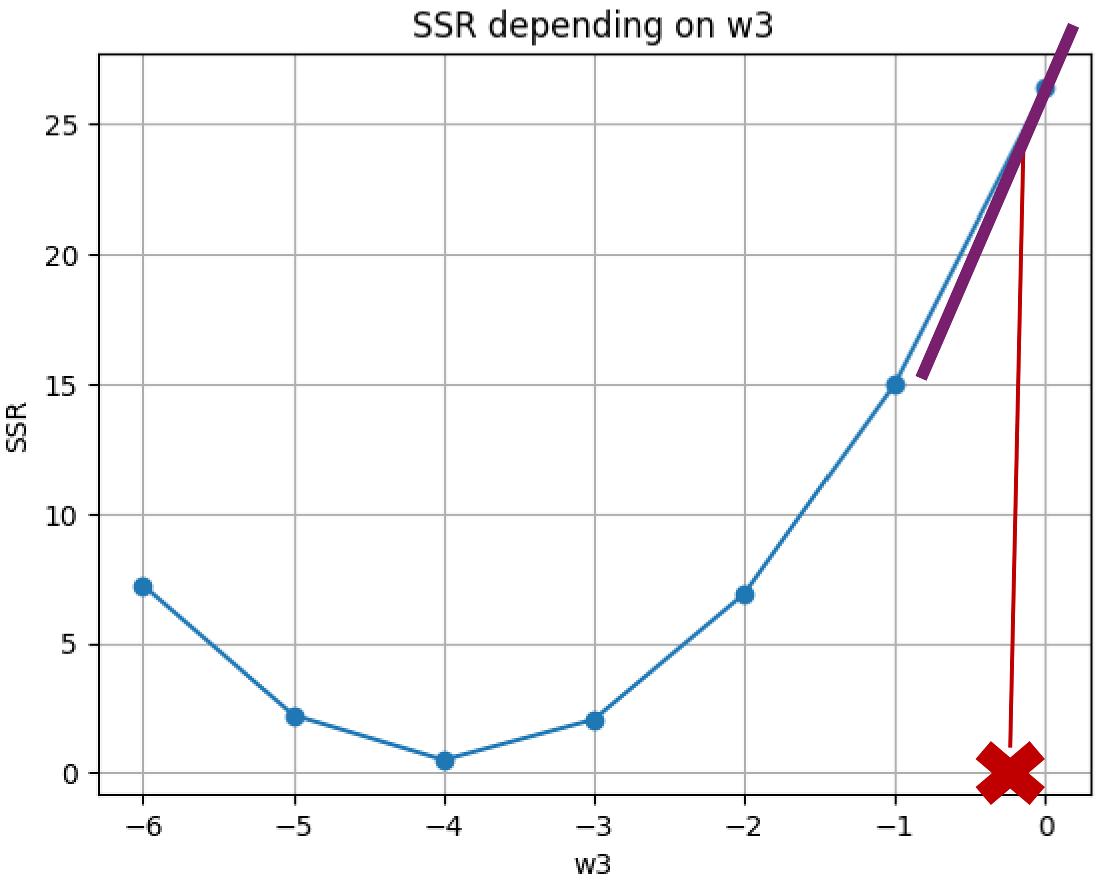

Pendiente = 9.87

Learning Rate = 0.01

Step Size = 9.87 x 0.01 = 0.0987

New W3 = 0 – 0.0987 = -0.0987

# Optimización único parámetro con backpropagation

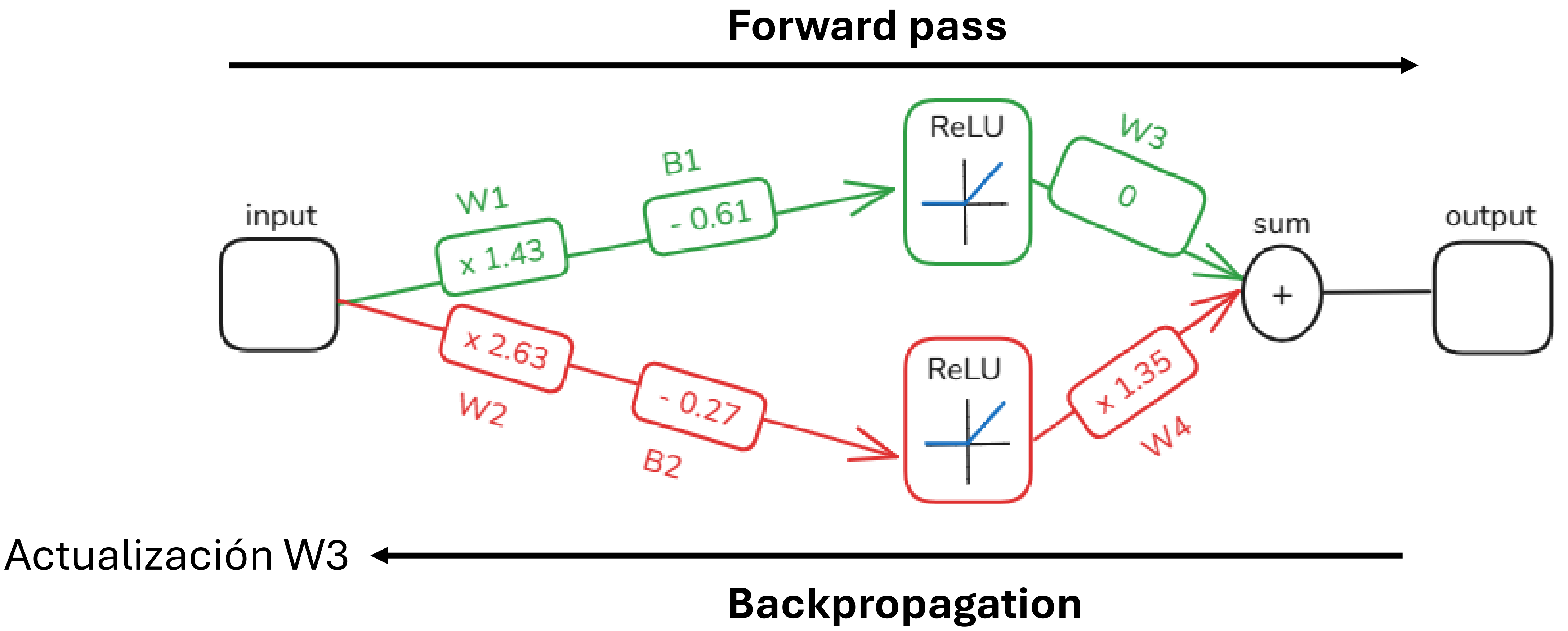



New W3 = 0 – 0.0987 = -0.0987

W3 = New W3

**Repetir!**

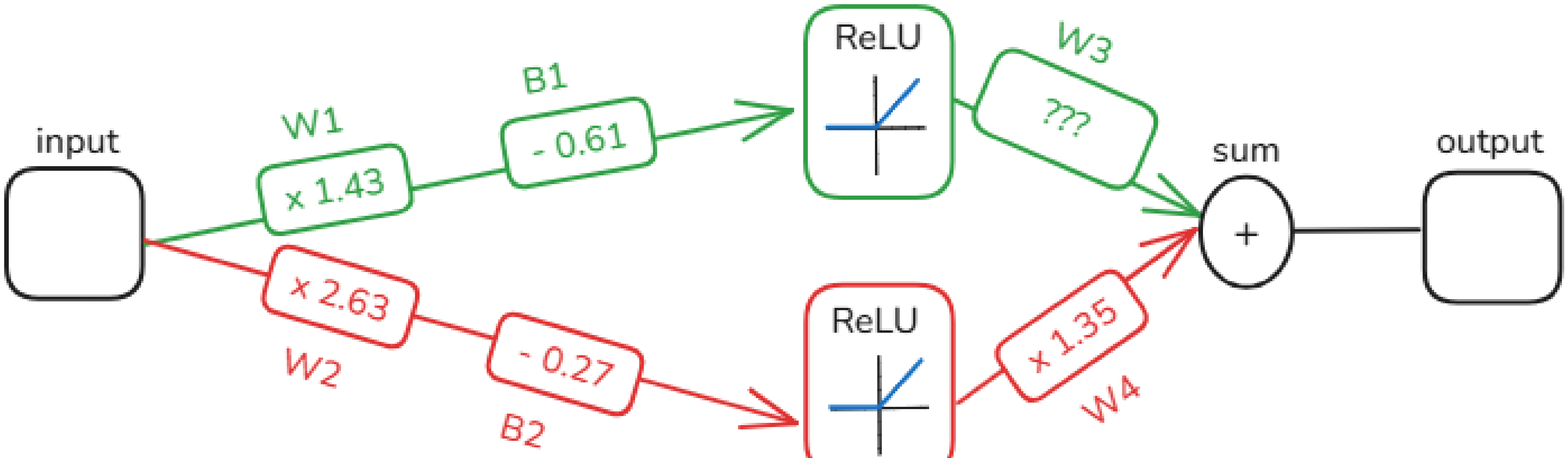
# Optimización único parámetro con backpropagation



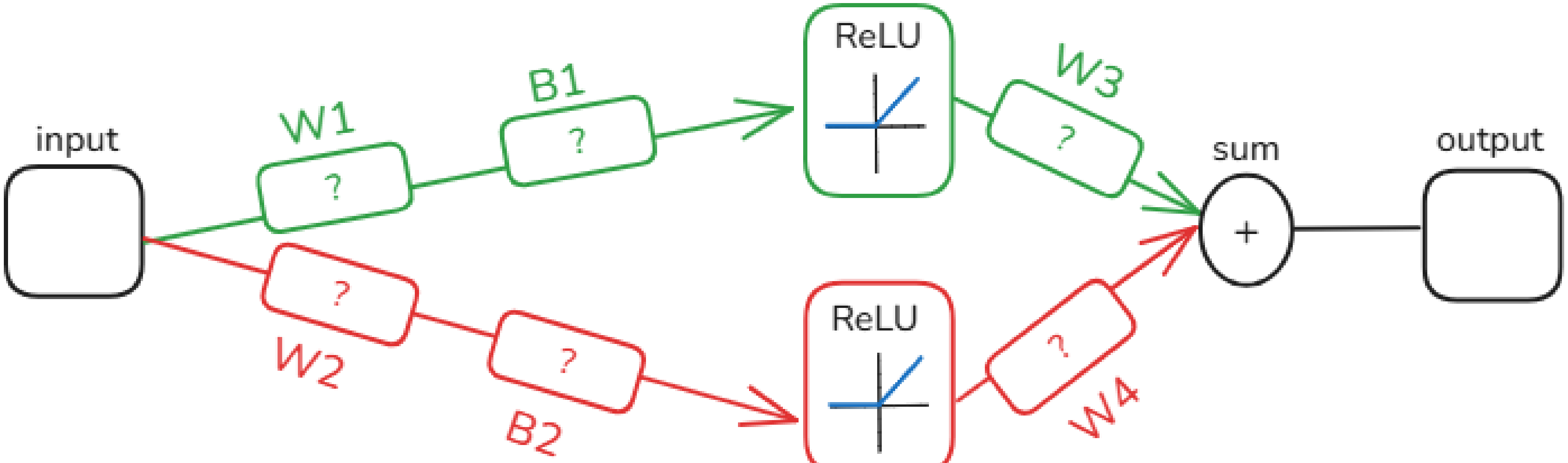
# Optimización único parámetro con backpropagation

¡Práctica!

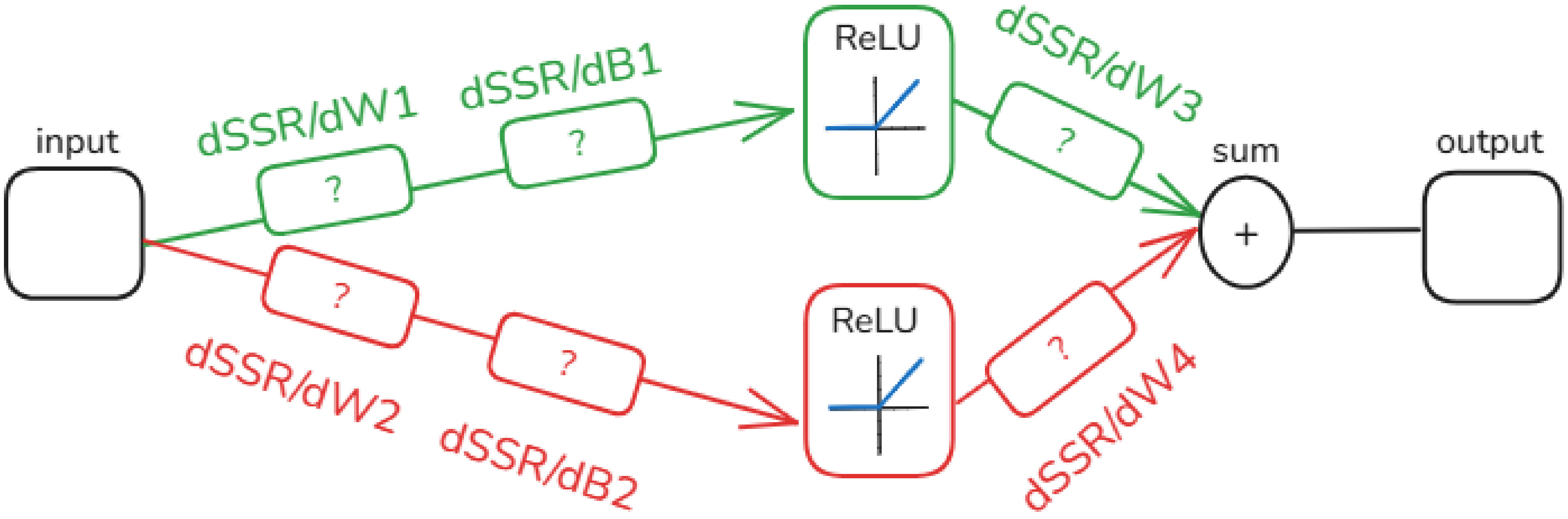
# Optimización mútliples parámetros con backpropagation



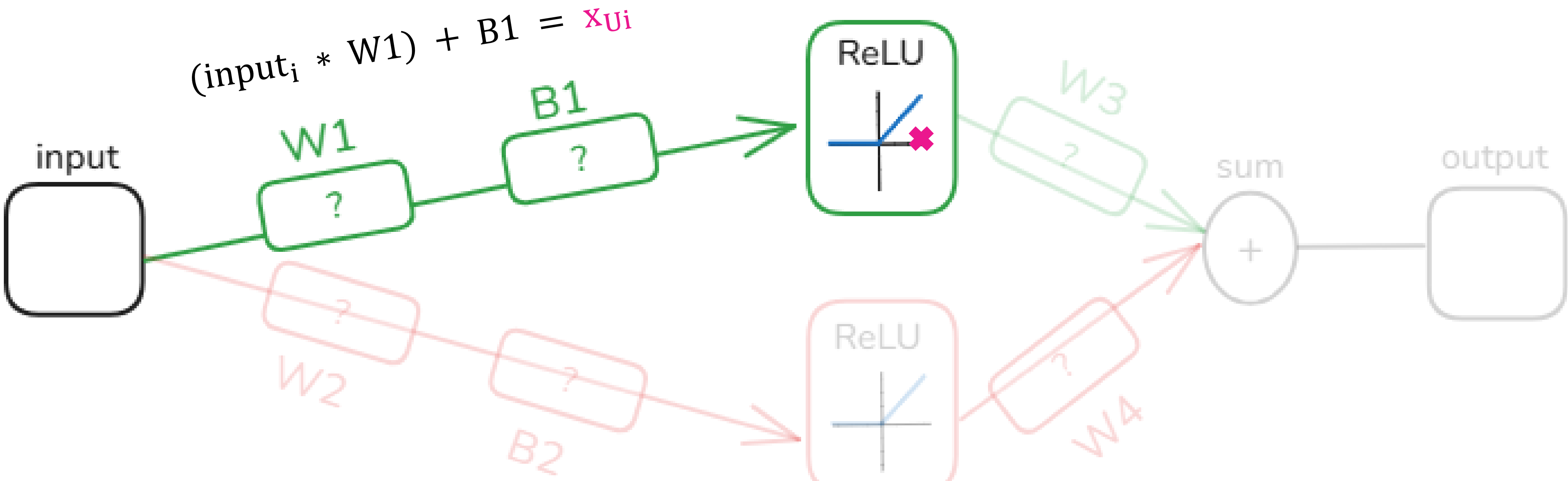
# Optimización mútliples parámetros con backpropagation



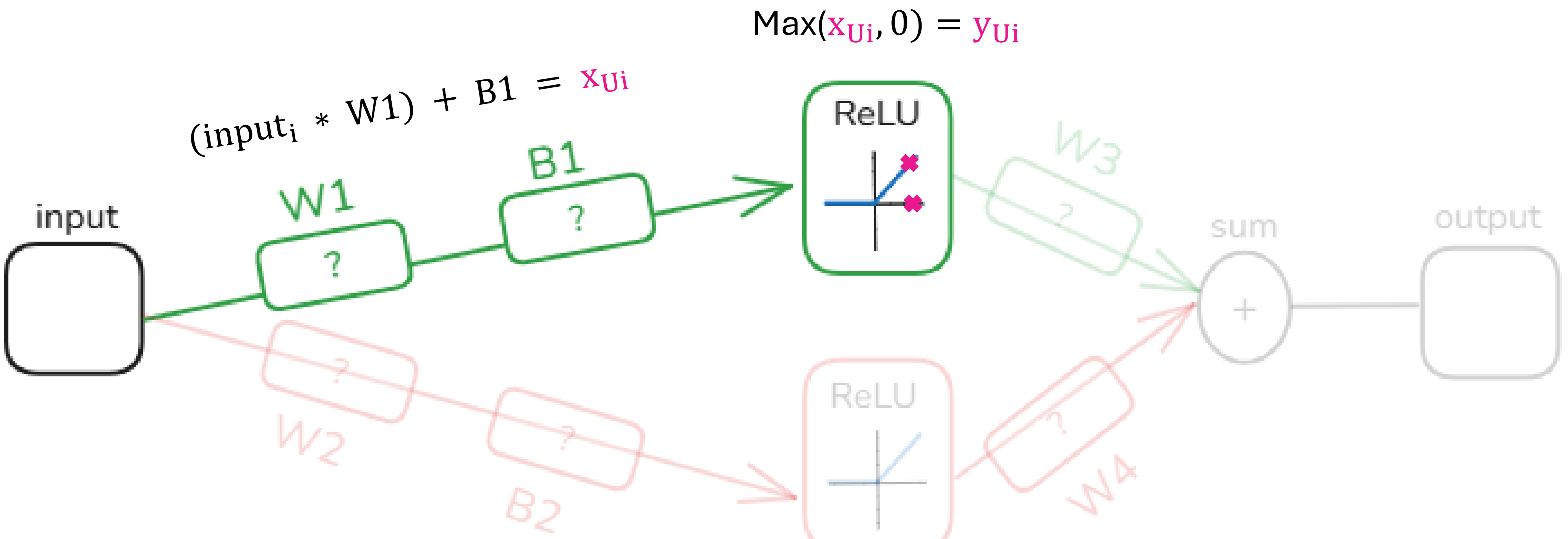
# Optimización mútliples parámetros con backpropagation



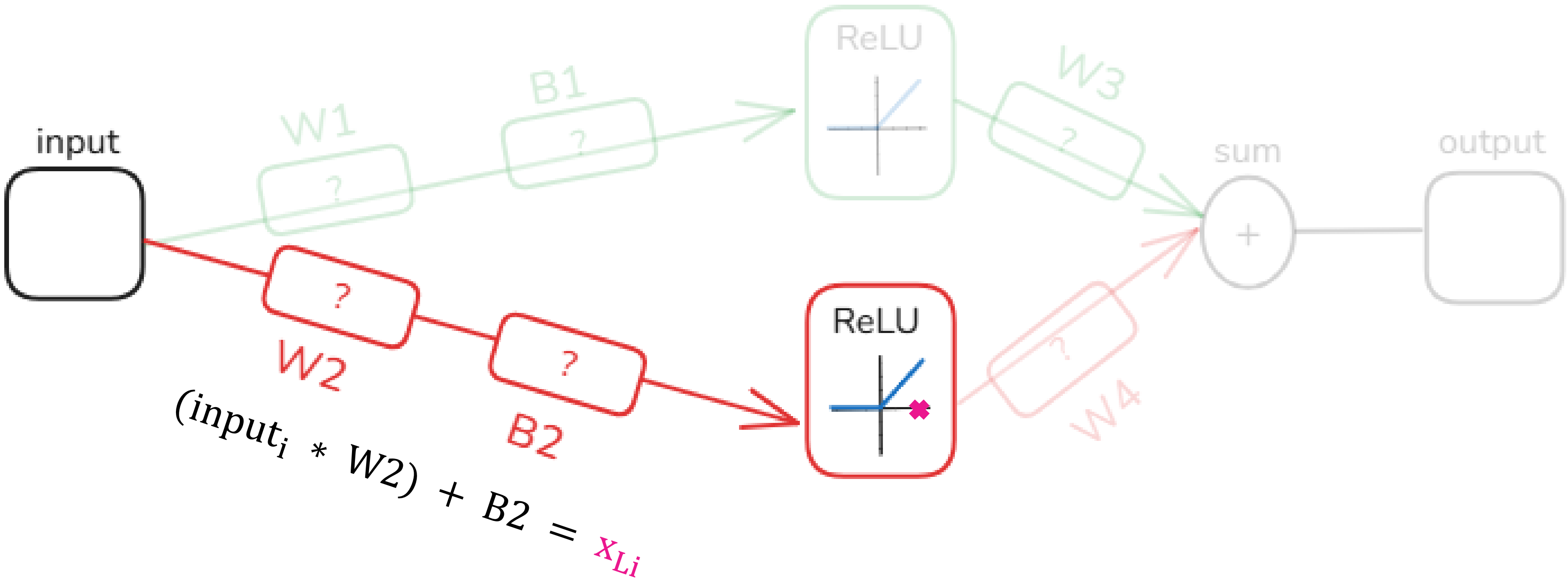
# Optimización mútliples parámetros con backpropagation



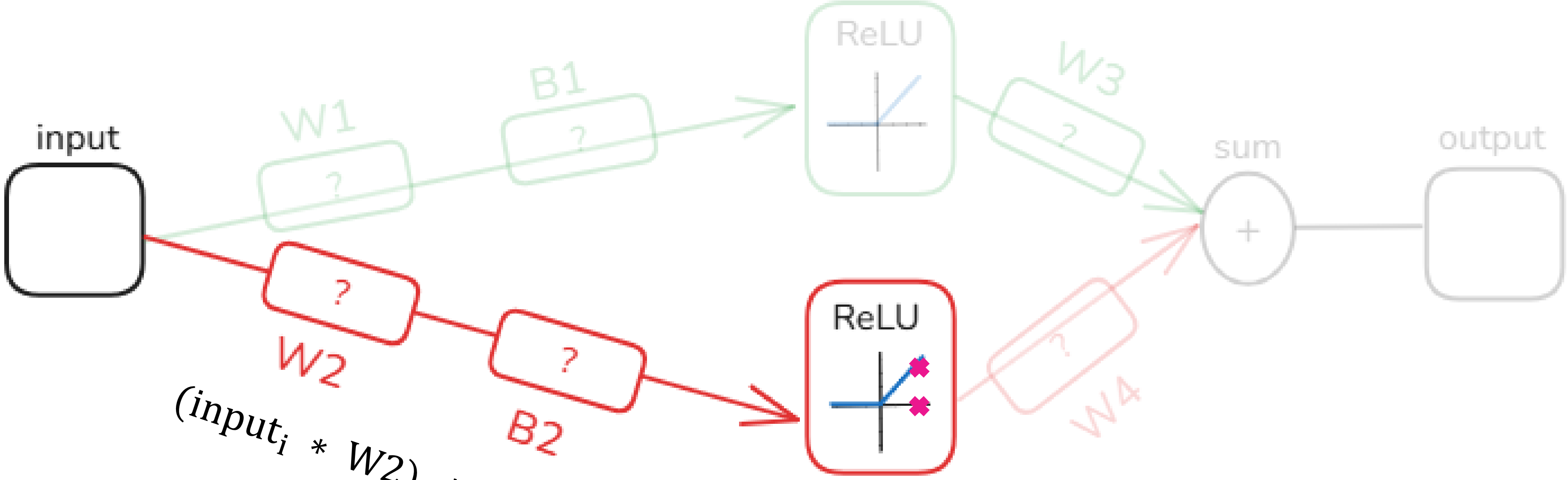
# Optimización mútliples parámetros con backpropagation



# Optimización mútliples parámetros con backpropagation



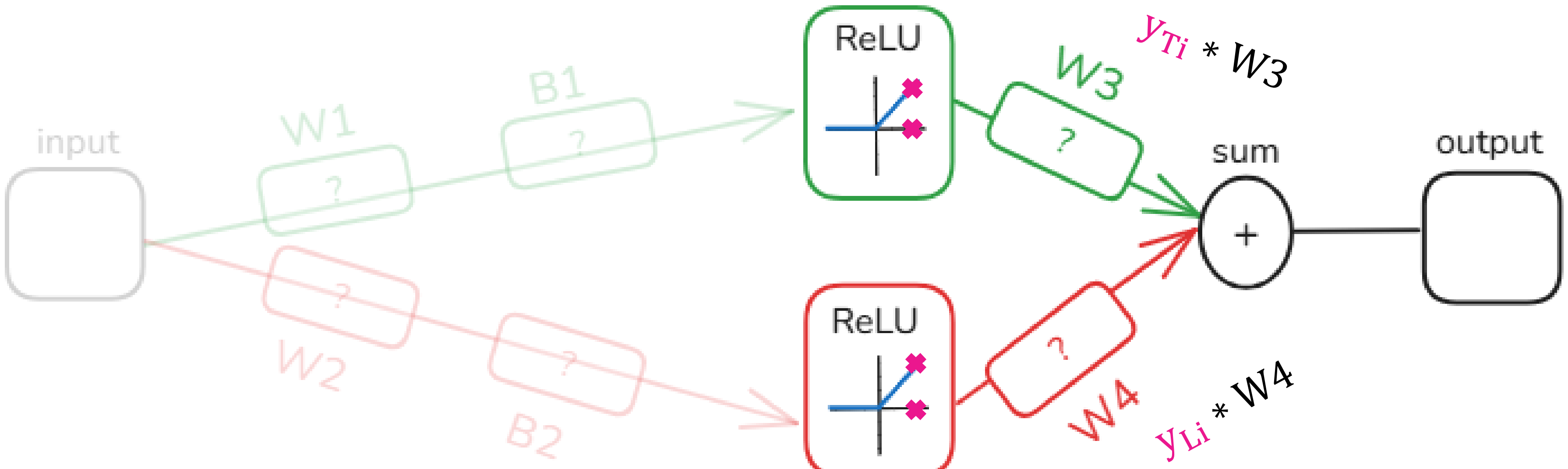
# Optimización mútliples parámetros con backpropagation




$(input_i * W2) + B2 = x_{Li}$

$\text{Max}(x_{Li}, 0) = y_{Li}$

# Optimización mútliples parámetros con backpropagation




Predicted = $(y_{Ti} * W3) + (y_{Li} * W3)$

# Optimización mútliples parámetros con backpropagation

Predicted = $(y_{Ti} * W3) + (y_{Li} * W4)$

SSR = $\sum_{i=0}^{n}(\text{Observed}_i - \text{Predicted}_i)^2$

# Optimización mútliples parámetros con backpropagation

$$\frac{\mathrm{dSSR}}{\mathrm{dW4}} = \frac{\mathrm{dSSR}}{\mathrm{dPredicted}} \, \mathrm{X} \, \frac{\mathrm{dPredicted}}{\mathrm{dW4}}$$

# Optimización mútliples parámetros con backpropagation

$$\frac{\mathrm{dSSR}}{\mathrm{dW4}} = \frac{\mathrm{dSSR}}{\mathrm{dPredicted}} \times \frac{\mathrm{dPredicted}}{\mathrm{dW4}}$$

$$\text{SSR} = \sum_{i=0}^{n}(\mathrm{Observed}_i - \mathrm{Predicted}_i)^2$$

$$\text{Predicted} = (y_{Ti} * W3) + (y_{Li} * W4)$$

# Optimización mútliples parámetros con backpropagation

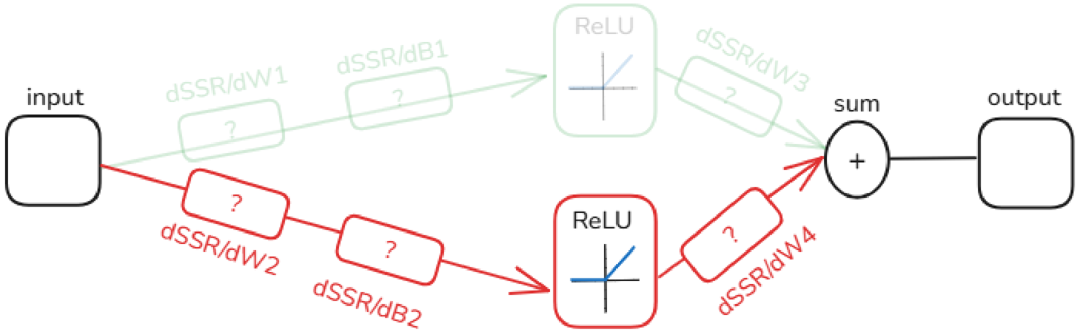
$$\frac{dSSR}{dW4} = \frac{d\sum_{i=0}^{n}(Observed_i - Predicted_i)^2}{dPredicted} \text{ x } \frac{d[(y_{Ti} * W3) + (y_{Li} * W4)]}{dW4}$$

# Optimización mútliples parámetros con backpropagation

$$\frac{dSSR}{dW4} = \sum_{i=0}^{n} -2(\text{Observed}_i - \text{Predicted}_i) \quad x \ (y_{Li})$$

# Optimización mútliples parámetros con backpropagation

**Lower Branch: derivative expression**



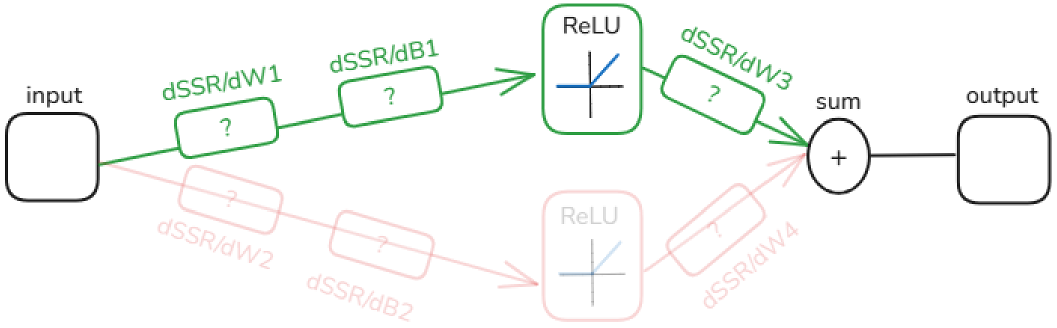

$$\frac{dSSR}{dW4} = \frac{dSSR}{dPredicted} \text{ X } \frac{dPredicted}{dW4}$$

$$\frac{dSSR}{dB2} = \frac{dSSR}{dPredicted} \text{ X } \frac{dPredicted}{dy_L} \text{ X } \frac{dy_L}{dX_L} \text{ X } \frac{dX_L}{dB2}$$

$$\frac{dSSR}{dW2} = \frac{dSSR}{dPredicted} \text{ X } \frac{dPredicted}{dy_L} \text{ X } \frac{dy_L}{dX_L} \text{ X } \frac{dX_L}{dW2}$$

# Optimización mútliples parámetros con backpropagation

**Upper Branch: derivative expression**



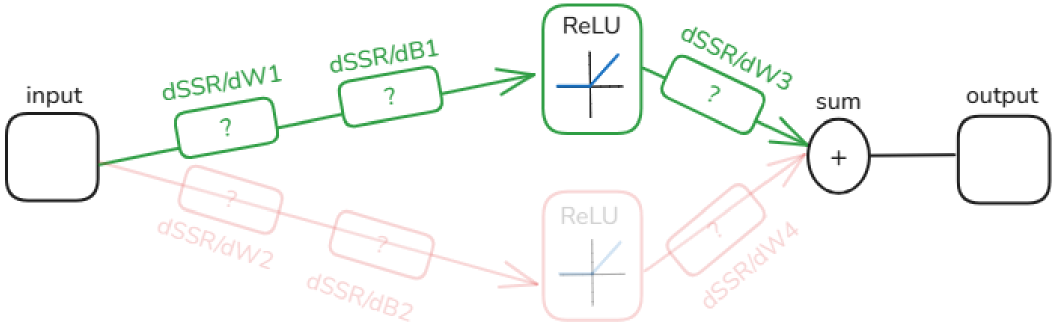

$$\frac{dSSR}{dW3} = \frac{dSSR}{dPredicted} \times \frac{dPredicted}{dW3}$$

$$\frac{dSSR}{dB1} = \frac{dSSR}{dPredicted} \times \frac{dPredicted}{dy_T} \times \frac{dy_T}{dX_T} \times \frac{dX_T}{dB1}$$

$$\frac{dSSR}{dW1} = \frac{dSSR}{dPredicted} \times \frac{dPredicted}{dy_T} \times \frac{dy_T}{dX_T} \times \frac{dX_T}{dW1}$$

# Optimización mútliples parámetros con backpropagation

**Upper Branch: derivative value**



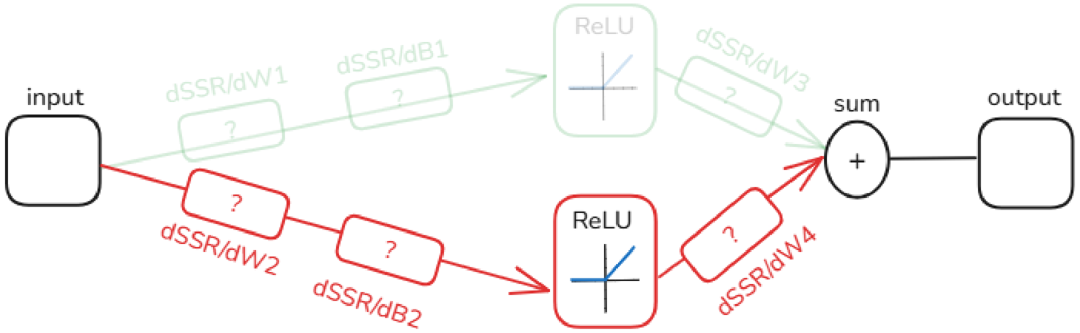

$$\frac{dSSR}{dW3} = \sum_{i=0}^{n} -2(\text{Observed}_i - \text{Predicted}_i) \text{ x } (y_{Ui})$$

$$\frac{dSSR}{dB1} = \sum_{i=0}^{n} -2(\text{Observed}_i - \text{Predicted}_i) \text{ x } (W3) \text{x} \begin{cases} 0, X_{Ui} < 0 \\ 1, X_{Ui} > 0 \end{cases} \text{x } 1$$

$$\frac{dSSR}{dW1} = \sum_{i=0}^{n} -2(\text{Observed}_i - \text{Predicted}_i) \text{ x } (W3) x \begin{cases} 0, X_{Ui} < 0 \\ 1, X_{Ui} > 0 \end{cases} \text{x Dose}_i$$

# Optimización mútliples parámetros con backpropagation

**Lower Branch: derivative value**




$$\frac{dSSR}{dW4} = \sum_{i=0}^{n} -2(\mathrm{Observed}_i - \mathrm{Predicted}_i) \ \mathrm{x} \ (y_{Li})$$

$$\frac{dSSR}{dB2} = \sum_{i=0}^{n} -2(\mathrm{Observed}_i - \mathrm{Predicted}_i) \ \mathrm{x} \ (W4) \mathrm{x} \begin{cases} 0, X_{Li} < 0 \\ 1, X_{Li} > 0 \end{cases} \mathrm{x} \ 1$$

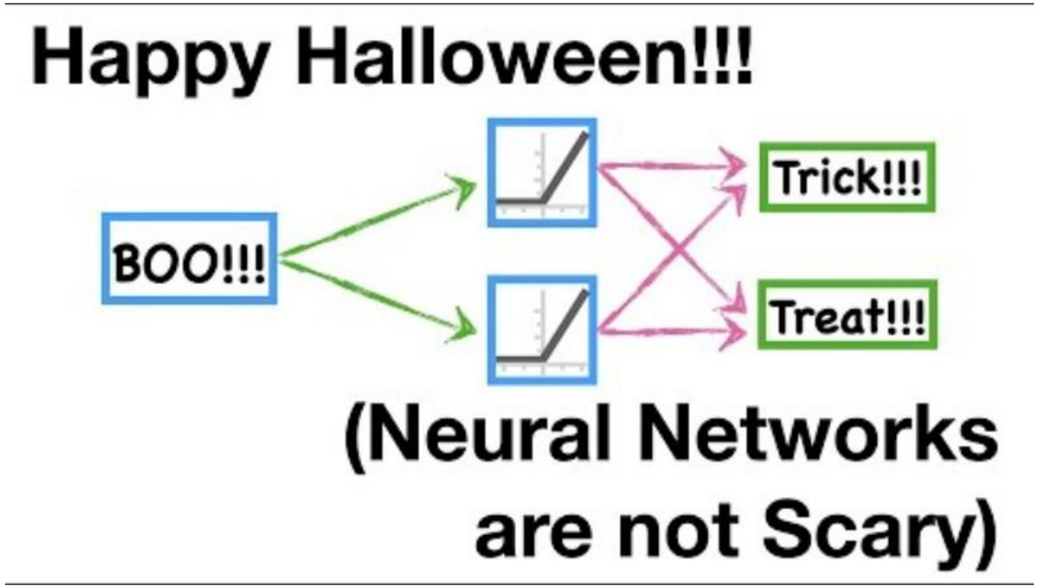
$$\frac{dSSR}{dW2} = \sum_{i=0}^{n} -2(\mathrm{Observed}_i - \mathrm{Predicted}_i) \ \mathrm{x} \ (W4) x \begin{cases} 0, X_{Li} < 0 \\ 1, X_{Li} > 0 \end{cases} \mathrm{x} \ \mathrm{Dose}_i$$

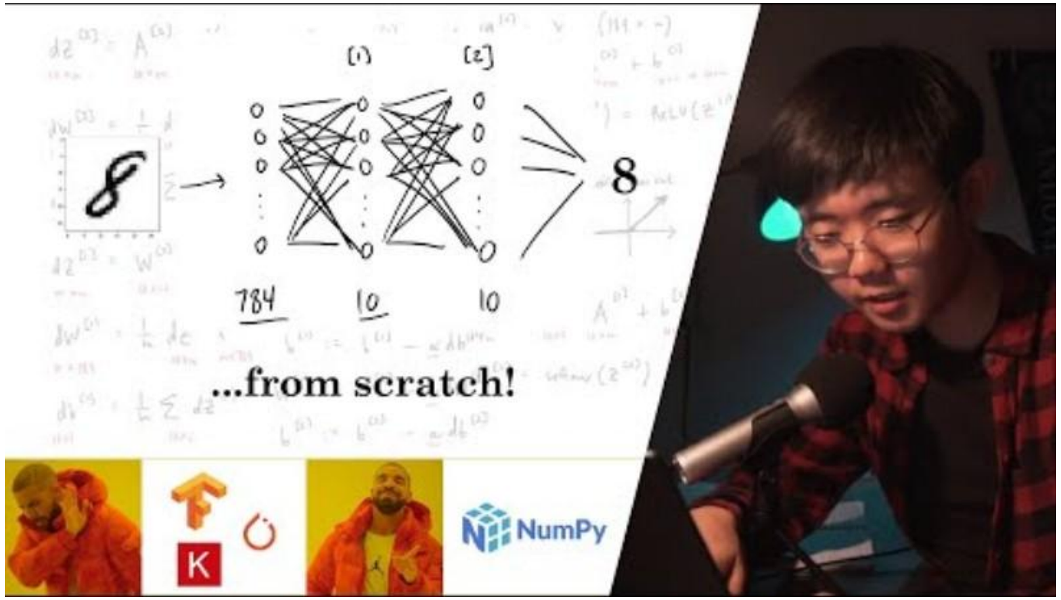
# Optimización mútliples parámetros con backpropagation

¡Práctica!

# Q&A

# Recomendaciones





@aisc_madrid
www.aiscmadrid.com