# Opinion dynamics

# Learning outcomes

How things **propagate** across networks

Compare different models of **diffusion**

**Choose** the right model for the right job

# Introduction

**Started** in the 1970s

Original models were from **physics**

Many disciplines, **different** uses

# Introduction

**Ideas, behaviours, rumours, information, opinions, fake news, etc.**

# Simple models, complex models

**Simple contagion**

Agents can be “infected” directly

**Complex contagion**

Non-linear or repeated interactions for agents to be “infected”

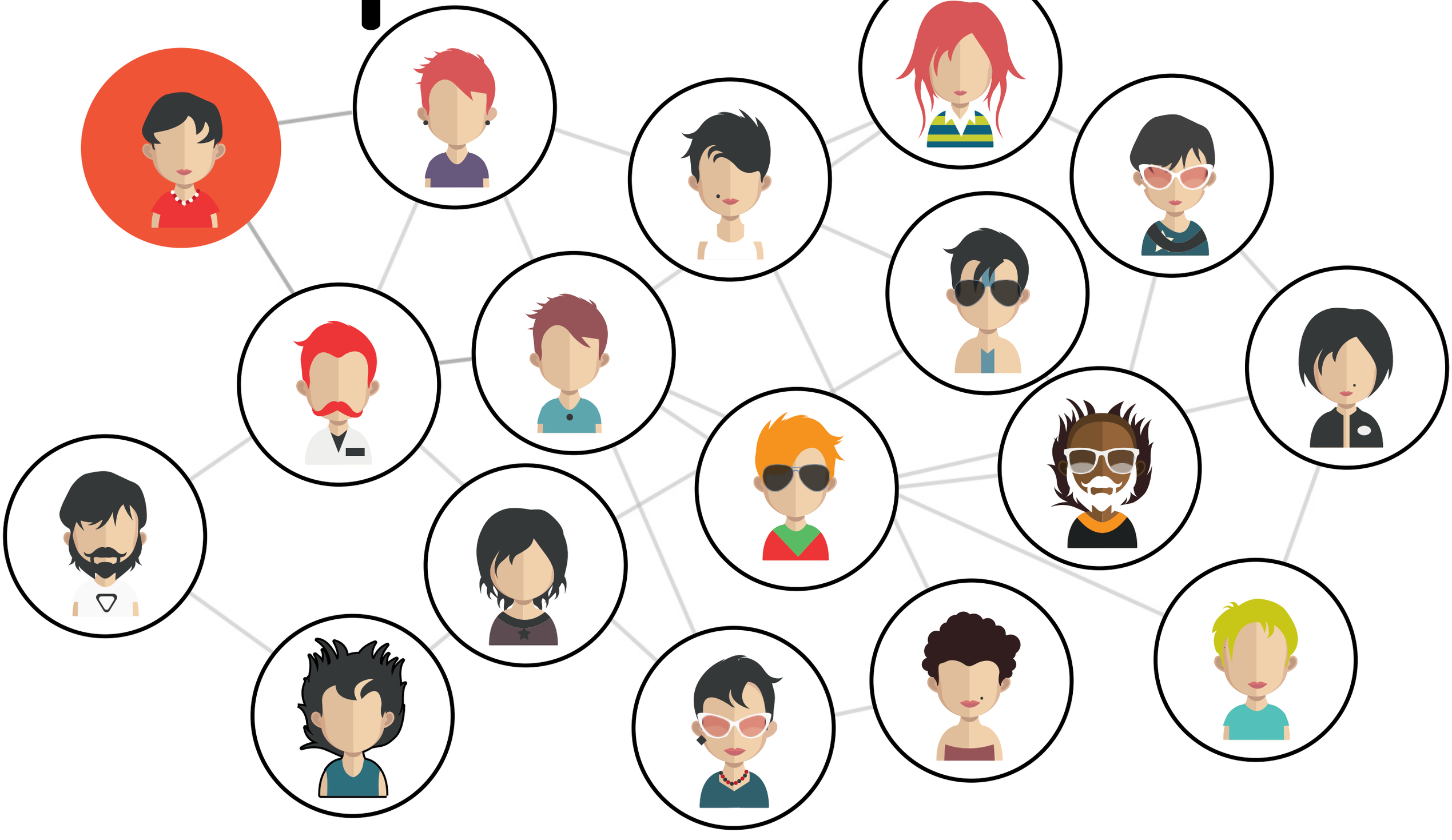
# Independent cascade

**Irreversible** states

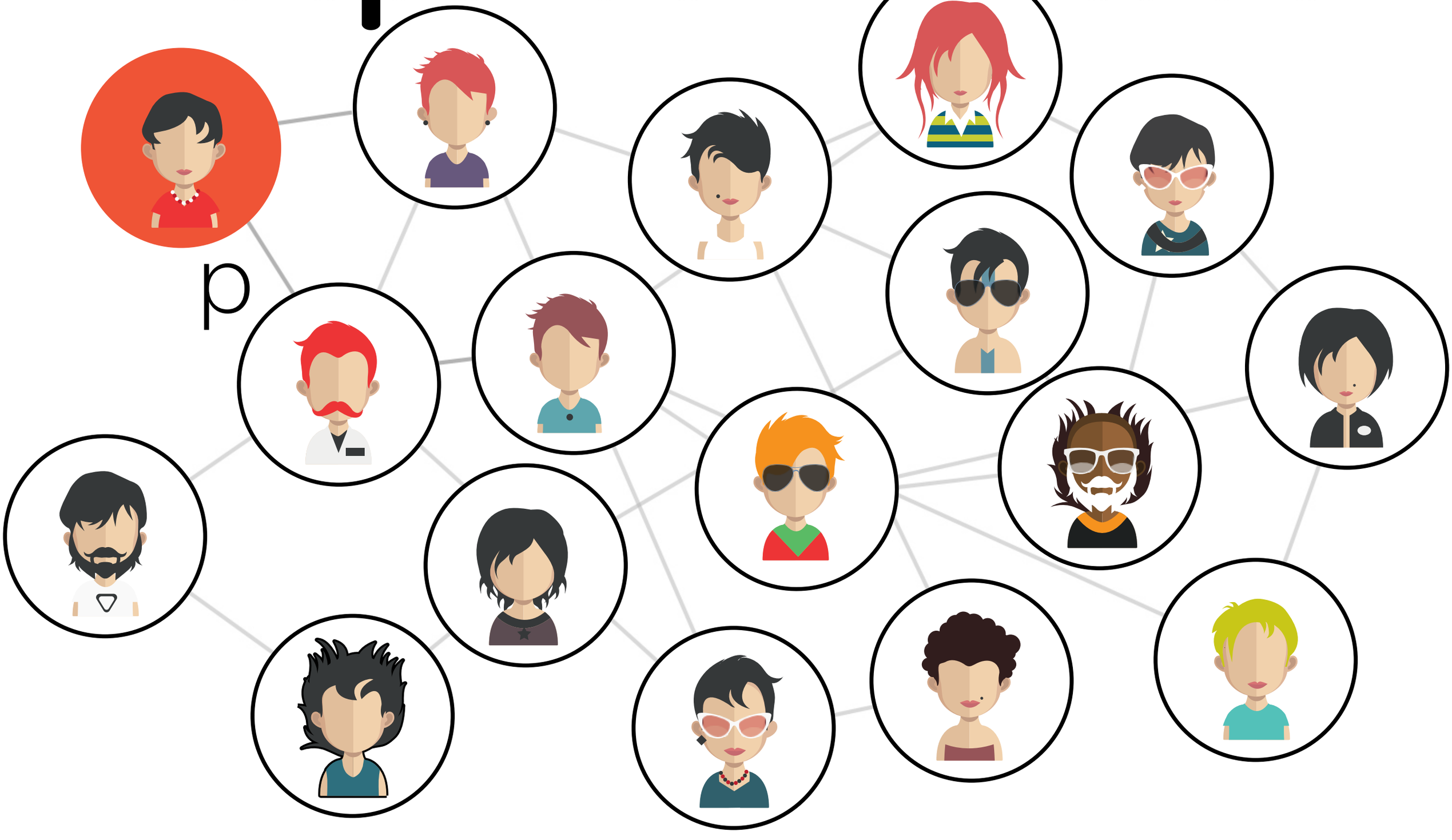
Easy to **compute**

Easy to **extend** to influence maximisation

# Independent cascade



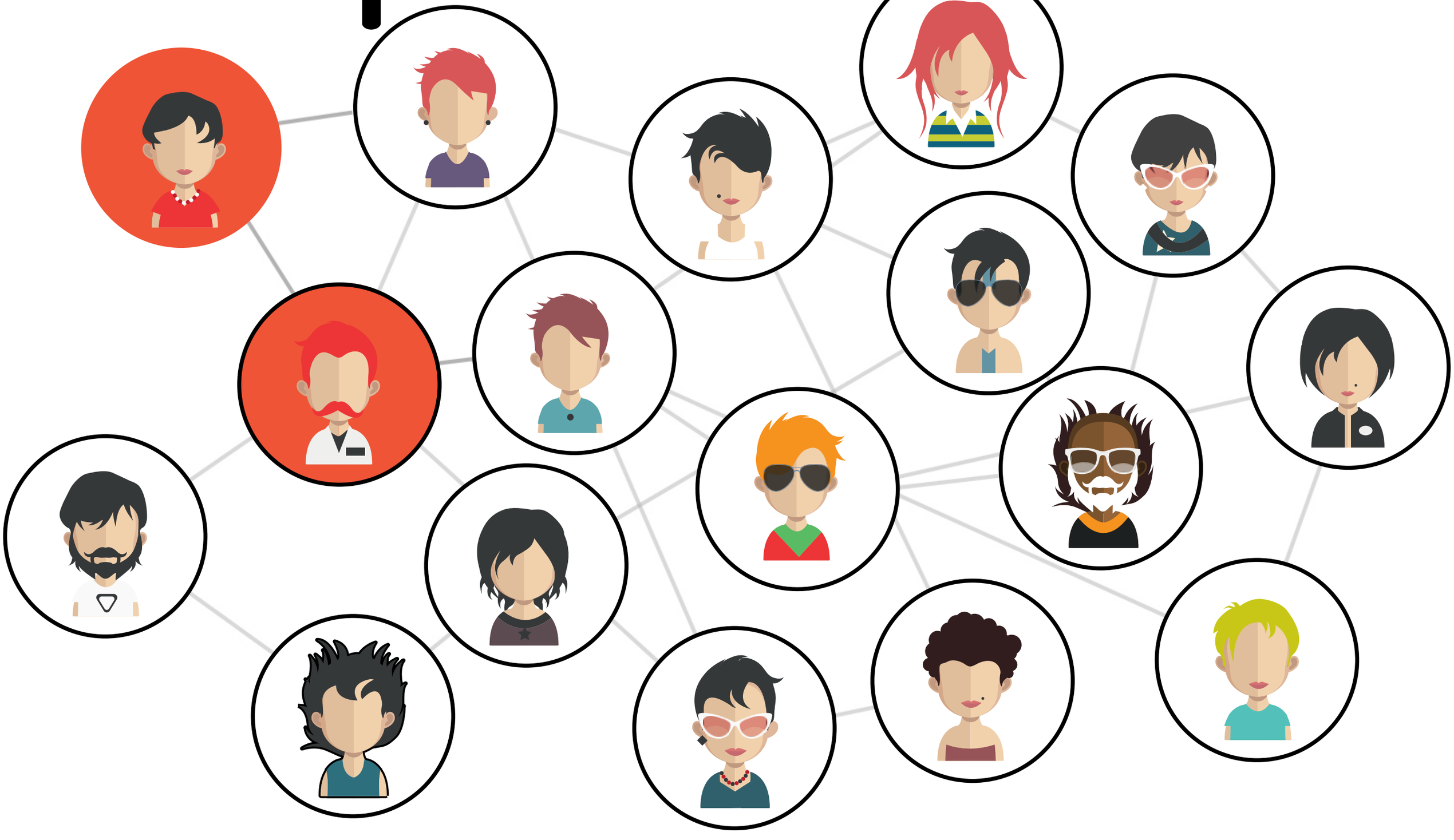
# Independent cascade



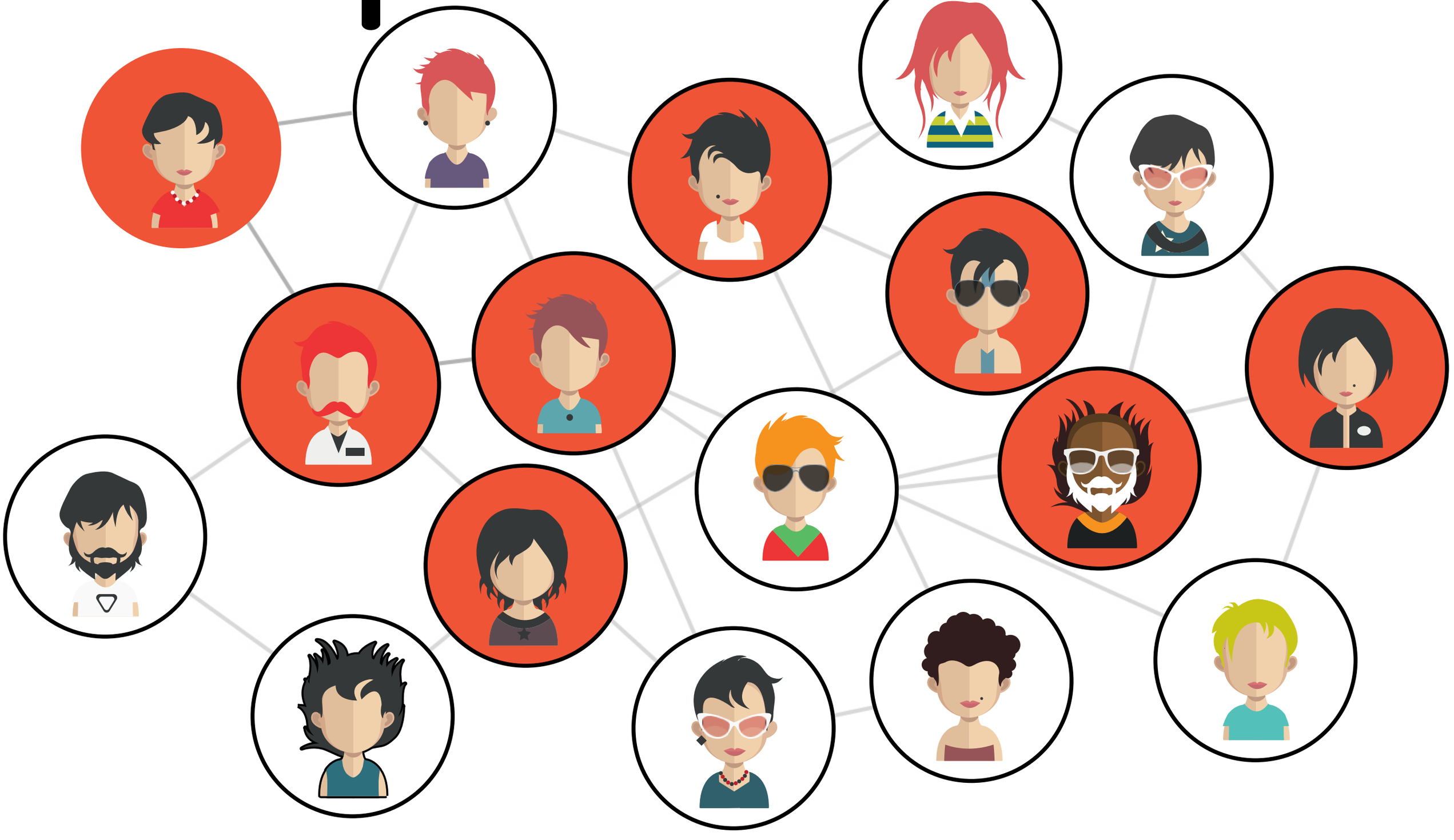
# Independent cascade

p=w

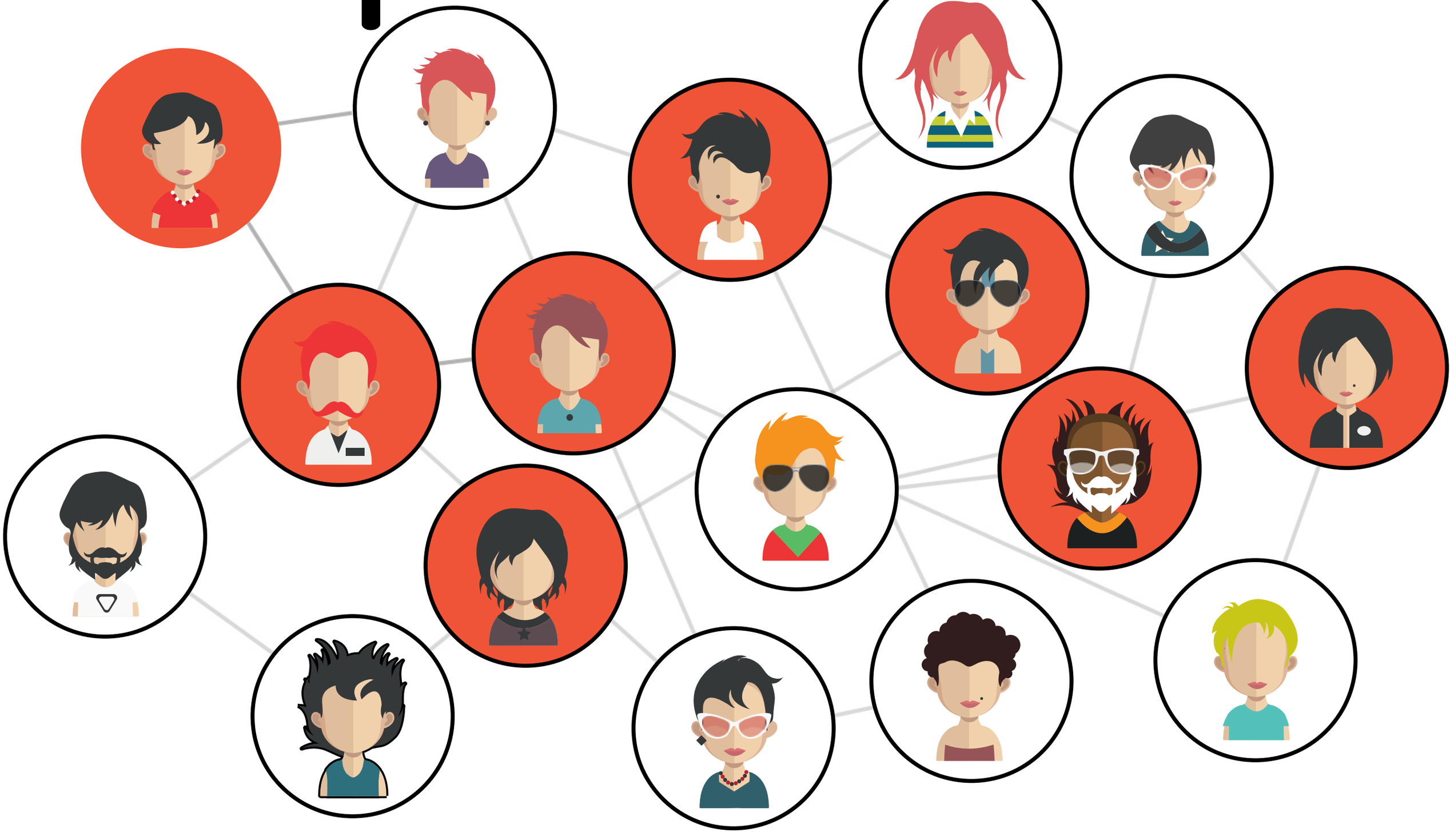
# Independent cascade



# Independent cascade



# Independent cascade



# Independent cascade

**Good for:**

information and rumor propagation

# Linear threshold model

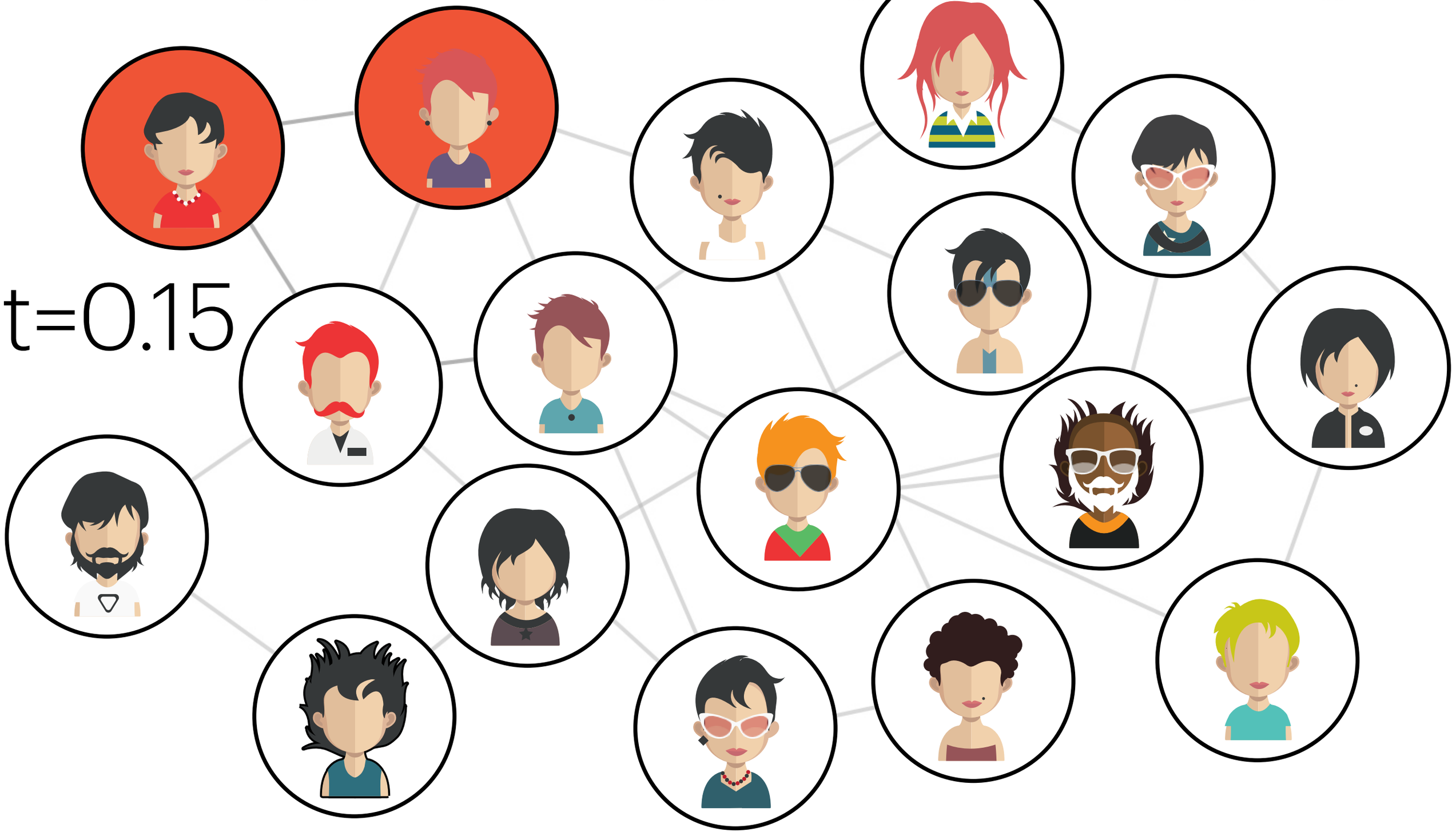
**Irreversible** states

Easy to **compute**

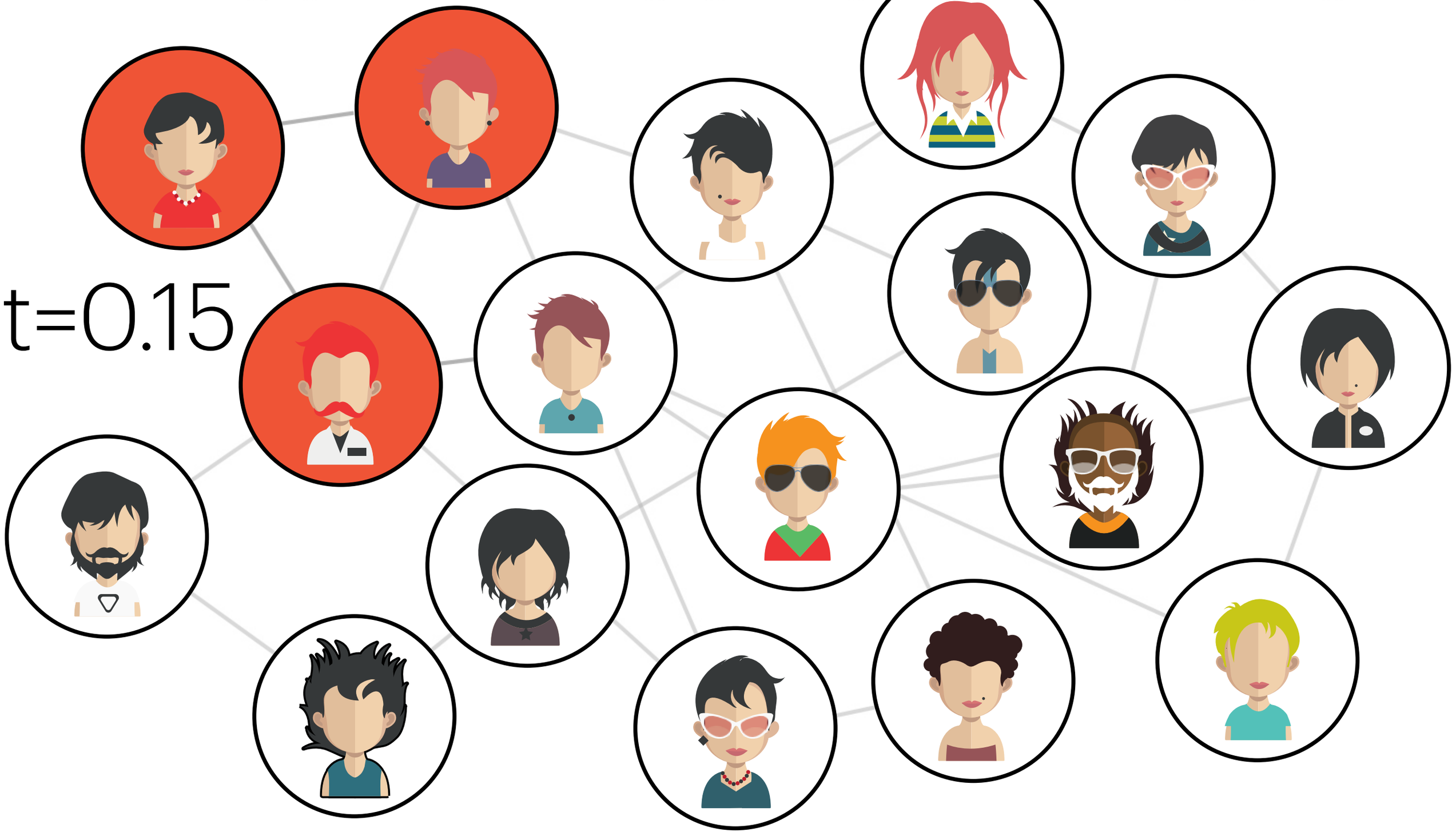
Toy model for **complex contagion**

# Linear threshold model

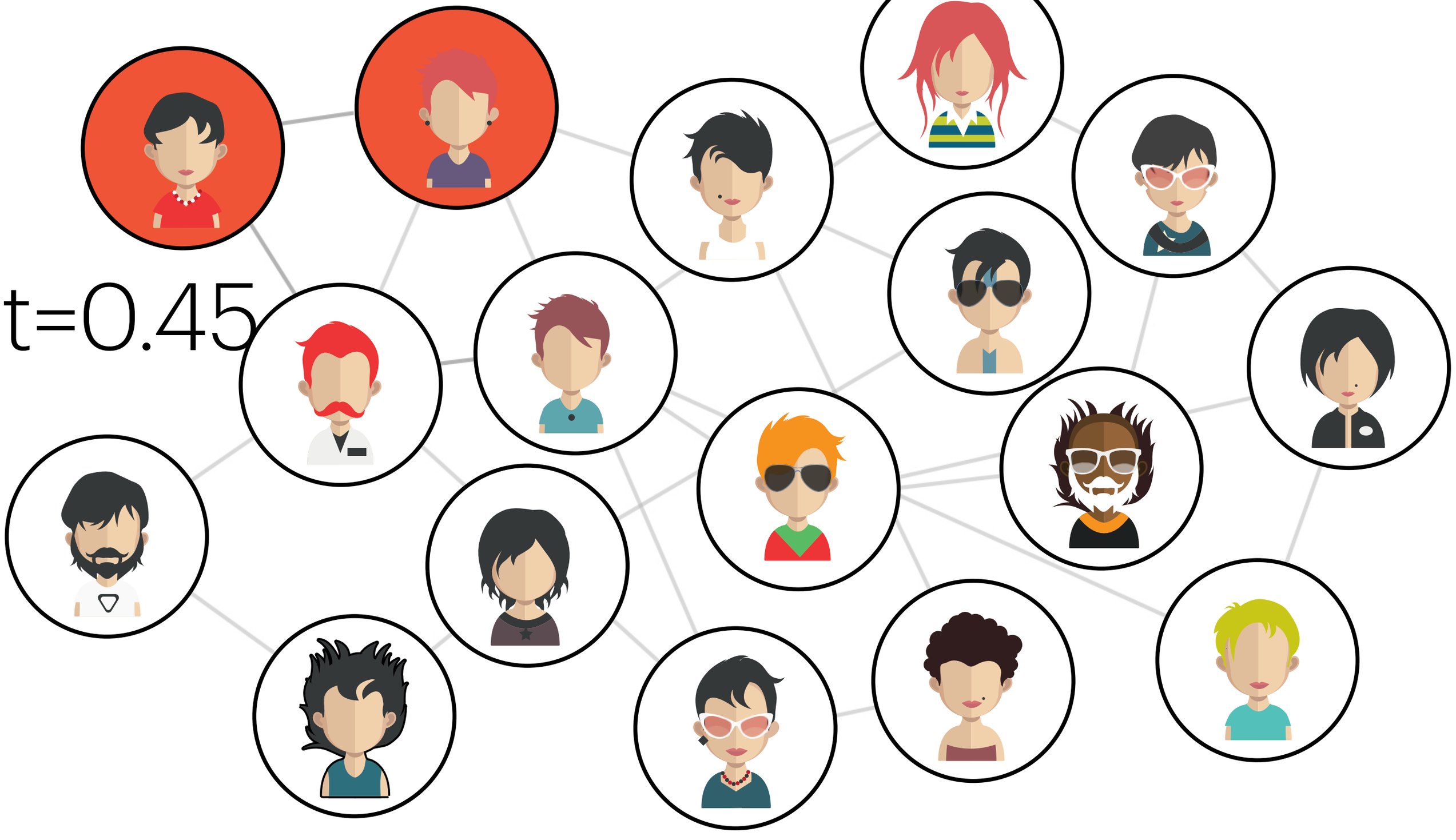
# Linear threshold model



# Linear threshold model



# Linear threshold model



# Time to play!

**www.ncase.me/crowds**

# Linear threshold model

**Good for:**

Group decisions, Majority voting, etc.

# Voter model

**Flipping** states

**Simple**, analytical solution for equilibrium

**Fails** when opinions are fine-grained

# Voter model

## Properties

"Always" reach consensus

Analytical formula for equilibrium

Many possible extensions

# Voter model

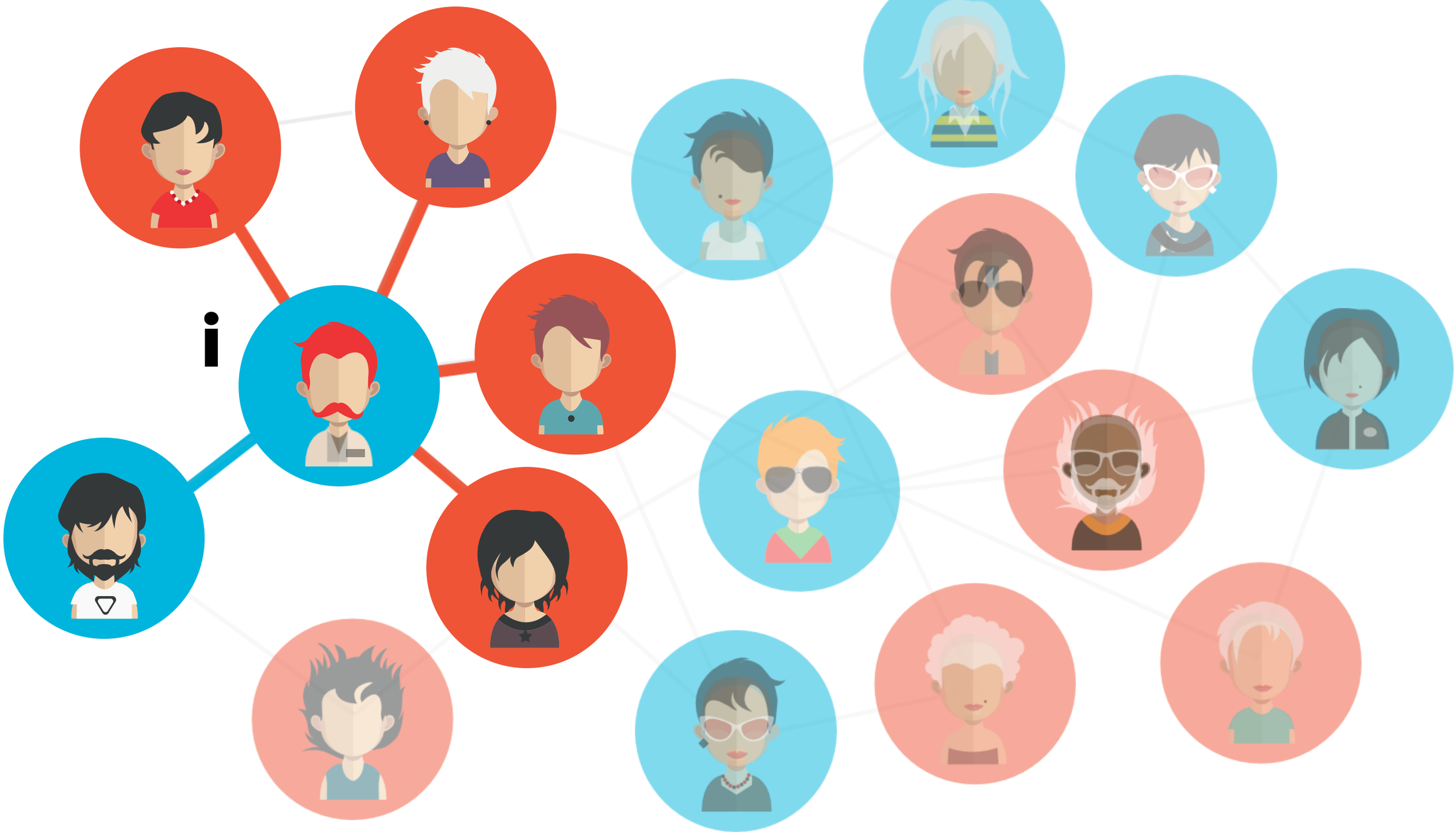
1) Pick a random node i

2) pick a random neighbour j of node i

3) change opinion of i to opinion of j

**Do this simultaneously for all the nodes**

# Voter model



# Voter model

i

## What will be the next colour of i?

# Voter model

## Good for:

anything with binary states that can be reverted

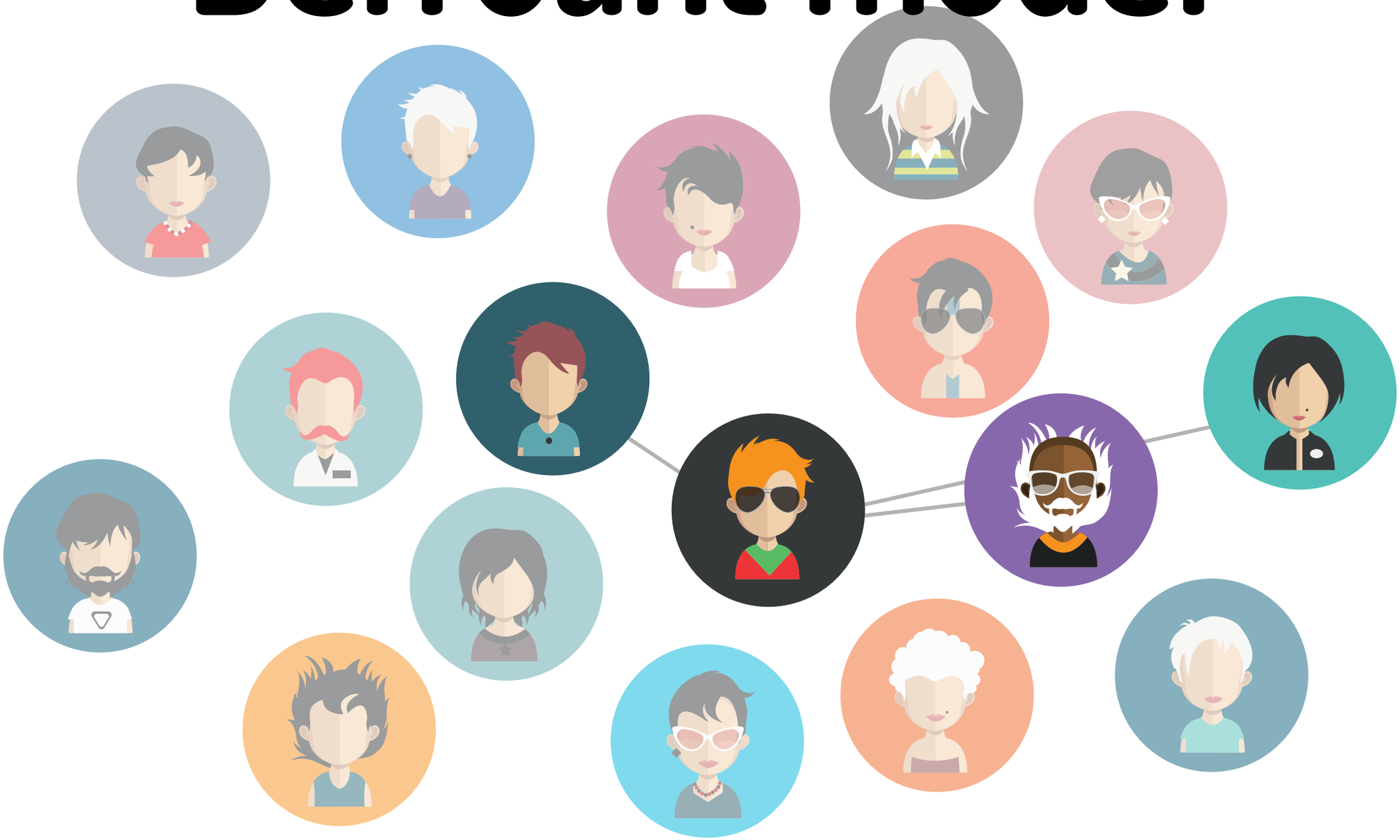
# Bounded confidence models

**Continuous** opinions

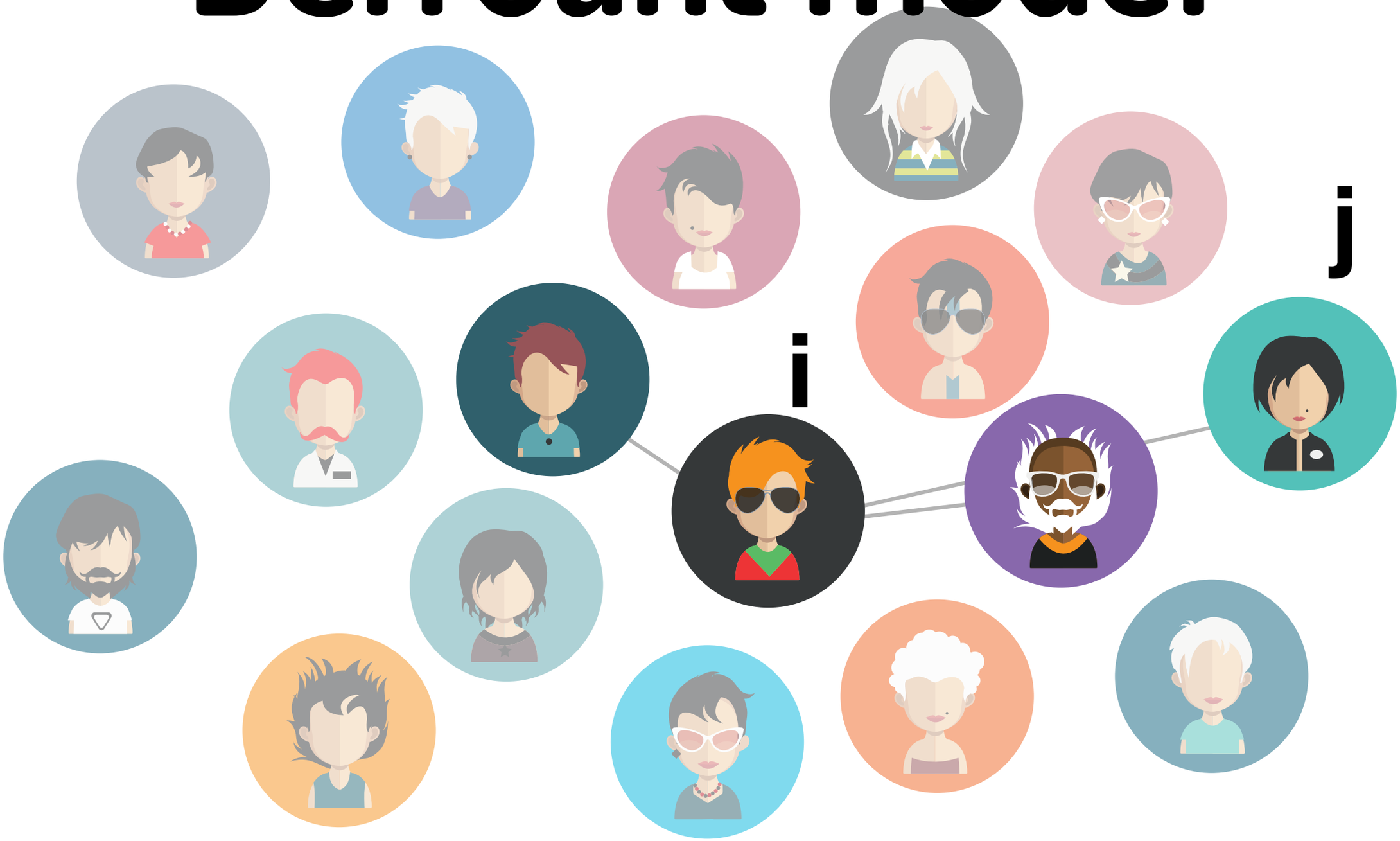
Usually between **0 and 1** but not necessarily

**Easy to implement** with agent-based models

# Deffuant model



# Deffuant model



# Deffuant model

## Equations

$$\begin{cases} o_i(t+1) = o_i(t) + \mu(o_j(t) - o_i(t)) \\ o_j(t+1) = o_j(t) + \mu(o_i(t) - o_j(t)) \end{cases}$$

# Deffuant model

Opinion agent i

Equations

$$\begin{cases} o_i(t+1) = o_i(t) + \mu(o_j(t) - o_i(t)) \\ o_j(t+1) = o_j(t) + \mu(o_i(t) - o_j(t)) \end{cases}$$

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Opinion agent i

Equations

Convergence parameter

$$\begin{cases} o_i(t+1) = o_i(t) + \mu(o_j(t) - o_i(t)) \\ o_j(t+1) = o_j(t) + \mu(o_i(t) - o_j(t)) \end{cases}$$

# Deffuant model

Opinion agent i

Equations

Convergence parameter

$$\begin{cases} o_i(t+1) = o_i(t) + \mu(o_j(t) - o_i(t)) \\ o_j(t+1) = o_j(t) + \mu(o_i(t) - o_j(t)) \end{cases}$$

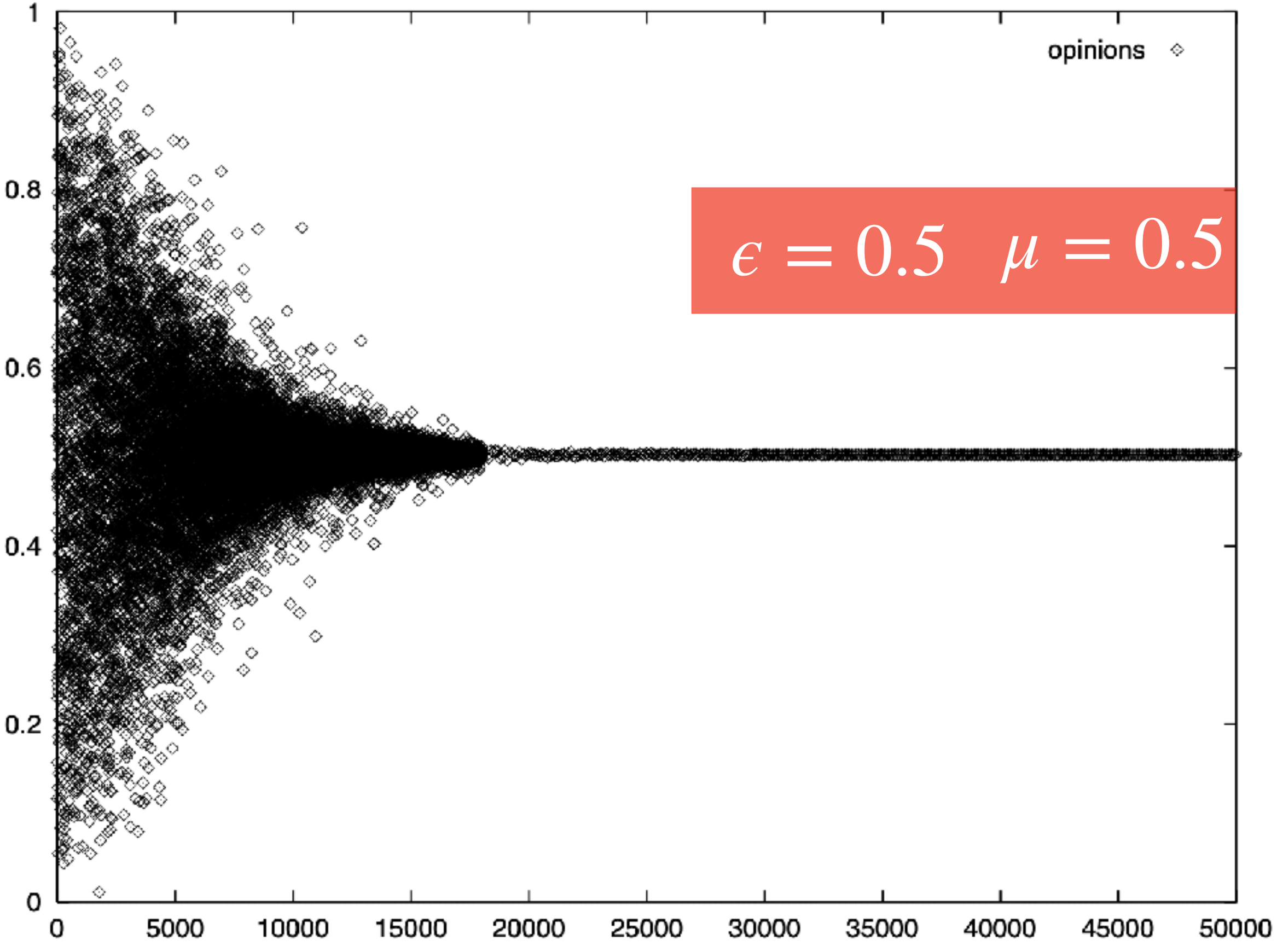
**Only If** $|o_i(t) - o_j(t)| < \epsilon$


TO EVERYONE WHO RESPECTS
$|o_i - o_j| < \epsilon$
DIFFERENT OPINIONS
imgflip.com

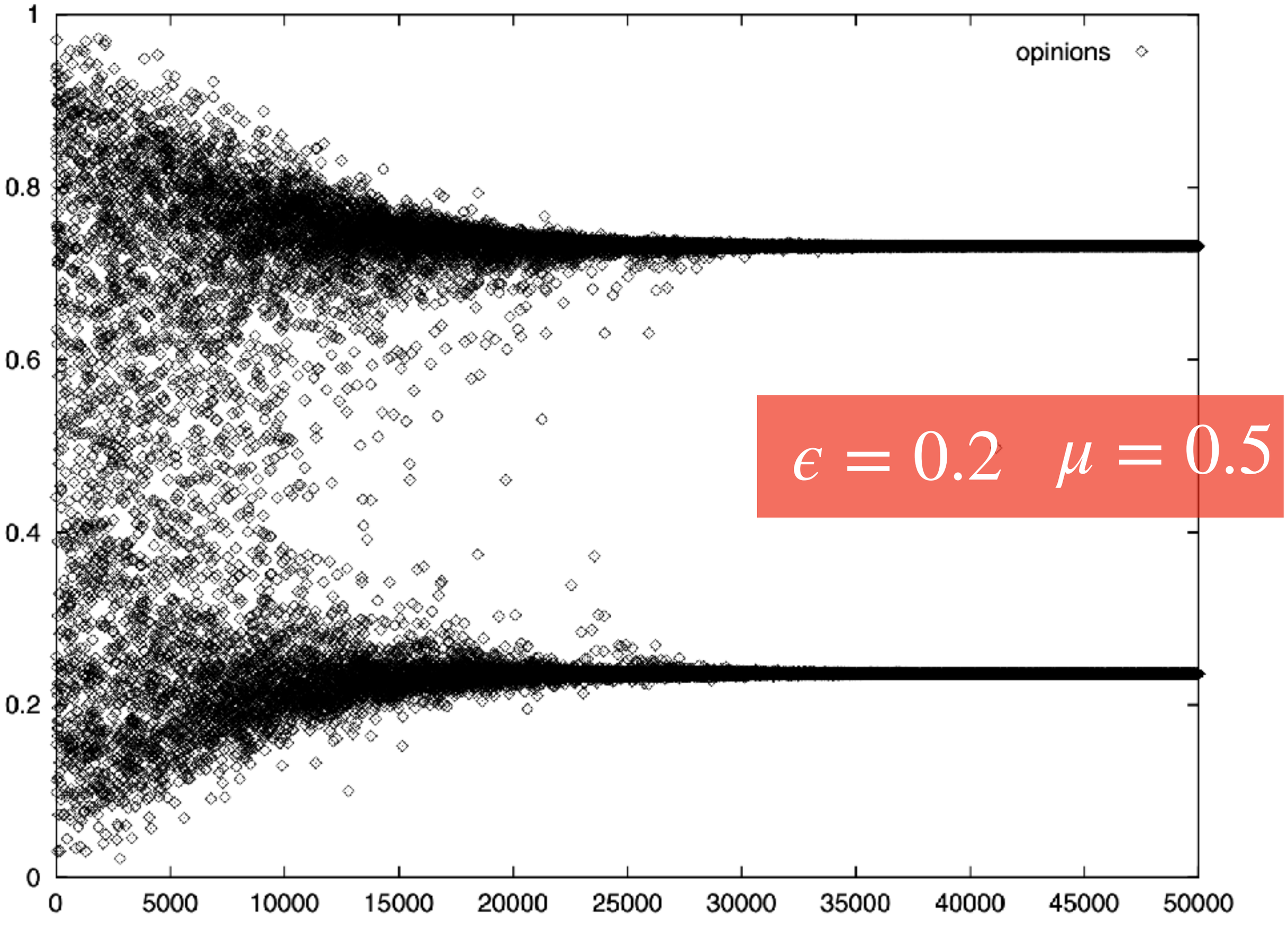
I DON'T ALWAYS LISTEN TO OTHER'S OPINIONS,

$$|o_i - o_j| > \epsilon$$

BUT WHEN I DO, I PUT ON MY 'I DON'T GIVE A SHIT' FACE.




$\epsilon = 0.5 \quad \mu = 0.5$




$\epsilon = 0.2 \quad \mu = 0.5$

# Deffuant model

**Good for:**

when you need continuous opinions

# Case study

An opinion dynamics model
**for prediction markets**

# Prediction markets

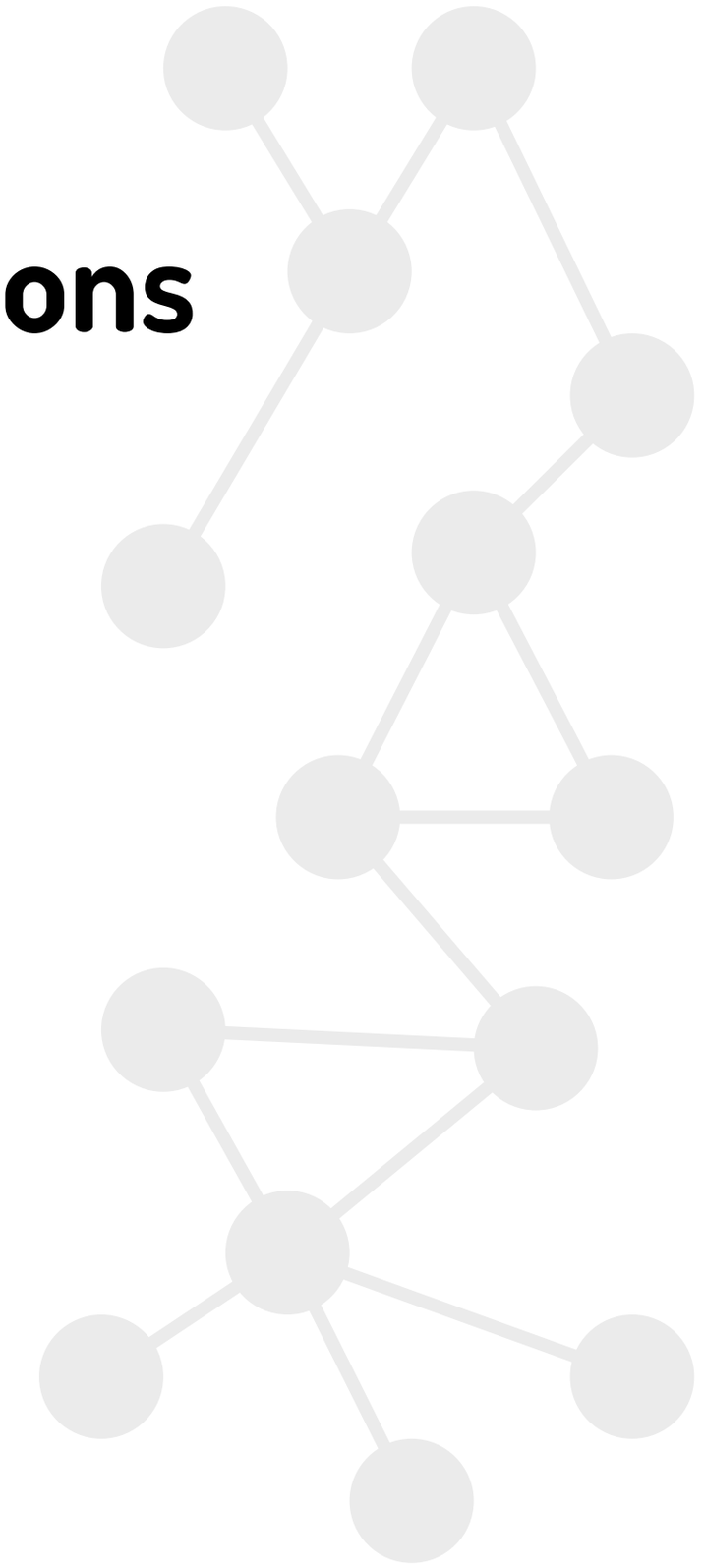
Markets on events that have a **definite** end-point
(e.g. political elections, football match, price of stock at time t)

Contract **pays 1** if correct **0 otherwise**

Price reflect **perceived probability** of that outcome to occur

# Model

Agents start with **random opinions**
(uniform, between 0 and 1)



# Model

Agents start with **random opinions** (uniform, between 0 and 1)

They “live” on a **barabasi-albert** network

# Model

Agents start with **random opinions** (uniform, between 0 and 1)

They “live” on a **barabasi-albert** network

They **communicate** with random neighbour

# Model

Agents start with **random opinions** (uniform, between 0 and 1)

They “live” on a **barabasi-albert** network

They **communicate** with random neighbour

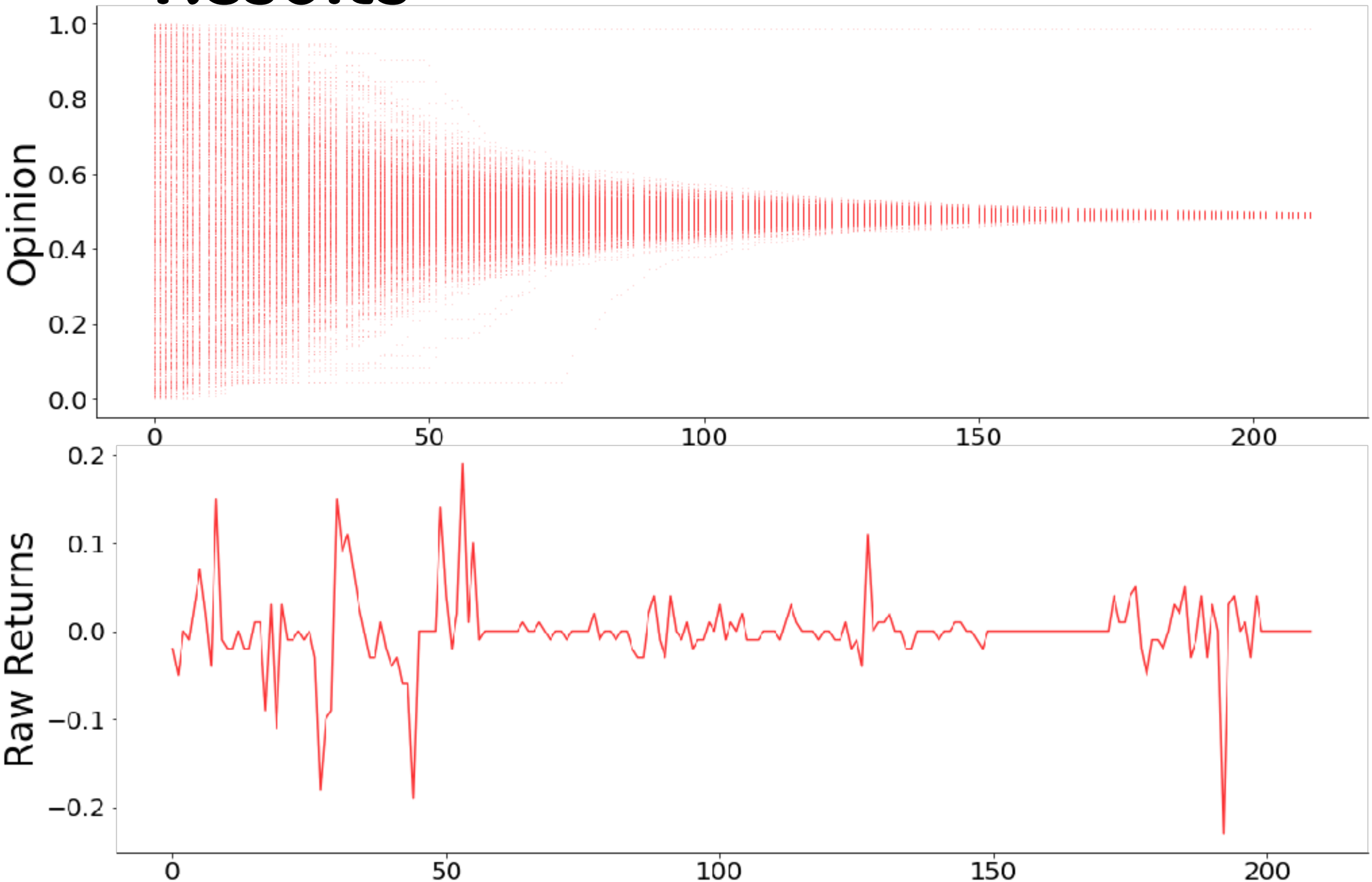
Some of them participate in the **market**. They buy if price is less than their opinion, and sell otherwise

# Simulations

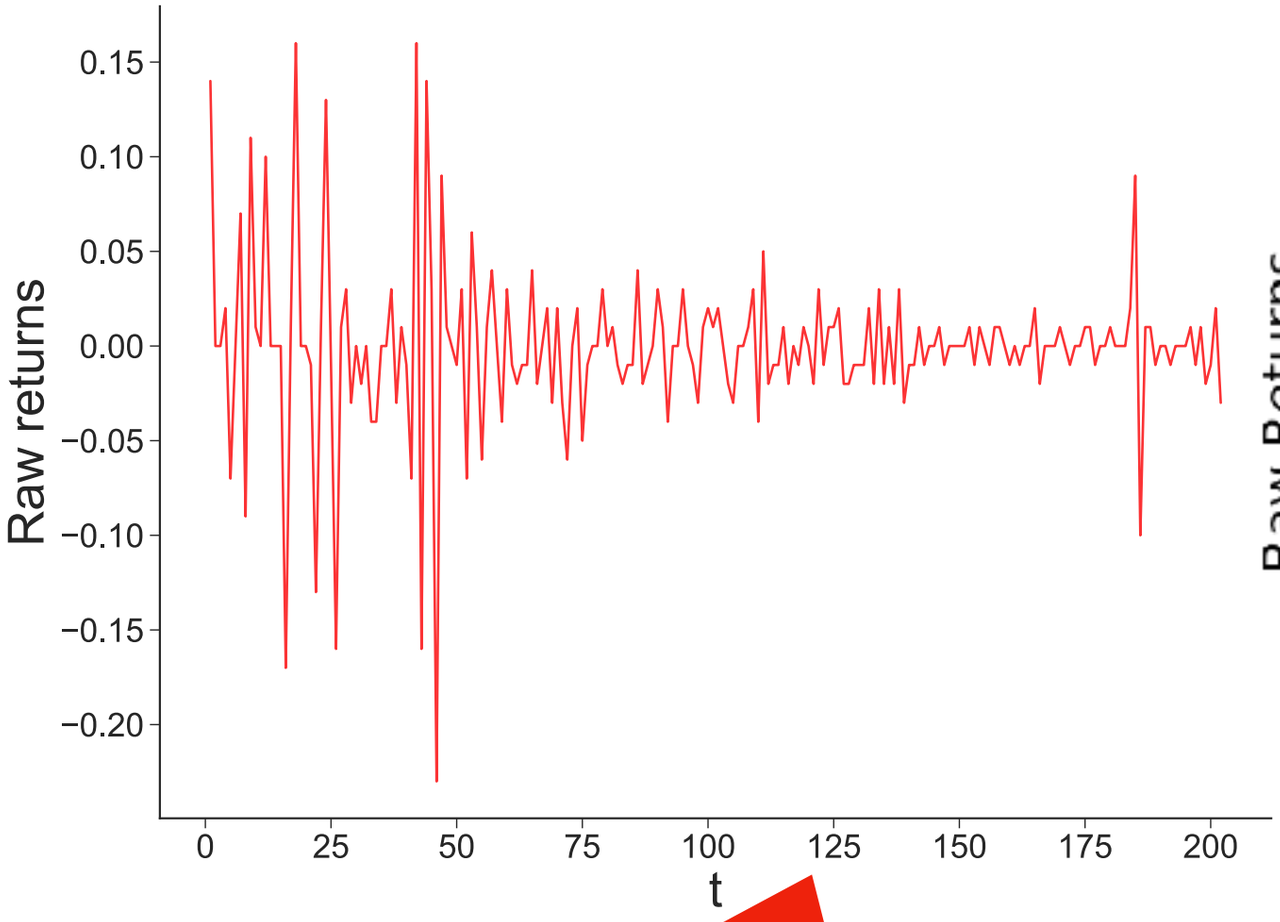
**Generate** price **data** with simulations

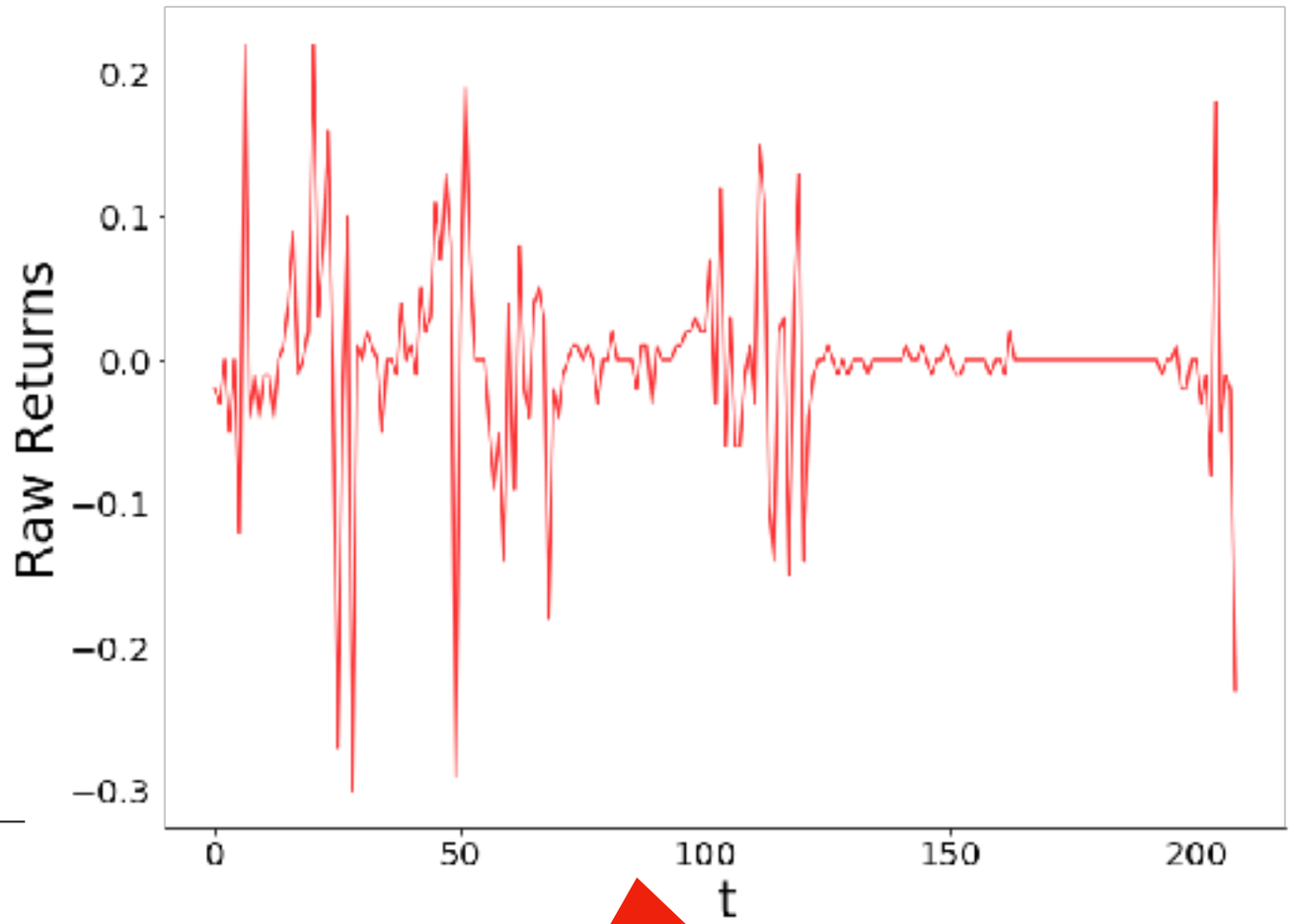
Compare with **empirical data** (3385 markets)

# Results


Opinion
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
Raw Returns
0.2
0.1
0.0
−0.1
−0.2
0
50
100
150
200

# Results

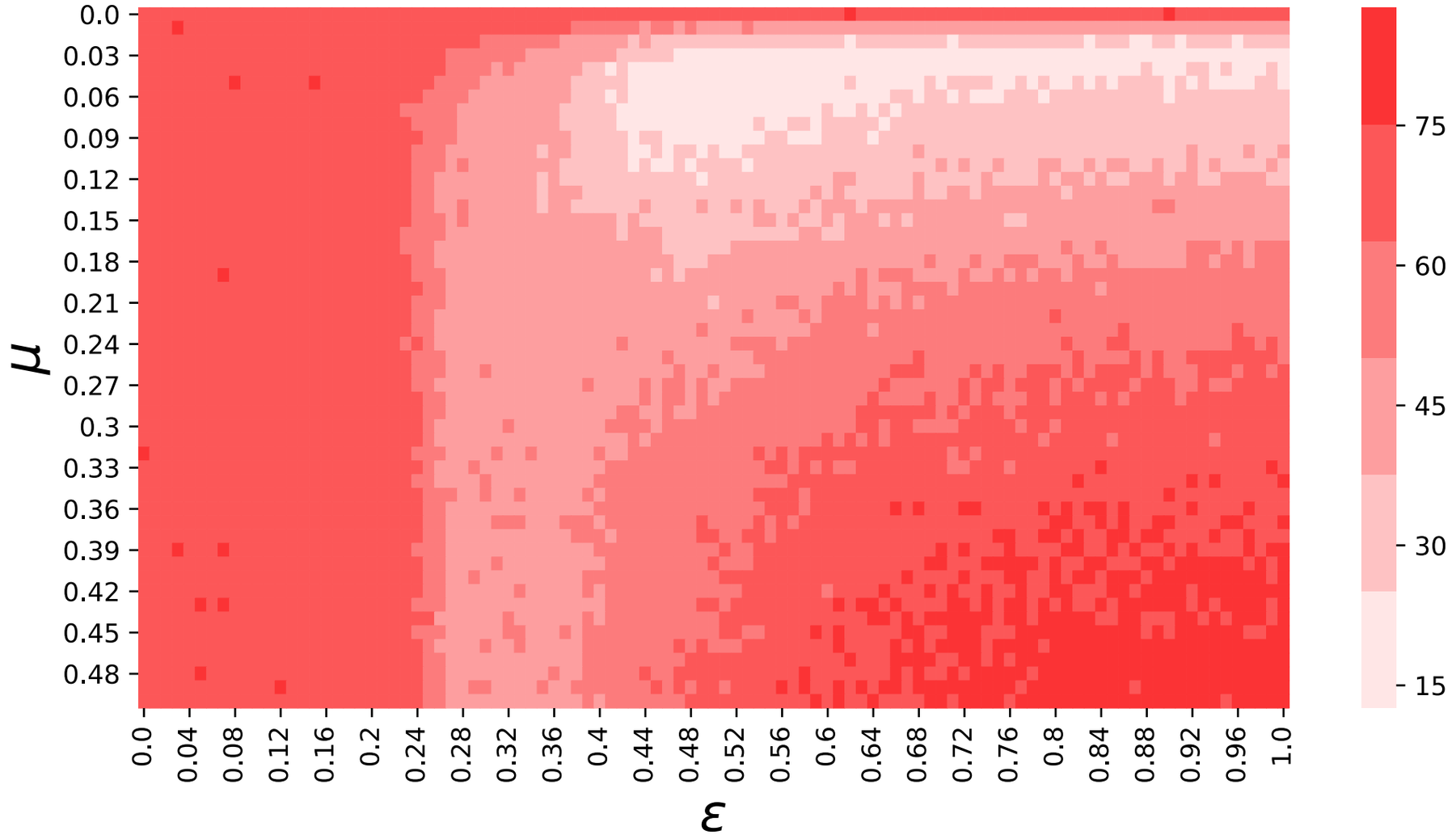


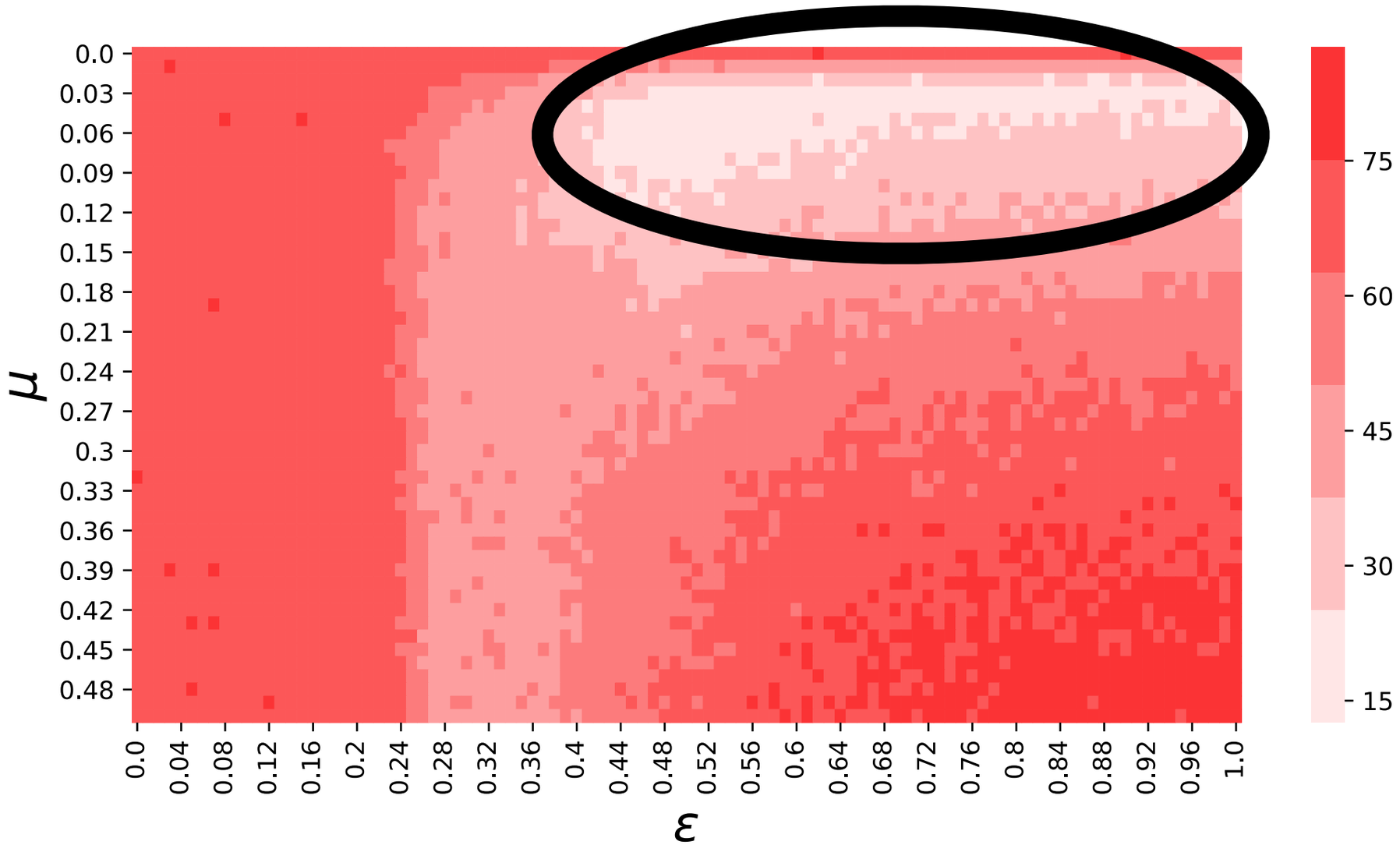

Historical (Brexit)

Simulated

# Results


0.0
0.03
0.06
0.09
0.12
0.15
0.18
0.21
0.24
0.27
0.3
0.33
0.36
0.39
0.42
0.45
0.48
μ
0.0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
0.36
0.4
0.44
0.48
0.52
0.56
0.6
0.64
0.68
0.72
0.76
0.8
0.84
0.88
0.92
0.96
1.0
ε
75
60
45
30
15

# Results


0.0
0.03
0.06
0.09
0.12
0.15
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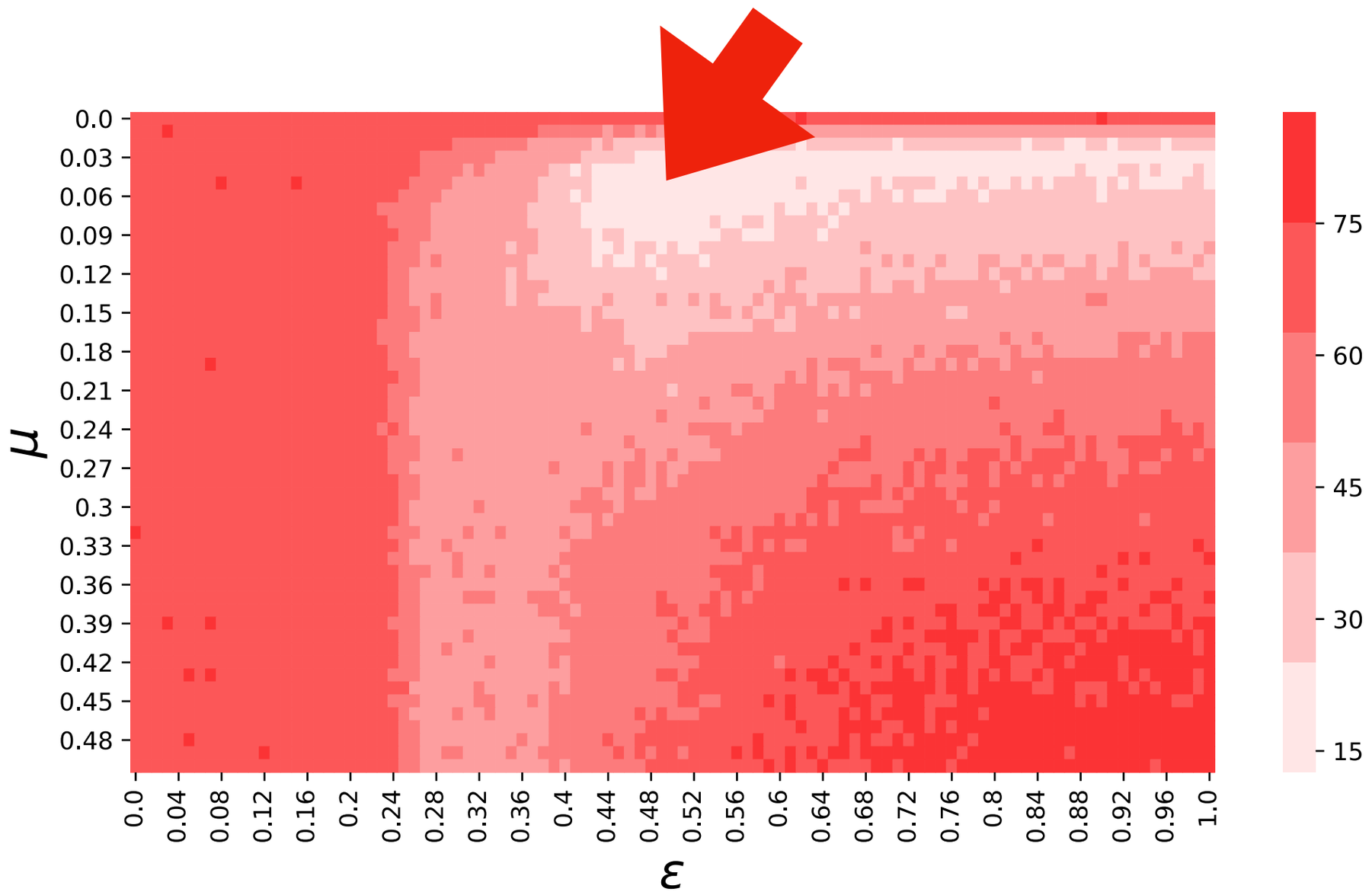
# Results


0.0
0.03
0.06
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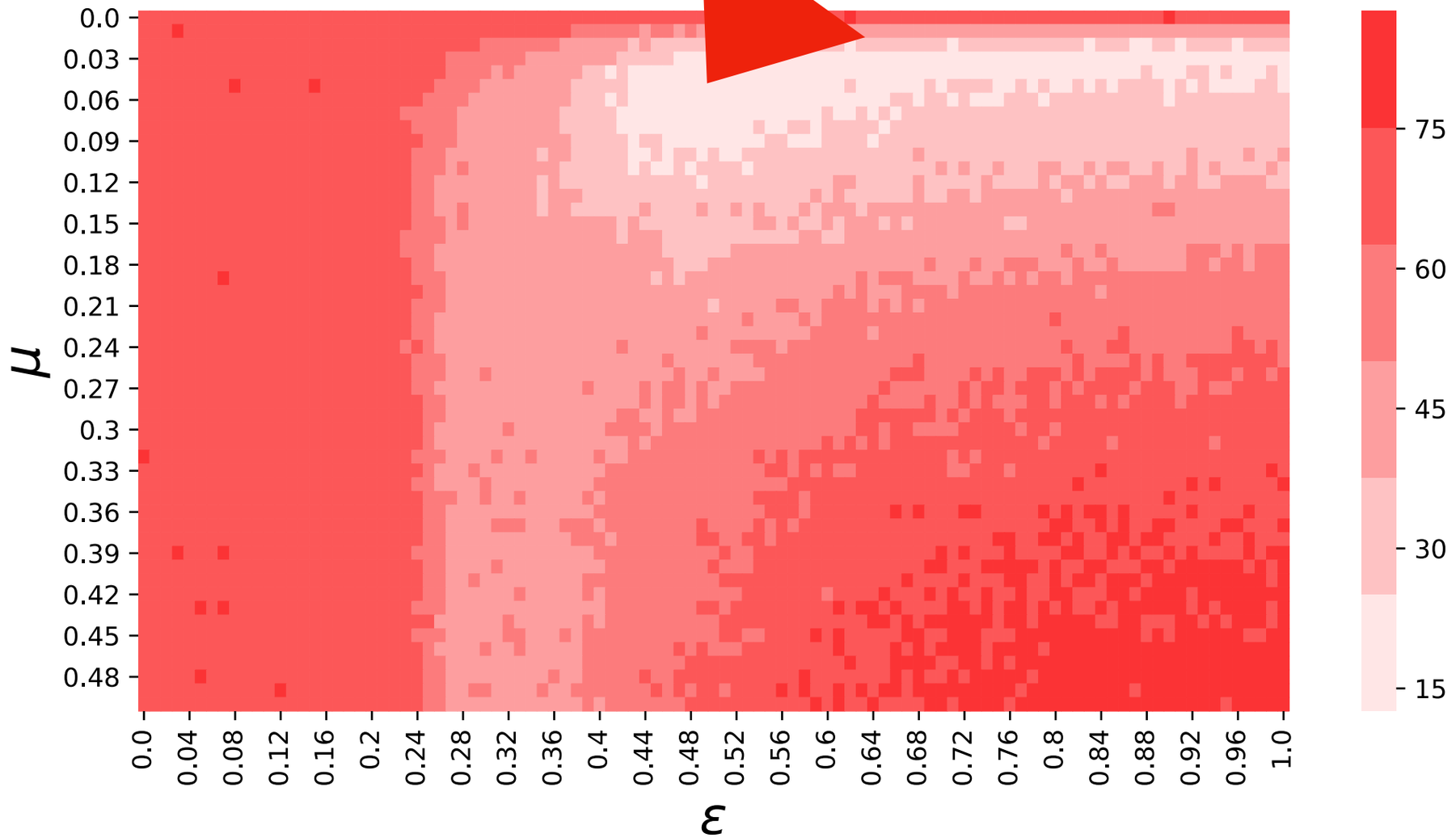
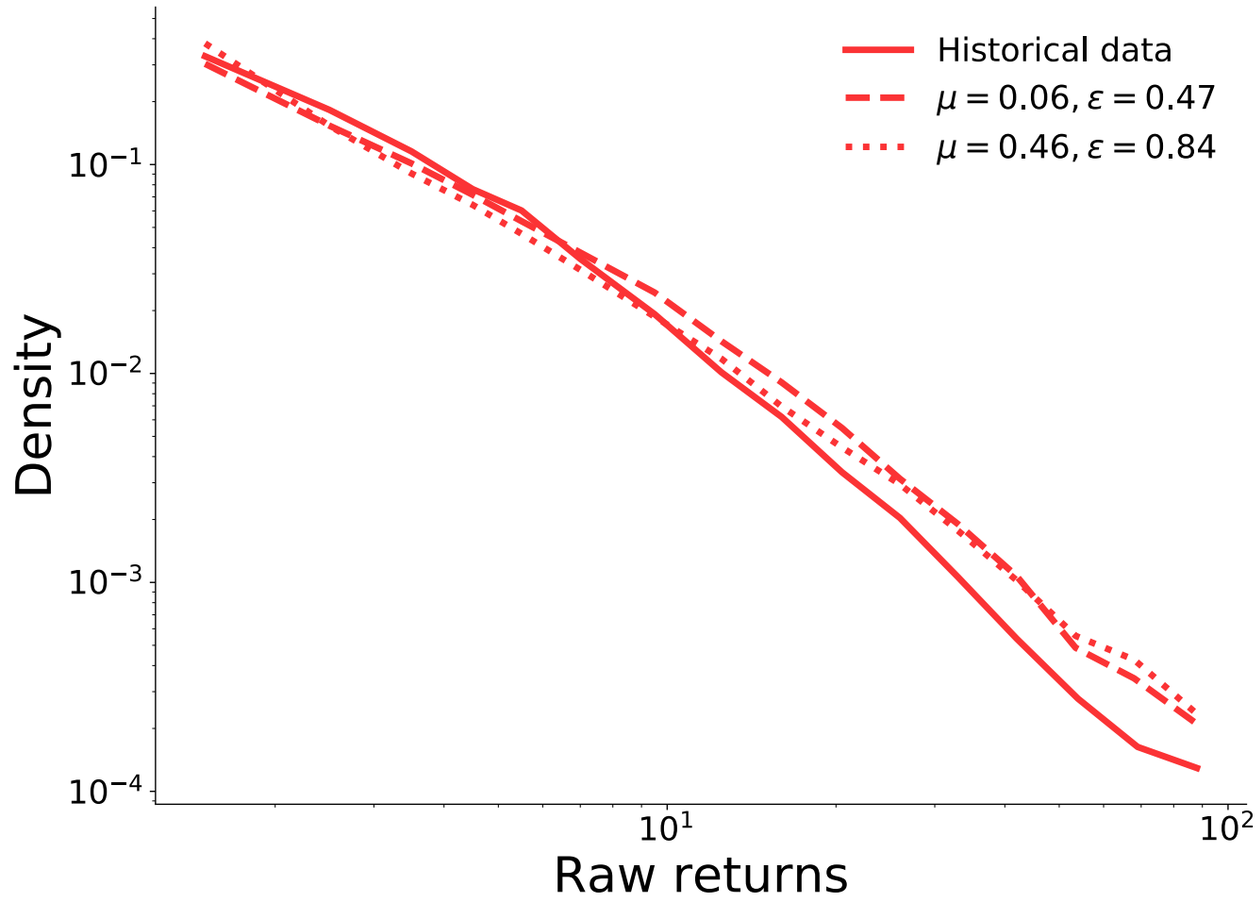
0.68
0.72
0.76
0.8
0.84
0.88
0.92
0.96
1.0
ε
75
60
45
30
15

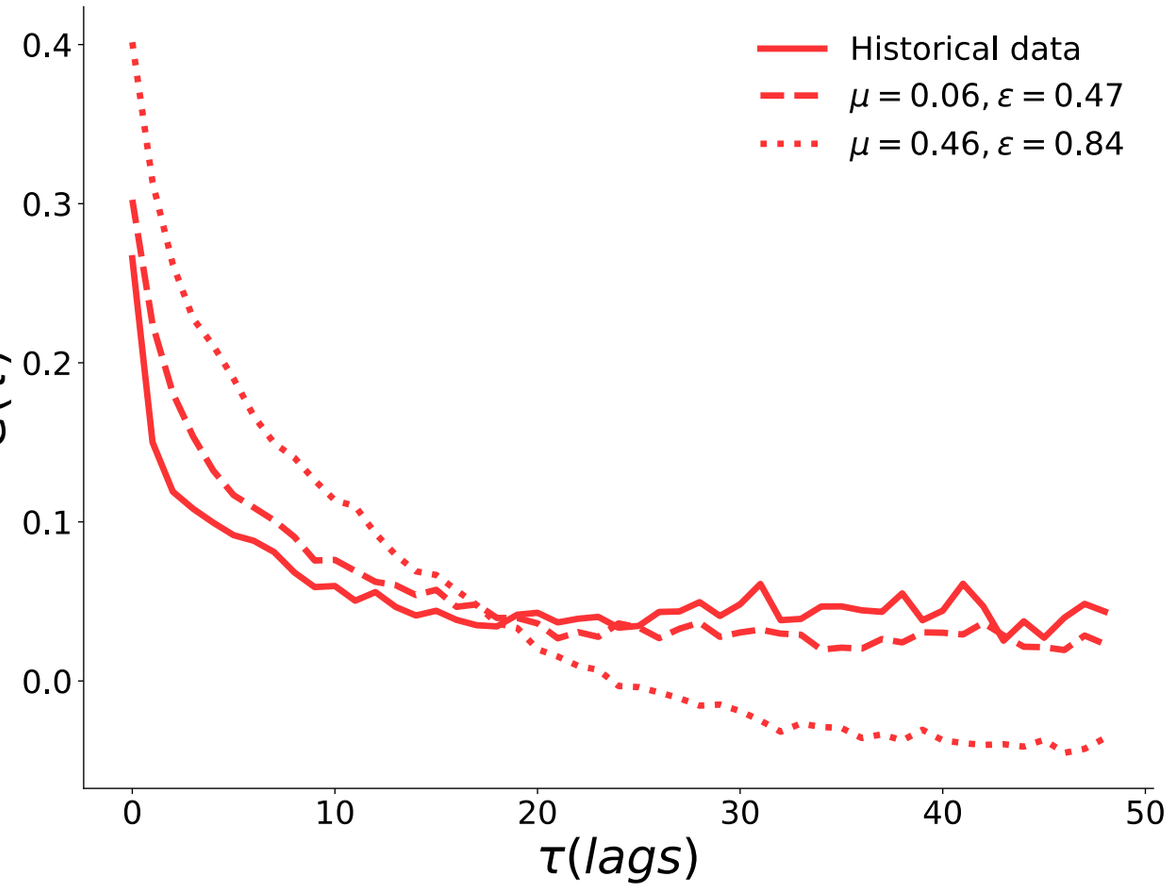
# Results

People exchange opinions with many,
but barely update theirs



# Results


Historical data
$\mu = 0.06, \varepsilon = 0.47$
$\mu = 0.46, \varepsilon = 0.84$
Density
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{1}$
$10^{2}$
Raw returns


Historical data
$\mu = 0.06, \varepsilon = 0.47$
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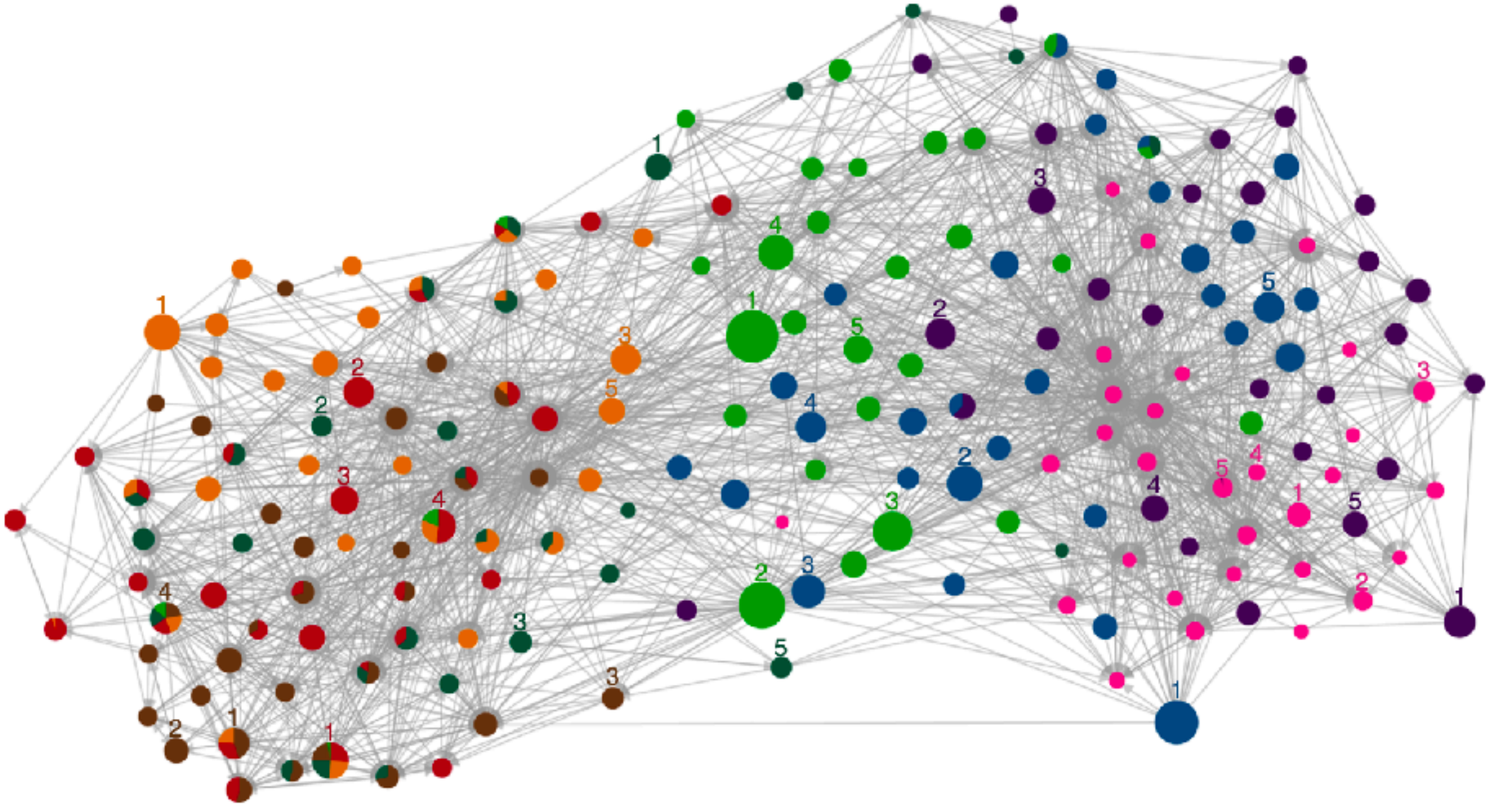
$C(\tau)$
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
$\tau(lags)$

# Case study ii

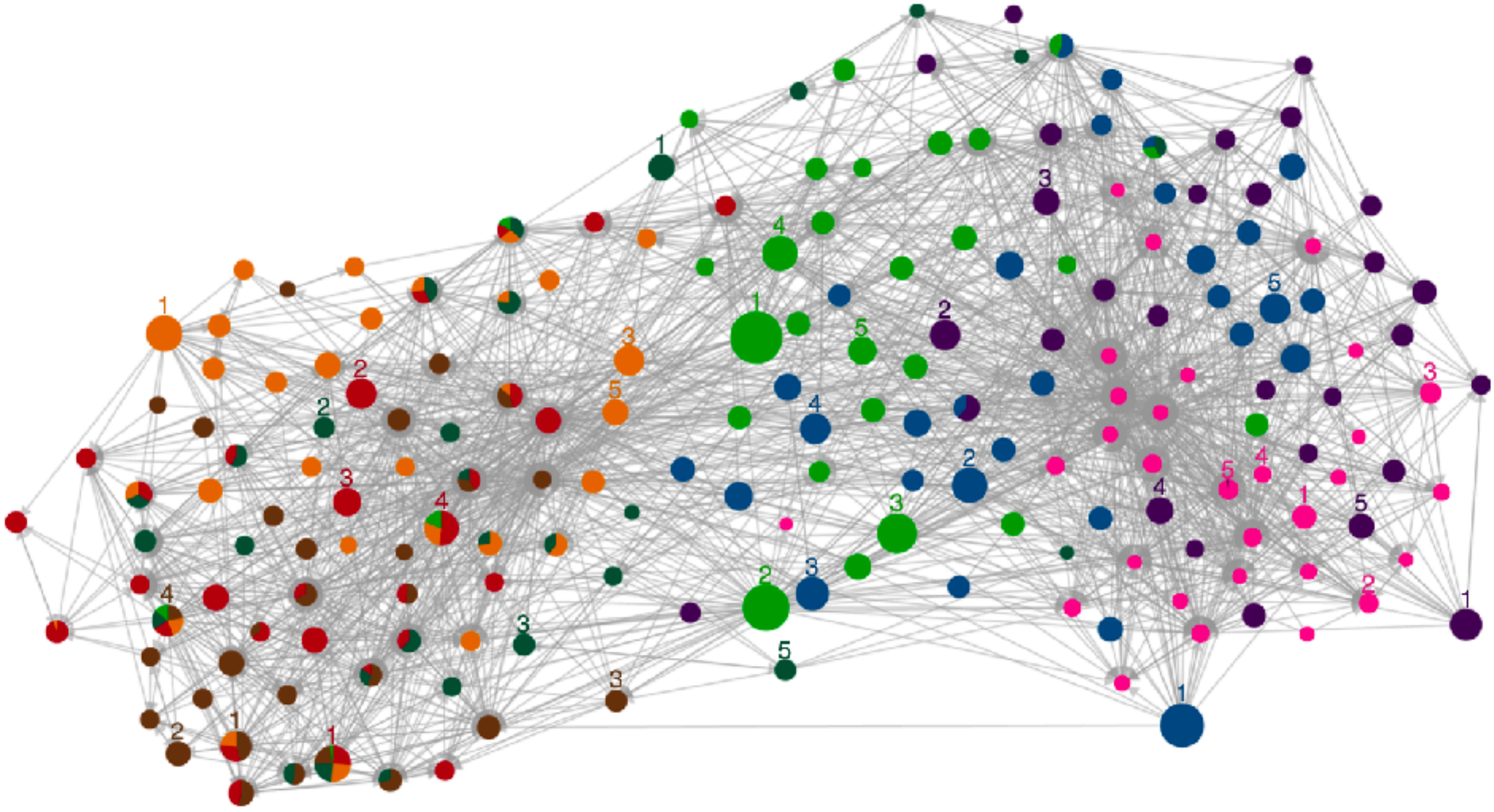
Fake news and Empirical Opinion dynamics on **twitter**

# Empirical opinion dynamics



| Fake news | Extreme bias (right) | Right | Right leaning | Center | Left leaning | Left | Extreme bias (left) |
|---|---|---|---|---|---|---|---|
| 1 @PrisonPlanet | 1 @realDonaldTrump[2,4,5] | 1 @FoxNews | 1 @WSJ | 1 @CNN | 1 @nytimes | 1 @HuffPost | 1 @Bipartisanism |
| 2 @RealAlexJones | 2 @DailyCaller | 2 @realDonaldTrump[1,4,5] | 2 @WashTimes | 2 @thehill | 2 @washingtonpost | 2 @TIME | 2 @PalmerReport |
| 3 @zerohedge | 3 @BreitbartNews | 3 @dcexaminer | 3 @RT_com | 3 @politico | 3 @ABC | 3 @thedailybeast | 3 @peterdaou |
| 4 @DRUDGE_REPORT[4,5] | 4 @wikileaks | 4 @DRUDGE_REPORT[4,5] | 4 @realDonaldTrump[1,2,5] | 4 @CNNPolitics | 4 @NBCNews | 4 @RawStory | 4 @crooksandliars |
| 5 @realDonaldTrump[1,2,4] | 5 @DRUDGE_REPORT[4,4] | 5 @nypost | 5 @RT_America | 5 @Reuters | 5 @Slate | 5 @HuffPostPol | 5 @BoldBlueWave |

# Empirical opinion dynamics



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| 2 @RealAlexJones | 2 @DailyCaller | 2 @realDonaldTrump[1,4,5] | 2 @WashTimes | 2 @thehill | 2 @washingtonpost | 2 @TIME | 2 @PalmerReport |
| 3 @zerohedge | 3 @BreitbartNews | 3 @dcexaminer | 3 @RT_com | 3 @politico | 3 @ABC | 3 @thedailybeast | 3 @peterdaou |
| 4 @DRUDGE_REPORT[4,5] | 4 @wikileaks | 4 @DRUDGE_REPORT[4,5] | 4 @realDonaldTrump[1,2,5] | 4 @CNNPolitics | 4 @NBCNews | 4 @RawStory | 4 @crooksandliars |
| 5 @realDonaldTrump[1,2,4] | 5 @DRUDGE_REPORT[4,4] | 5 @nypost | 5 @RT_America | 5 @Reuters | 5 @Slate | 5 @HuffPostPol | 5 @BoldBlueWave |

# Which model would you use?

## Video becoming viral

## Marketing

## Financial markets

# Summary

Several **models** of opinion dynamics

Practical **applications**

**Case studies**