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# Modelling the impact of interventions aimed at reducing meat consumption using agent-based modelling

# The team

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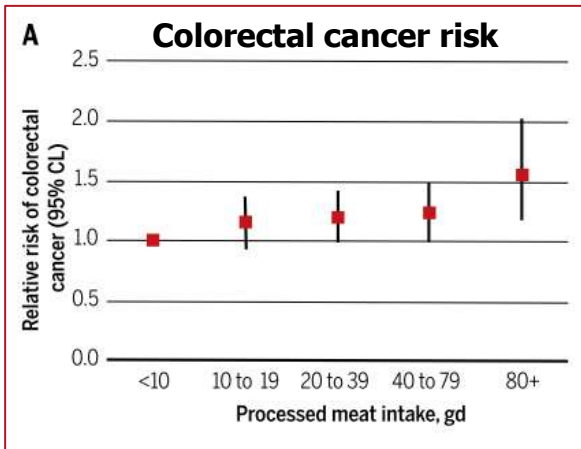
Graham W Horgan



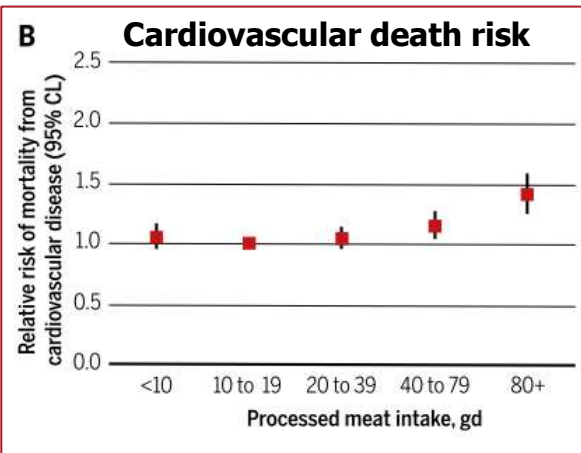
# Agenda

- Research background and objectives
  - The methodology
    - Agent-based modelling
    - MeatNet model
  - Results and discussion
  - Conclusions and future research
  - Q&A
-

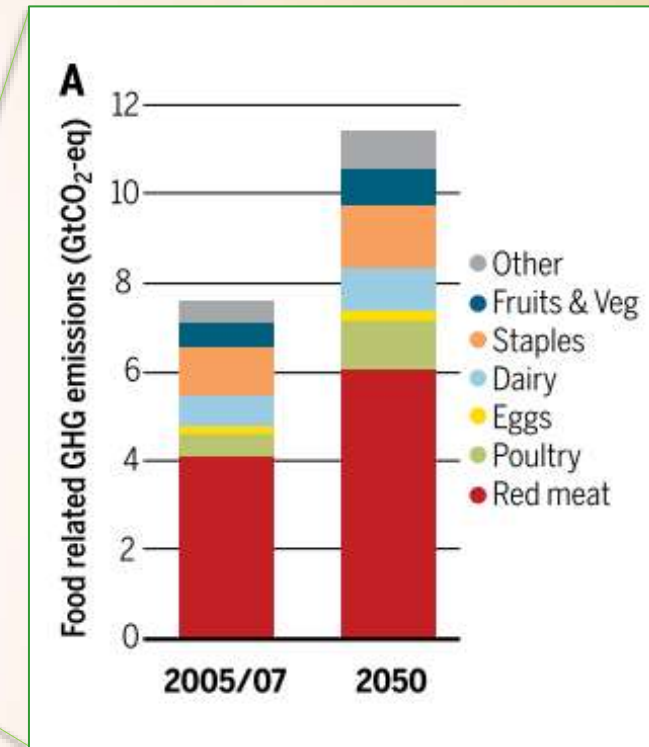
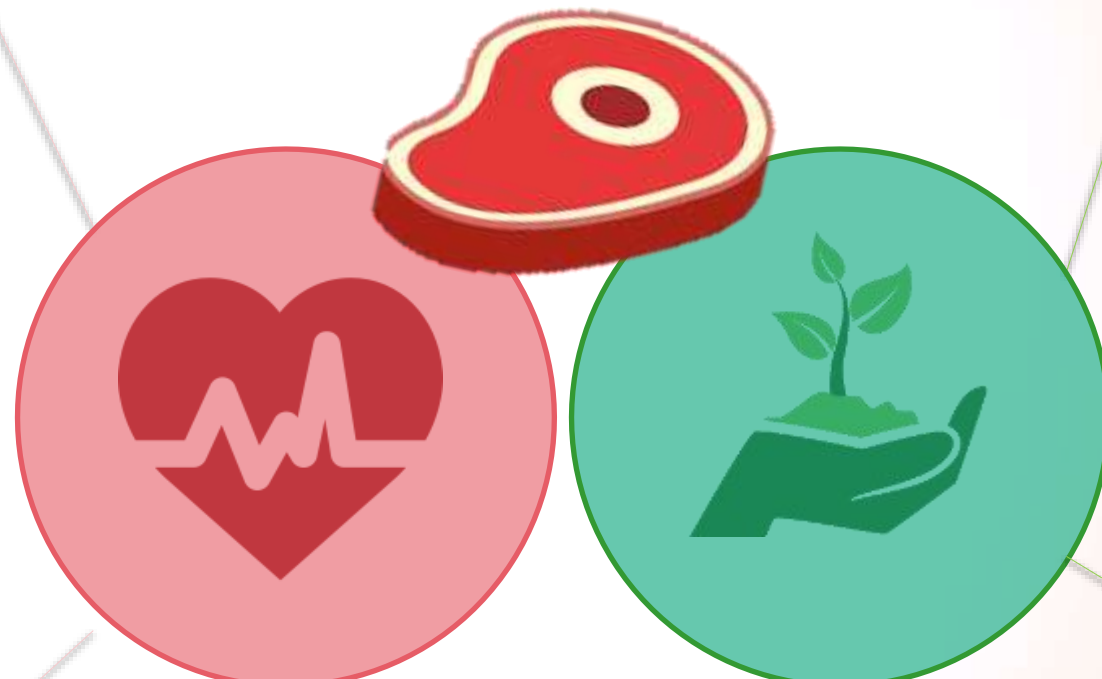
# The problem with meat consumption



[1]



[2]



[3]

# Aim of the research and methodology

To investigate if meat consumption could be changed through **social influence** within personal networks.

We considered two daily contexts:

- meals consumed at **home** with household members
- meals consumed at the **workplace** with co-workers

The effects at the society level of different **social marketing interventions** applied in the **workplace environment** were investigated by developing an agent-based model.

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# Social marketing interventions in real-life

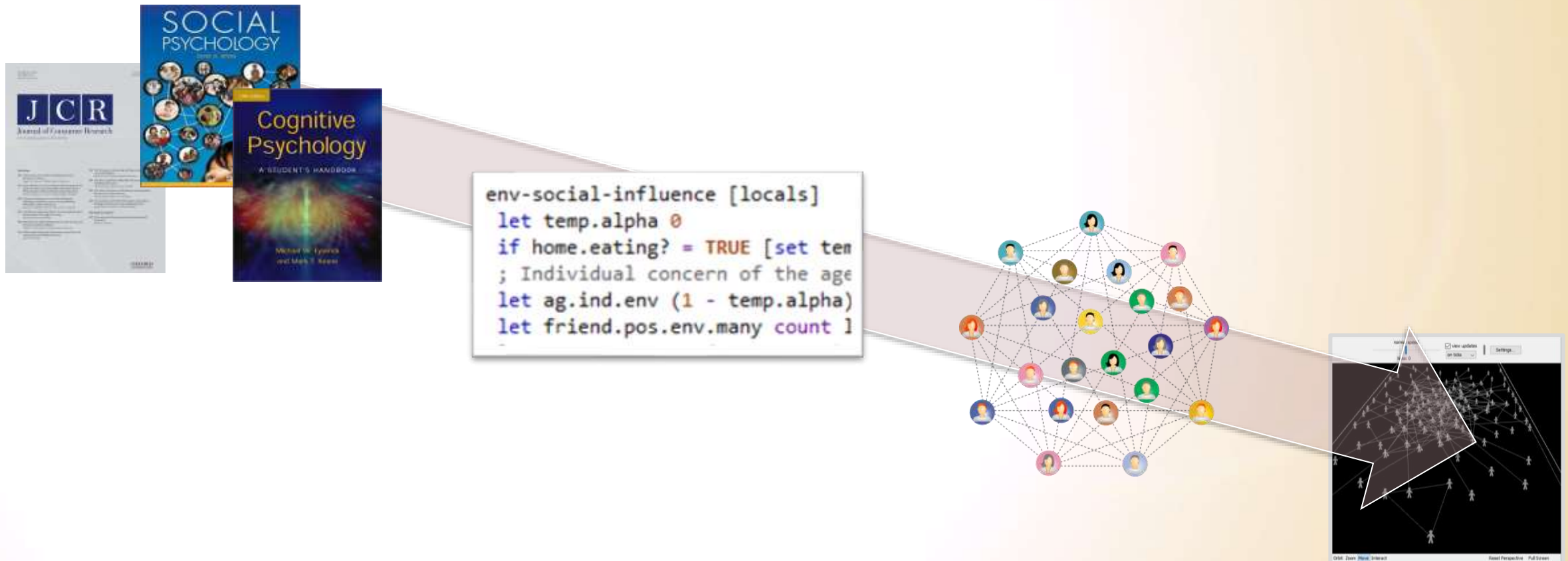


## Norm-based message

**“A lot of people aren’t aware that the typical student eats their five servings of fruits and vegetables each day. Students eat more fruit and vegetables than you’d expect” [1]**

# Agent-based modelling

Agent-based modelling (ABM) is a computational method that simulates **individuals** making decisions according to programmable rules (Badham et al., 2018).



[<sup>1</sup>] Badham, Chattoe-Brown, Gilbert, Chalabi, Kee, & Hunter (2018).

# Some reasons for using agent-based models

- Account for **non-linear mechanisms** (e.g. thresholds)
- ABMs are dynamic and can incorporate **feedback**
- Agents can include a variety of characteristics (i.e. **heterogeneity**)
- Agents can **react/adapt** to changes in the environments
- They can help studying **complex systems** (like public health) because system-level phenomena emerges from the interaction of the individuals



# Complex systems



**Complexity** is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties.

Mikulecky (2011)

# Modelling from the bottom-up



File Edit Tools Zoom Tabs Help

Interface Info Code

Edit Delete Add abc Button slower ticks: 0 view updates on ticks Settings...

density 95 %

setup go once go

%-similar-wanted 33 %

**Percent Similar** # agents 2475  
% similar 50.3

**Number-unhappy** num-unhappy 404  
% unhappy 16.3

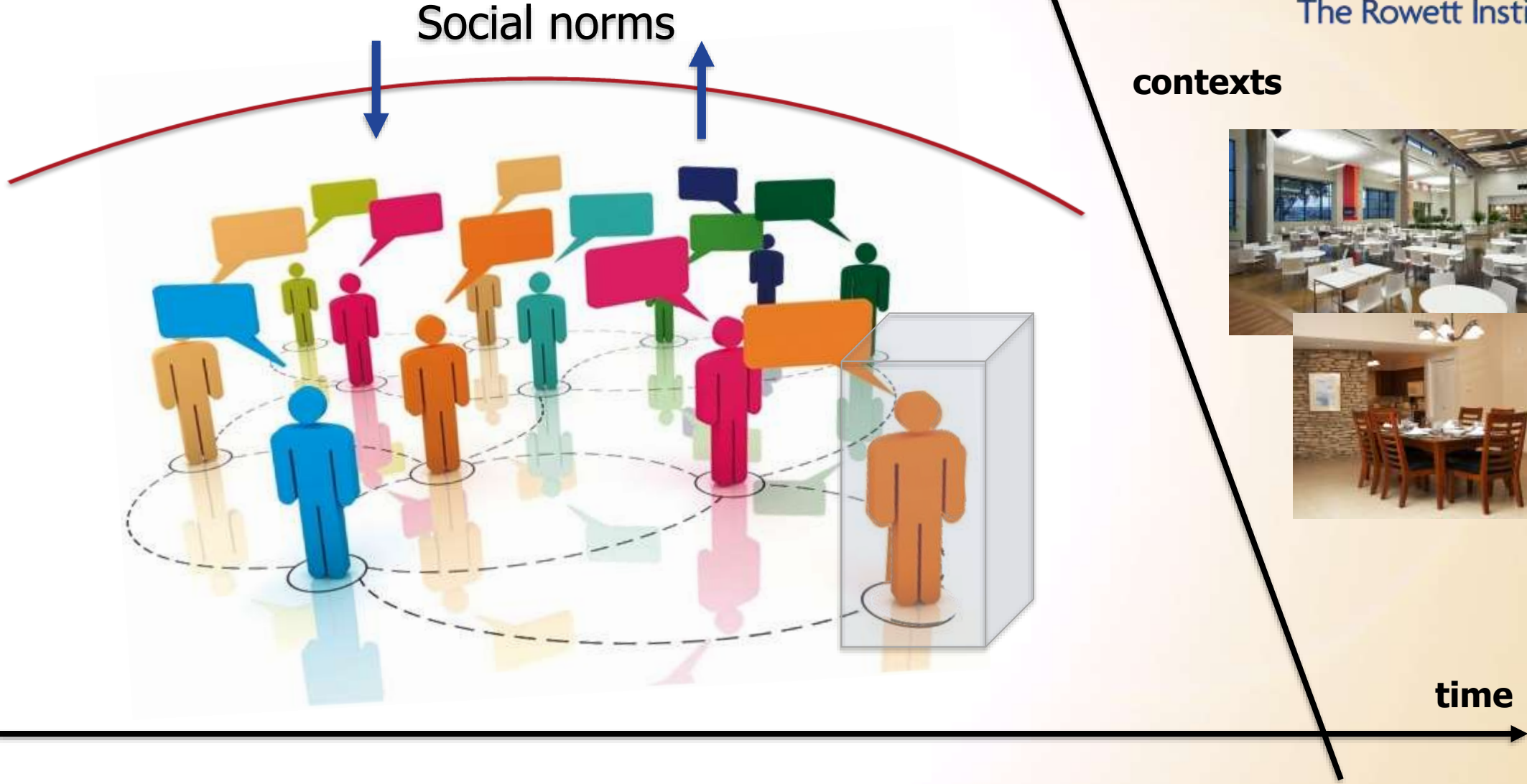
visualization square-x

Command Center Clear

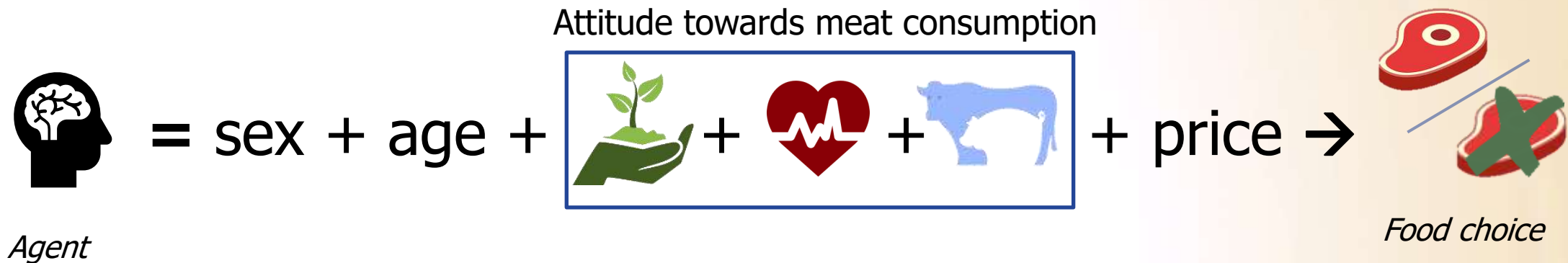
observer >

[\*] Source: Wilensky, U. (1997). NetLogo implementation of Schelling segregation model (1978).

# Complex social systems



# Modelling consumers like virtual agents



For the decision - Data from the **British Social Attitude Survey** (2014)

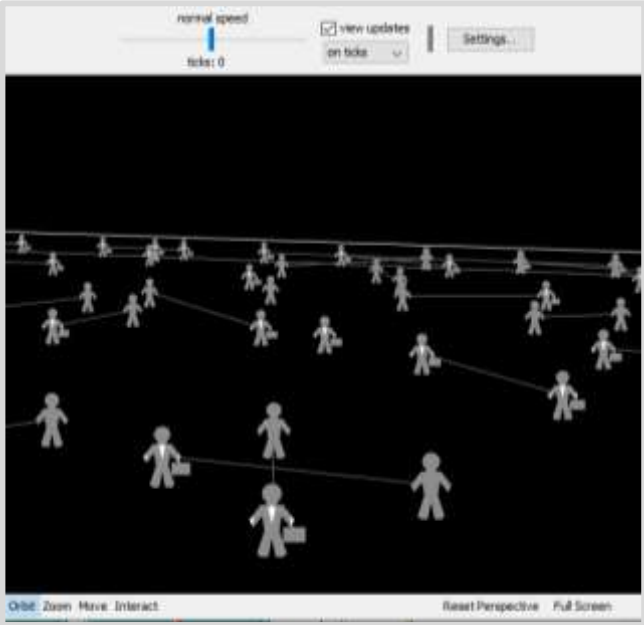
- 2759 consumers – 18 y.o. or over
- There are a number of predictors of meat consumption

For the amount - Data from **National Diet Nutrition Survey** (2008/9 - 2013/14)

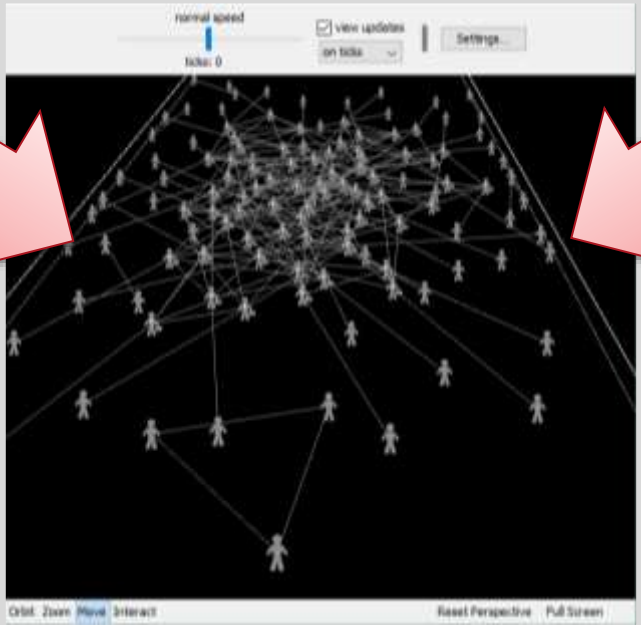
- Meat intake depends on respondent's sex, time of the day, and context

# Social ties and time framework

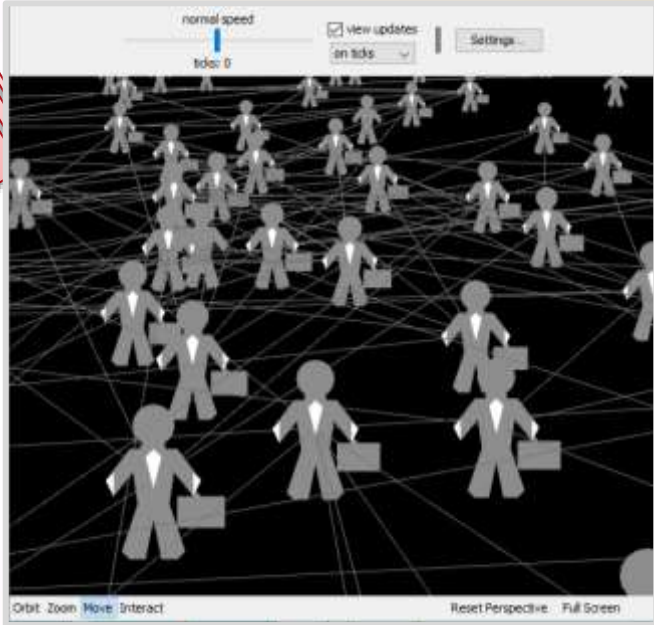
Household members



Combined networks



Co-workers



Mon

Tue

Wed

Thu

Fri



# The main “rules” of social influence

- An agent can perceive the concerns of others  
(i.e. agents talk about their concerns from time to time)
  - An agent is affected only by those agents its network
  - An intervention will shift agent's attention towards those agents that owns higher concerns than itself
  - Susceptibility is normally distributed among agents... however, household members tend to have greater influence than co-workers
  - Agents' re-evaluate its concerns after interacting with others
-

# Putting together social influence rules



## Weighted mean of the agent's concern (C)

- **Alpha ( $\alpha$ )**  
Individual susceptibility to household members/co-workers
- **Gamma ( $\gamma$ )**  
Effect derived from social marketing intervention

$$C_{i,t} = (1 - \alpha_i)C_{i,t-1} + \alpha_i \frac{\sum_{j \in \text{peers}(i)} (1 + \gamma) C_{j,t-1} + \sum_{j \in \text{peers}(i)} (1 - \gamma) C_{j,t-1}}{\sum_{j \in \text{peers}(i)} (1 + \gamma) + \sum_{j \in \text{peers}(i)} (1 - \gamma)}$$

$C_{j,t-1} > C_{i,t-1}$        $C_{j,t-1} \leq C_{i,t-1}$

# Intervention options

## Target agents by:

- age
- sex
- concerns

## Messages focus on:

- environmental costs
- health consequences
- animal welfare

## Contexts:

- workplace
- households

## Other options:

- length of time
- one-off/recurrent



g/week per  
agent



Likelihood of  
eating meat



# Original interface

Interface Info Code

Edit Delete Add

Setup S 1year M Go2 G Run2 R

Layout? NONE Network? N/A On Off Labels? Arrange A Label: (Fam-ID: Team-ID)

reset-perspective On Off show-size?

Colours? pMeat Refresh colours C

Experiment.id Experiment.label  
3 ;MC\_Environment\_ECWorkers Data export

On Off MeatNet-gMeat-Weekly-Report? On Off Report-int-beh-gap?

On Off Export-System-Output? On Off Export-gMeat/Year?

On Off Export-pMeat/year? On Off Export-time.map?

On Off Export-concerns/year? On Off MeatNet-gMeat-EE-Report?

On Off Export-Consumers-Output? On Off blocknotes?

On Off count-family-size?

Temporary simulation controls  
Eating labels On Off seed? Labels=p(meat) Mark veg\*

Sensitivity analysis parameters:  
On Off ext-source? par.ext.source.max 0.10  
par.veg.threshold 0.150 common.SI.agents 25

Define and create networks  
Family-SN: fam members and families.  
No. Fams 272 On Off family-SN?  
Fams SN Density 0  
Work-SN: colleagues at the workplaces.  
Cyan: bridges among teams.  
No. Teams 53 On Off work-SN?  
Work SN Density 0 Work Clust Coeff 0  
On Off actual-workers? #workers 207  
%workers 0.0 %  
mean-team-size 4 agents  
%interconnection 50 % of team

Policies/Interventions  
Price increase  
meat.price.increase 1.00 \*100  
Norm-based interventions  
On Off SNI.YN.Active?  
Int.Target Env concerned  
Int.Diffusion Only workplaces  
SNI.Int.Length 157 Weeks  
Campaigns investments (0 = N/A)  
.25/.50/.75 = Small/Medium/Big  
gamma.env 0.50  
gamma.hlt 0.00  
gamma.awe 0.00  
On Off SNI.cycle?

ticks 0 #days 1 #Week 1 Year 2014 Current day Monday Current meal Lunch

p(consume.meat)  
0.8  
0.4  
0 (was 0.???) 10  
mean.p  
Low Income  
Mid-High Income  
avg p() 0.743 %Veg\* 4.03  
meat.price.index 0  
p(consume.meat)(t0) 0.74

Consumed meat  
1  
50 0 10  
Meat  
Females  
Males  
Low income  
Mid-High income  
Avg g/meal 0

Concerns  
5  
1  
0 0 10  
avg.env 2.89 avg.hlt 2.95 avg.awe 3.19  
Time decay of ca...  
1  
0  
env  
health  
an.welf

On Off plotbyincome?  
On Off plotbysex?  
ag.gMeat.week 0 gMeat.day 0  
gMeat.breakfast 0 gMeat.Lunch 0 gMeat.Dinner 0

Command Center  
observer: "imported: 395"  
observer: "imported: 396"  
observer: "imported: 397"  
observer>

# Original interface

Interface Info Code

Edit Delete Add abc Button

Setup S 1year M Go2 G Run2 R

Define and create networks

Family-SN: fam members and families.

No. Fams 272  On  Off family-SN?

Fams SN Density 0

Work-SN: colleagues at the workplaces.  
Cyan: bridges among teams.

No. Teams 53  On  Off work-SN?

Work SN Density 0 Work Clust Coeff 0

On  Off actual-workers? #workers 207

%workers 0.0 %

mean-team-size 4 agents

%interconnection 50 % of team

Policies/Interventions

Price increase

meat.price.increase 1.00 \*100

Norm-based interventions

On  Off SNI.YN.Active?

Int.Target Env concerned

Int.Diffusion Only workplaces

SNI.Int.Length 157 Weeks

Campaigns investments (0 = N/A)  
.25/.50/.75 = Small/Medium/Big

gamma.env 0.50

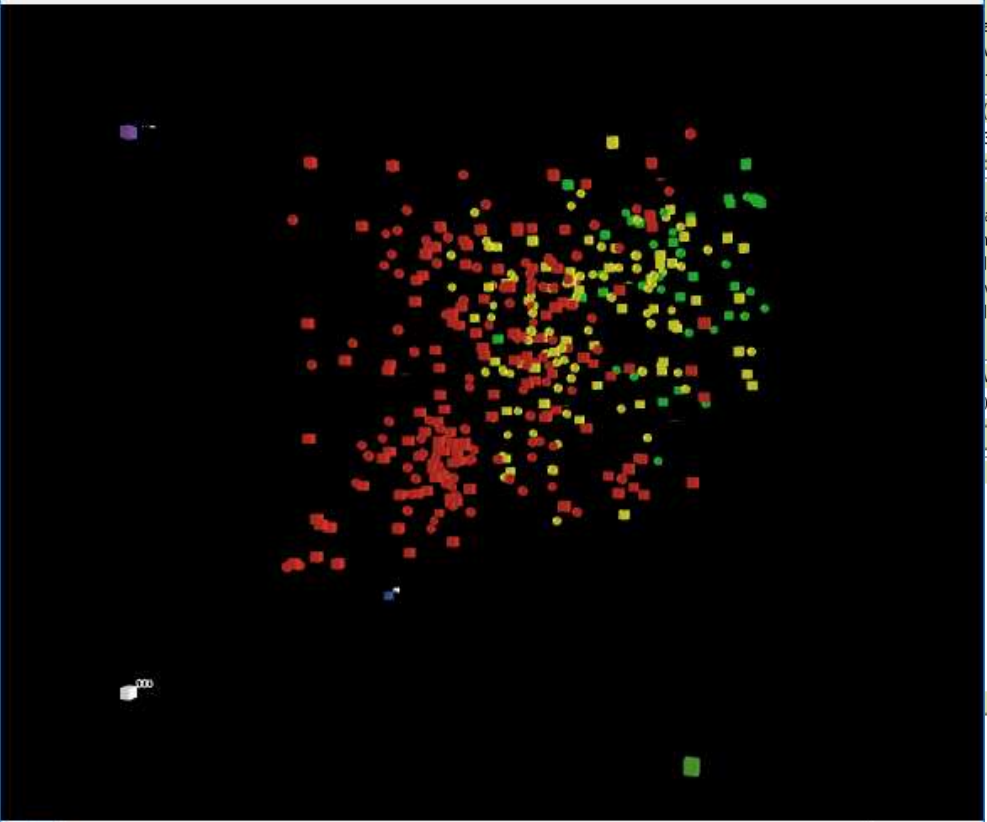
gamma.hlt 0.00

gamma.awe 0.00

On  Off SNI.cycle?

3D View

ticks: 64 normal speed  view updates on ticks Settings...



Orbit Zoom Move Reset Perspective Full Screen

Current day Monday Current meal Lunch

meat.price.index 0

%Veg\* 4.03

p(consume.meat)(t0) 0.74

On  Off plotbyincome?

On  Off plotbysex?

ag.gMeat.week 0 gMeat.day 0

gMeat.breakfast 0 gMeat.Lunch 0 gMeat.Dinner 0

avg.env 2.89 avg.hlt 2.95 avg.awe 3.19

Time decay of ca...  
1 0 10  
env health an.welf

Command Center

```
observer: "imported: 395"  
observer: "imported: 396"  
observer: "imported: 397"  
observer >
```

# A more friendly interface

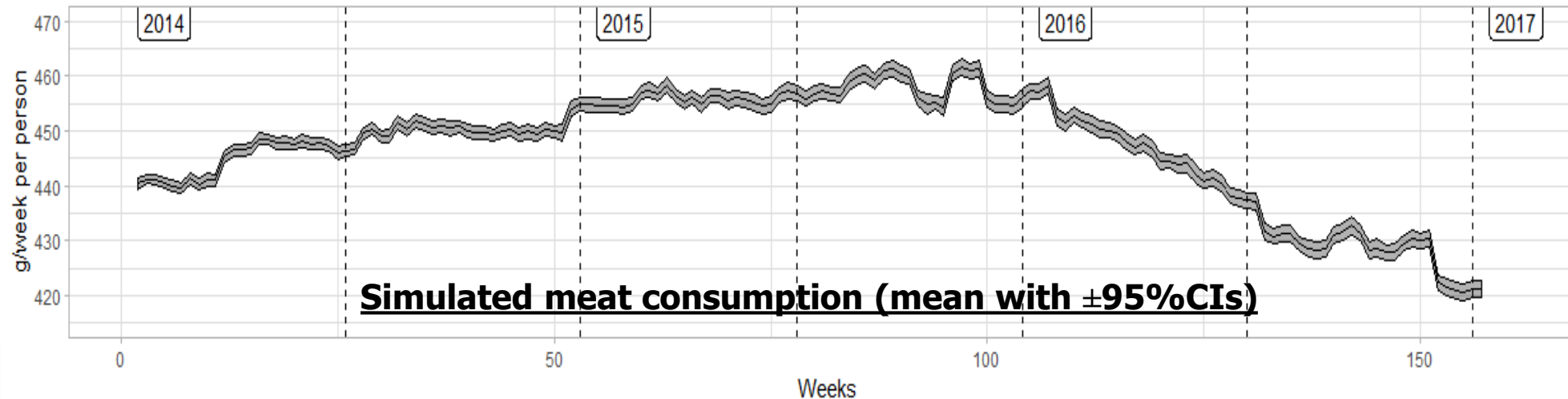
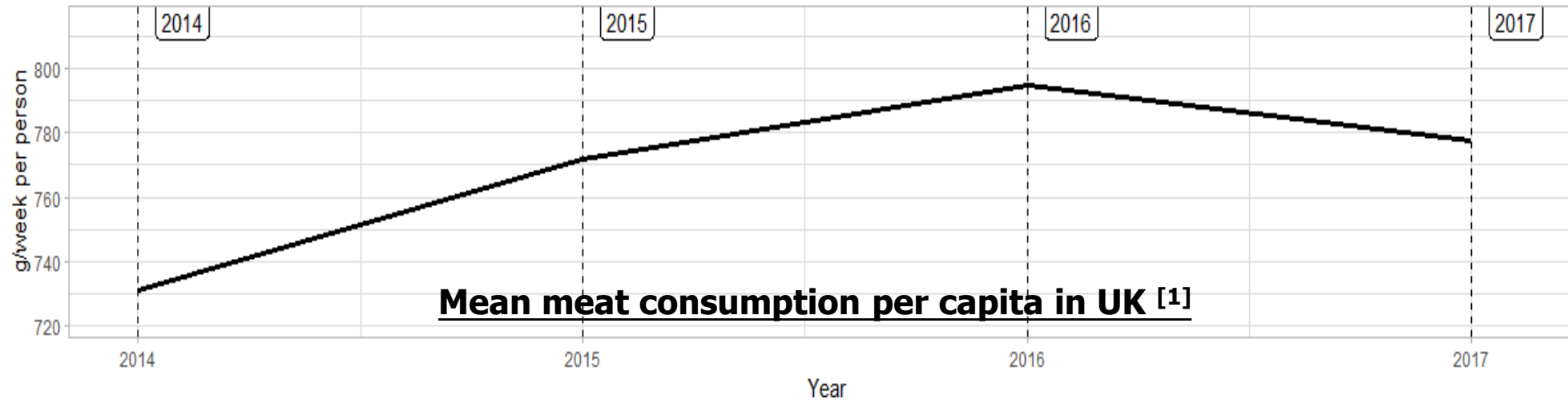


Snapshots from a user-friendly version of the simulation model.

# External validation

Comparison of reported meat consumption with the simulated meat consumption

The Rowett Institute



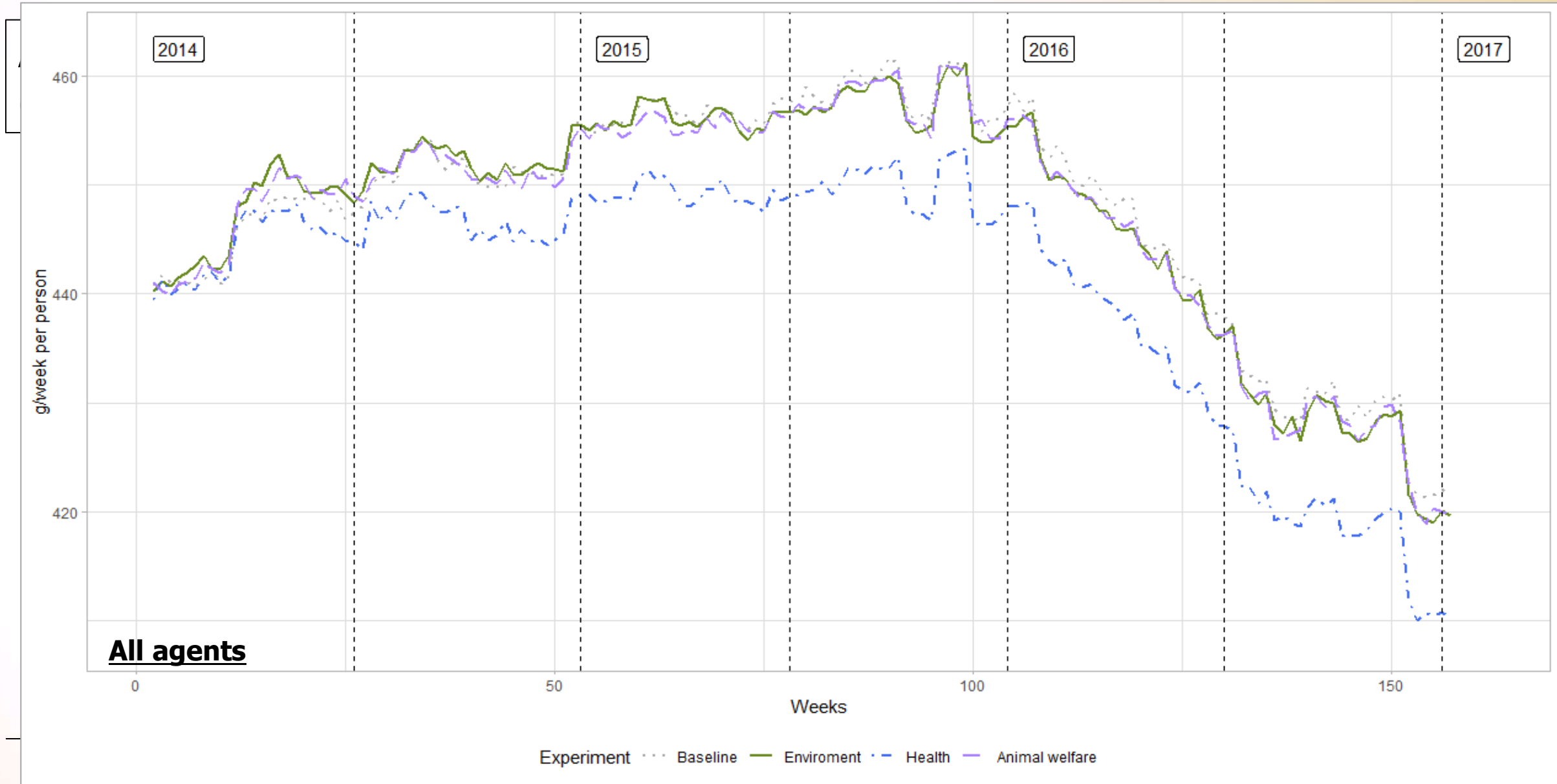
[1] Data elaborated by the Agriculture and Horticulture Development Board (2018).

# What works best? (1)

A comparison between messaging about (A) environment, (B) health, or (C) animal welfare associated with meat consumption

For instance, "*most people think that eating meat is bad for the environment*"

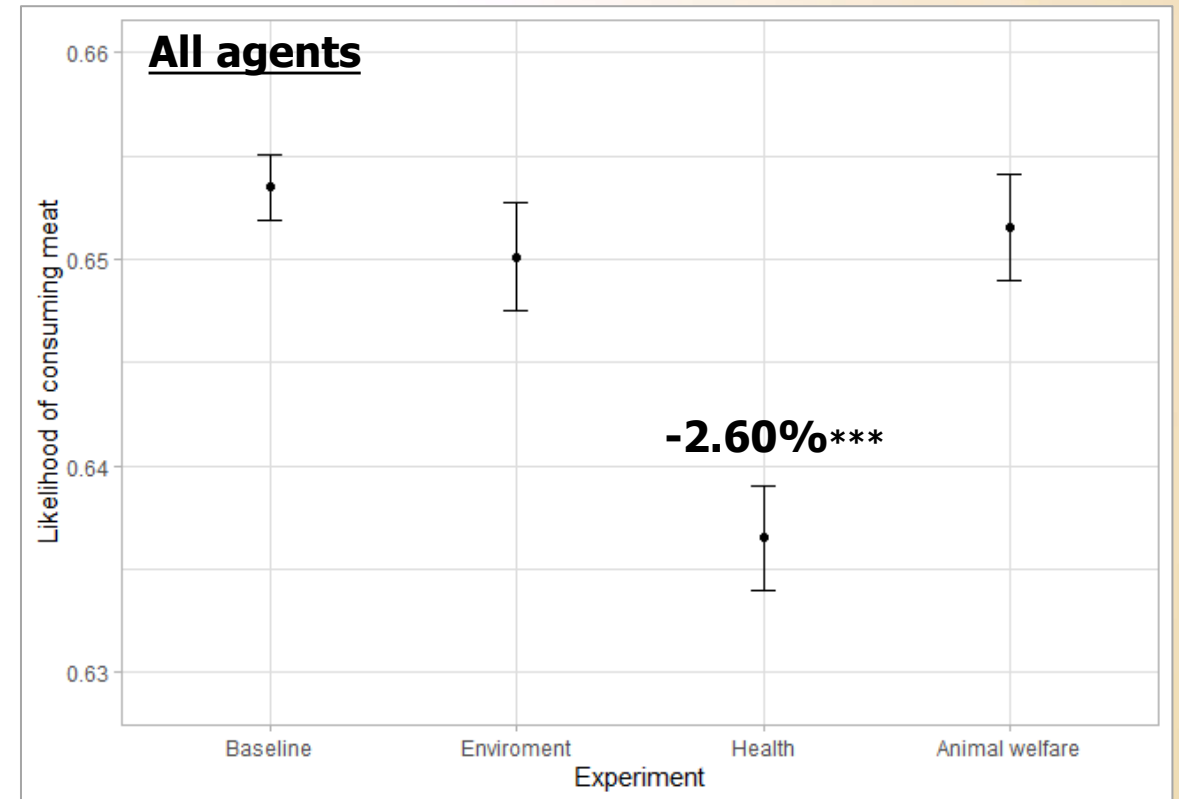
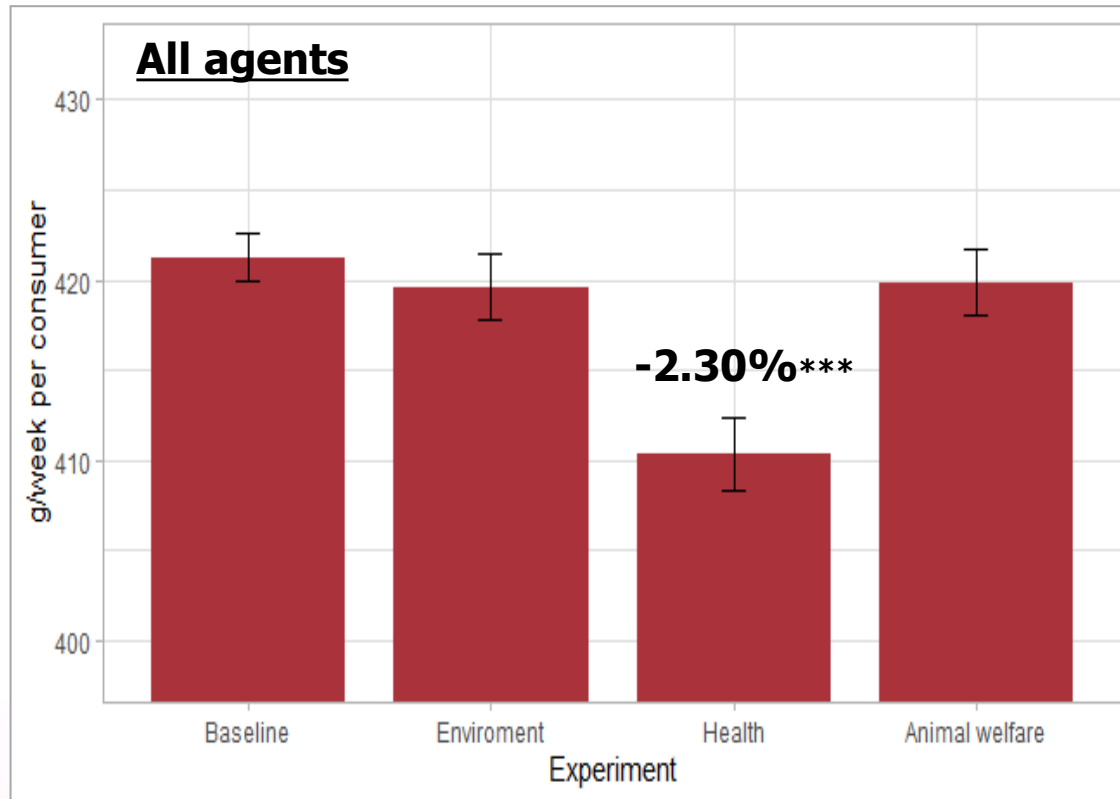
# What works best? (1)



# What works best? (2)

A comparison between messaging about (A) environment, (B) health, or (C) animal welfare associated with meat consumption

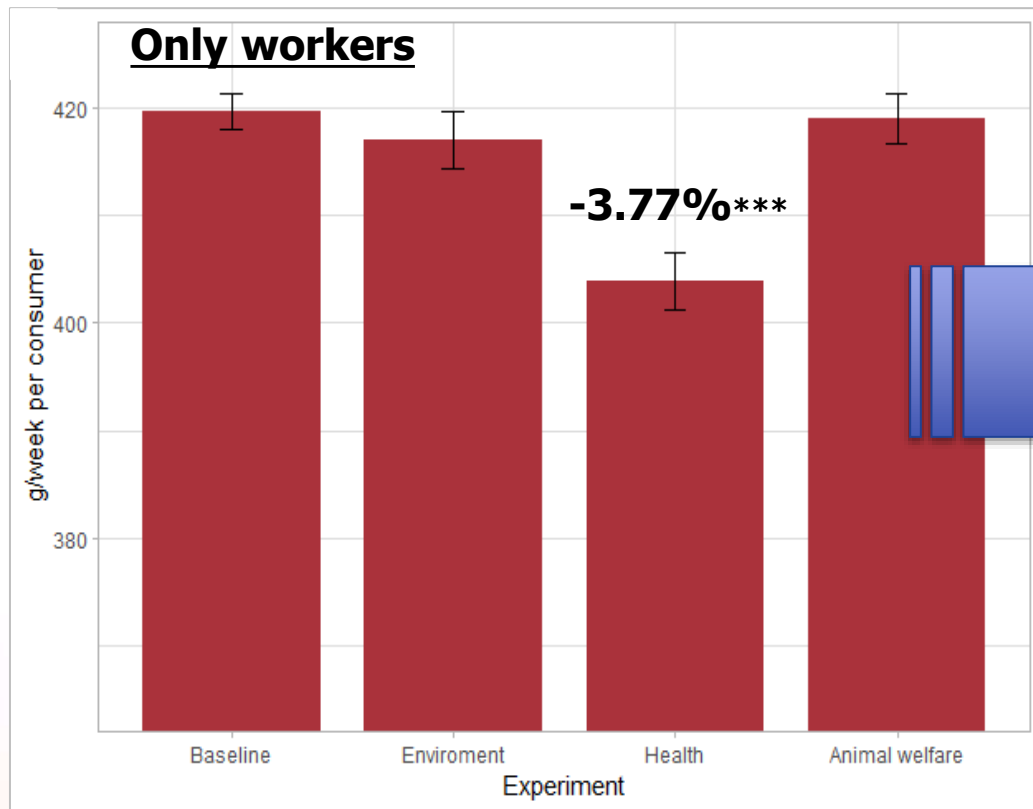
For instance, "most people think that eating meat is bad for the environment"



# What works best? (3)

A comparison between messaging about (A) environment, (B) health, or (C) animal welfare associated with meat consumption

For instance, "most people think that eating meat is bad for the environment"



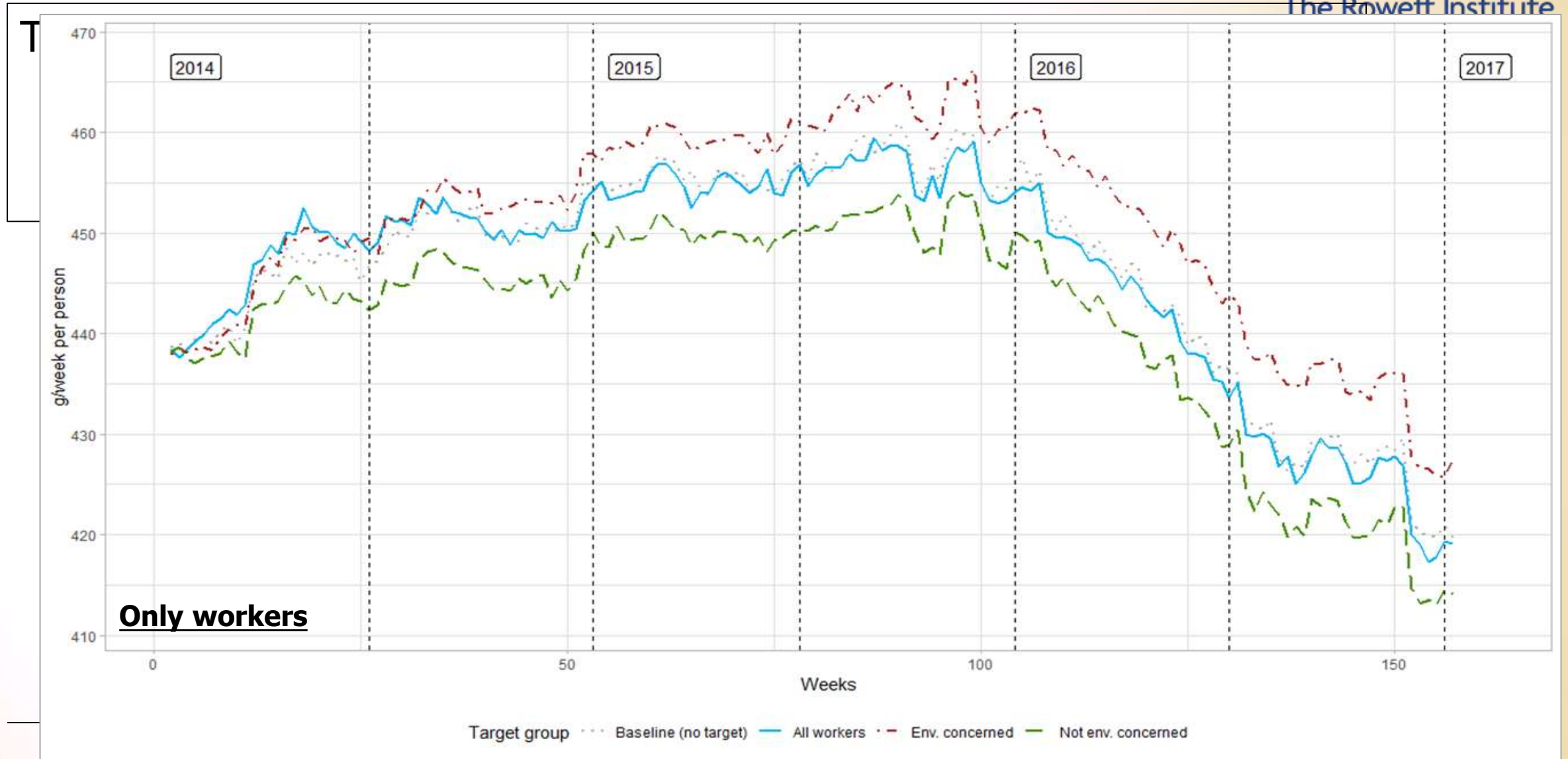


# Undesired effects (1)

The same (environmental) intervention targeted to different groups:

- A. all workers
- B. workers with *low* concern for the environment (~7% of workers)
- C. workers with *high* concern for the environment (~9% of workers)

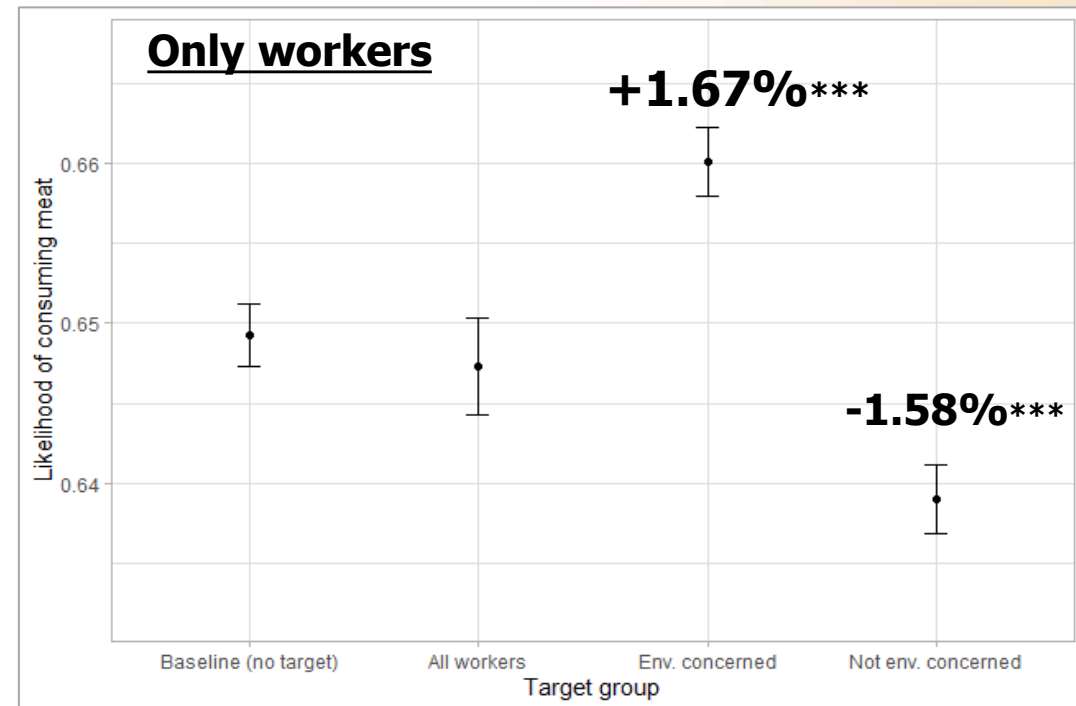
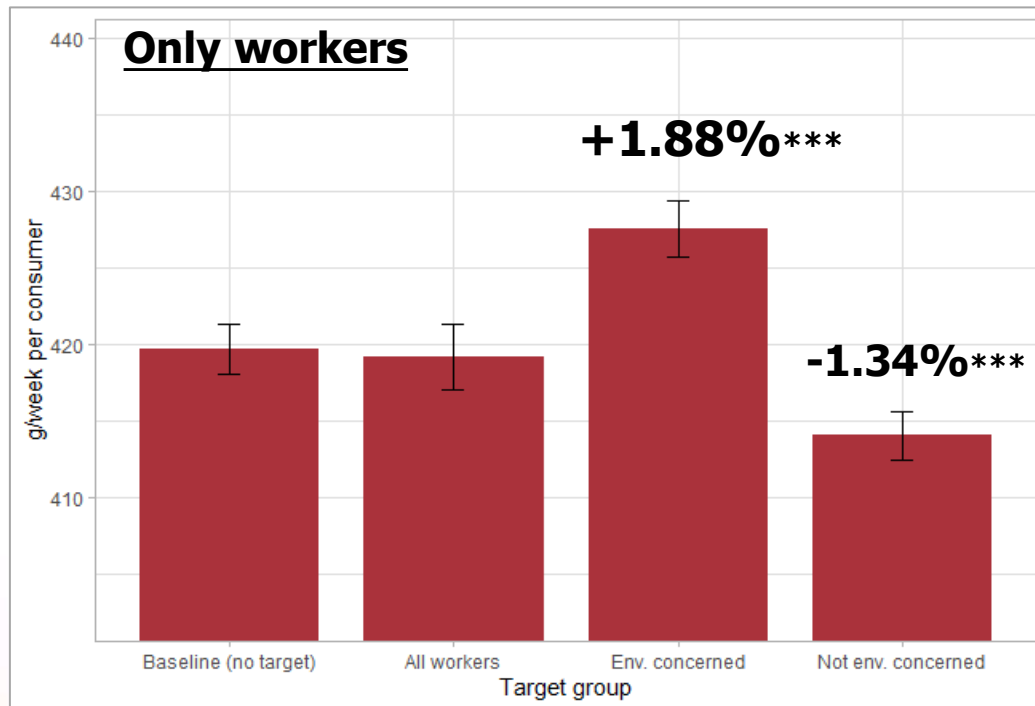
# Undesired effects (1)



# Undesired effects (2)

The same (environmental) intervention targeted to different groups:

- A. all workers
- B. workers with *low* concern for the environment ( $\sim 7\%$  of workers)
- C. workers with *high* concern for the environment ( $\sim 9\%$  of workers)



# Conclusions and future research

- The results suggest that focusing on **health** rather than environment or animal welfare could be the best approach to reduce meat consumption.
- Workers could affect household members in a positive manner. The simulation showed has the potential emergence of “**social spillover**”.
- Targeting the wrong groups of workers could result in potential **undesired effects**.

# Conclusions and future research

## *Main limitations*

- We did not included children influence on adults' food choices.
- The interventions accurately targets all workers within the hypothetical organization with specifics characteristics (e.g. a certain age range): this might be harder to achieve in the real-world.

We expect the results from the simulation will **inform the development of real-world interventions** in the next few years of research.

# Thank you

Contact: [andrea.scalco@abdn.ac.uk](mailto:andrea.scalco@abdn.ac.uk)

# All questions are welcome



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## An Agent-Based Model to Simulate Meat Consumption Behaviour of Consumers in Britain

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*Journal of Artificial Societies and Social Simulation* 22(4) 8, 2019

Doi: 10.18564/jasss.4124 Url: <http://jasss.soc.surrey.ac.uk/22/4/8.html>

Received: 04-06-2019 Accepted: 06-09-2019 Published: 31-10-2019

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***Journal of Artificial Societies and Social Simulation, 22(4)***