Just follow the group

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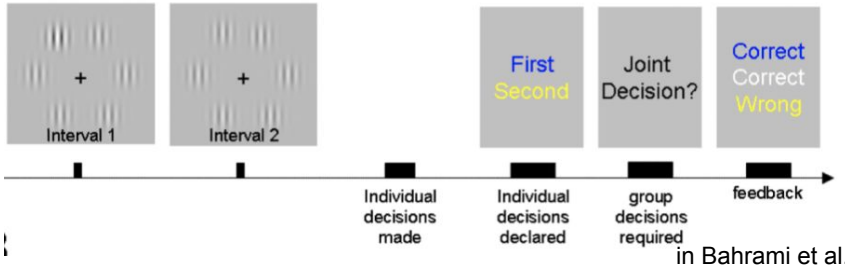
Theoretical background

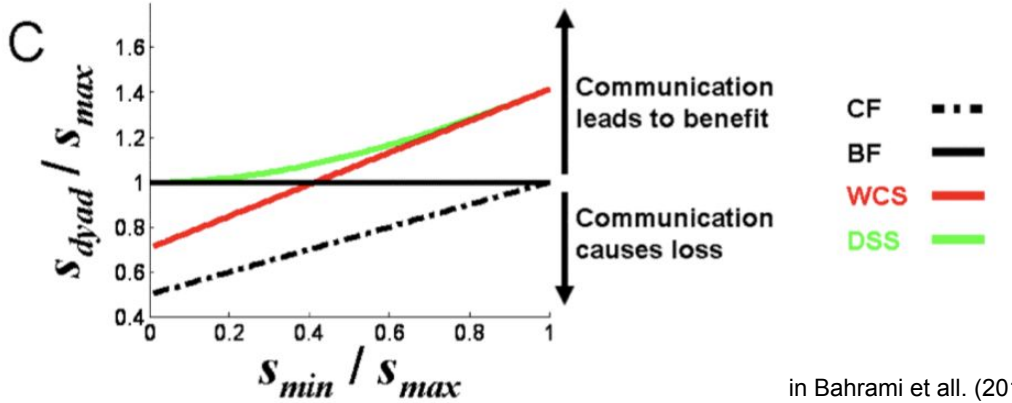
How it all started?



in Bahrami et al. (2010)

➔ Bahrami, B., Olsen, K., Latham, P. E., Roepstorff, A., Rees, G., & Frith, C. D. (2010) *Optimally interacting minds*

- Are two heads better than one?
- Coin flip (CF)
- The behaviour and feedback (BF)
- Weighted Confidence Sharing (WCS)
- Direct Signal Sharing (DSS)



in Bahrami et all. (2010)

Further development

- ➔ Migdał, P., Rączaszek-Leonardi, J., Denkiewicz, M., & Plewczynski, D. (2012) *Information-sharing and aggregation models for interacting minds*
  - ◆ Implementation of the decision making models

- ➔ Denkiewicz, M., Rączaszek-Leonardi, J., Migdał, P. (2013) *Interacting Minds Solving a Simple Perceptual Task*
  - ◆ Extension of the Bahrami et al. (2010) study on 3 deciding agents

Decision making models we implemented

Based on: Migdał et al. (2012) *Information-sharing and aggregation models for interacting minds*

- ➔ Voting
- ➔ Random responder
- ➔ Best decides
- ➔ Weighted Confidence Sharing
  - ◆ each agent shares its confidence: $z = x/\sigma$
- ➔ Direct Signal Sharing
  - ◆ each agent shares their direct signal: $y = x/\sigma^2$

Each agent has:

- ◆ x - seen stimuli
- ◆ σ - uncertainty about the decision
- ◆ s - score

Our project

Project ideas

- ➔ dynamic multi-agent model as an analogy to the experiments
- ➔ agents can interact randomly with one another
- ➔ reaching a joint decision about stimuli
- ➔ interaction alters agents' memories changing their belief in the given stimulus value

How will such a system behave?

Hypothesis

- ➔ There is a difference, between different decision-making models, in the speed of information spread.
- ➔ The sensitivity of agents has an influence on the speed of information spread between different decision making models.
- ➔ It exists certain stimuli dispersion and sensitivity that can cause the answer chosen by the group to drift be the wrong one.
- ➔ The effect of ‘wisdom of the crowd’ is present.

Inside the model

Created in Python with use of MESA library

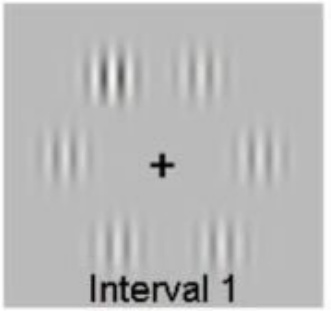
One step of the simulation

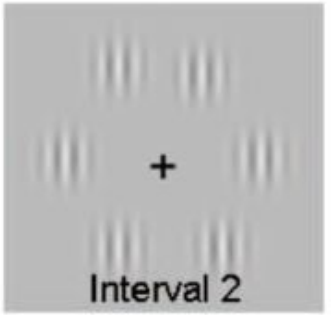
in Bahrami et all. (2010)

c is difference in contrast between 2nd stimuli and the 1st

c > 0 means 2nd stimuli is target

here **c** < 0





- ➔ We choose randomly n agents
- ➔ We sample a stimuli **c** for a group
  - ◆ for example c ~ N(1,1) if we assume globally 2nd answer is true and c > 0 means 2nd answer
- ➔ We sample a stimuli **x** for each group's member
  - ◆ x ~ N(c + bias, variance)
- ➔ Individual decision is based on a test whether x > 0
- ➔ Group makes a decision according to a specific model
- ➔ Group decision is considered true and bias of each agent from the interacting group is changed accordingly to this decision

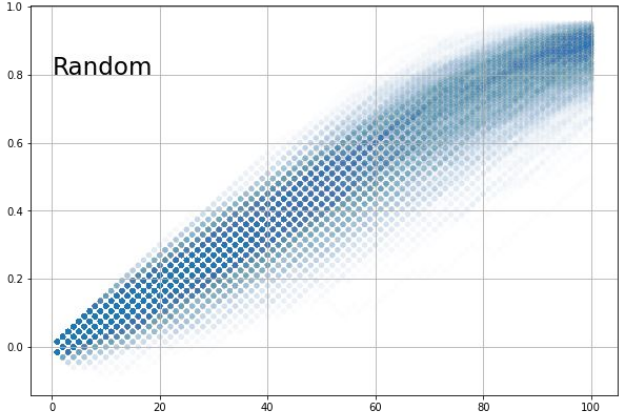
What next?

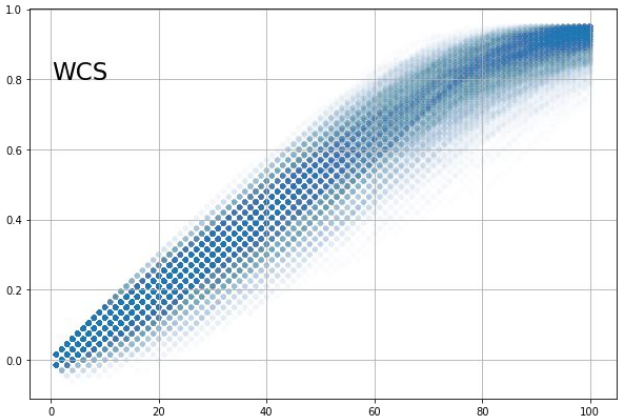
- ➔ We repeat whole process many times (we run many steps of the model)
- ➔ We run simulation many times (with fixed number of steps)
- ➔ We check how mean bias (belief of the population) changes in time
- ➔ We check how number of right decisions on individual and group level changes

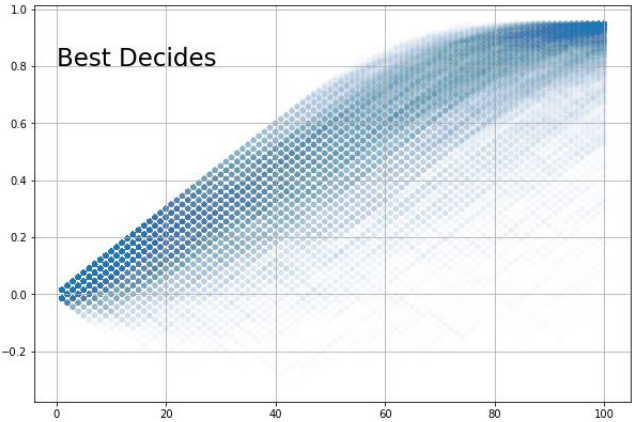
Results

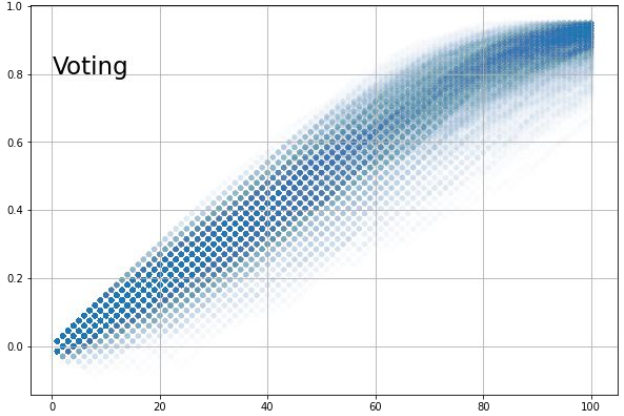
Results: different information-sharing models

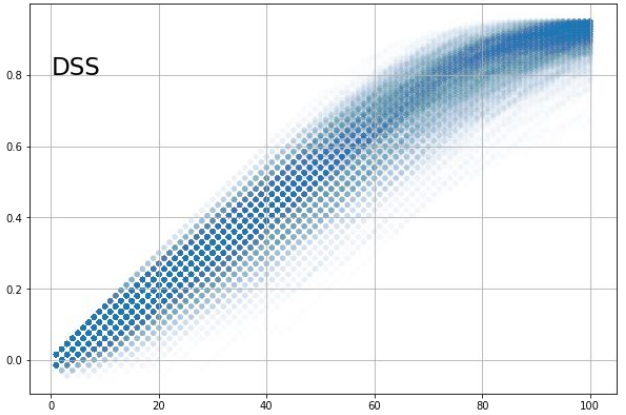
Parameters
iterations = 1000
steps = 100
c ~ N(1,1)
group sizes = 3
population = 10
rate of bias change = 0.05
start bias = 0
variance = 1
min bias = -1
max bias = 1









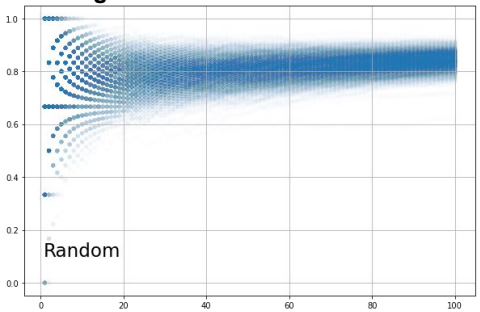


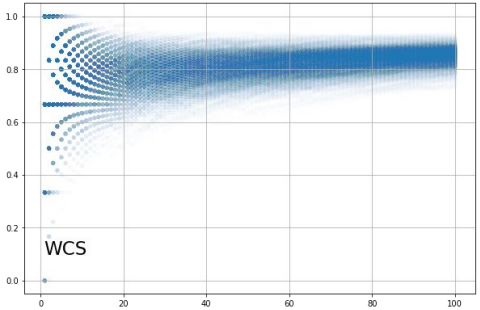
X axis - step,
Y axis - mean bias (belief of population)

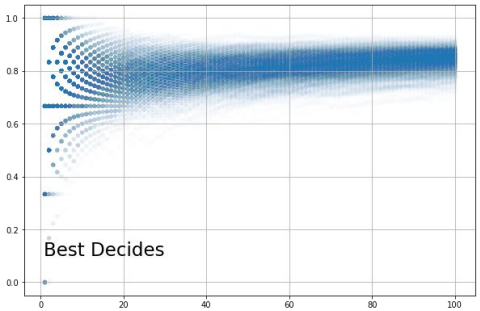
Results: number of right decisions on individual and group level

Parameters
iterations = 1000
steps = 100
c ~ N(1,1)
group sizes = 3
population = 10
rate of bias change = 0.05
start bias = 0
variance = 1
min bias = -1
max bias = 1

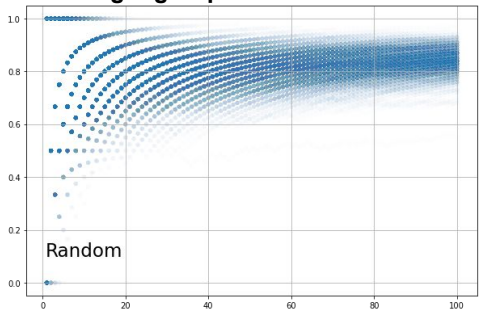
Right individual decisions ratio

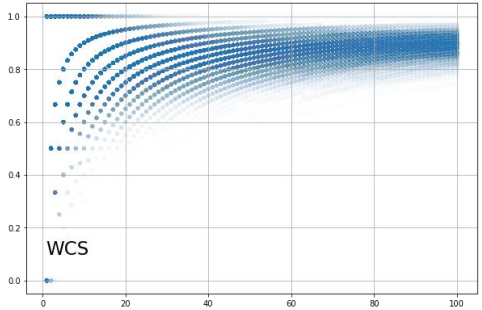


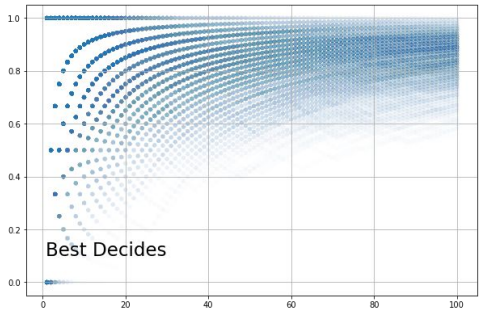




Right groups decisions ratio



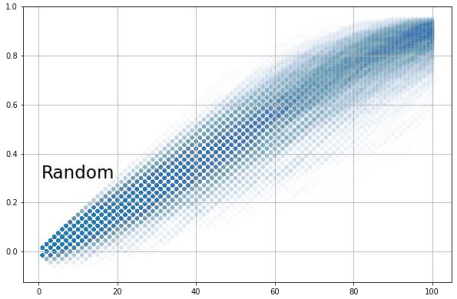


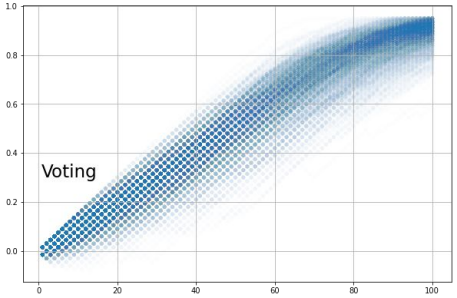


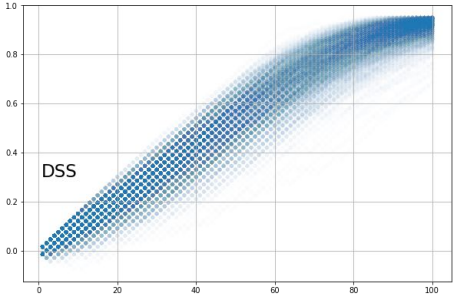
Results: different group sizes

Parameters
iterations = 1000
steps = 100
c ~ N(1,1)
population = 10
rate of bias change = 0.05
start bias = 0
variance = 1
min bias = -1
max bias = 1

3







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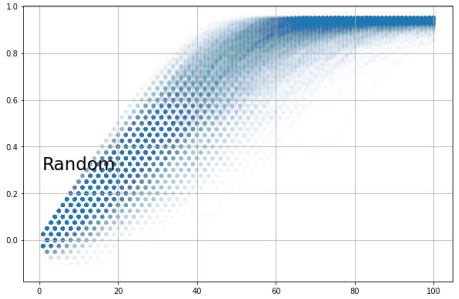
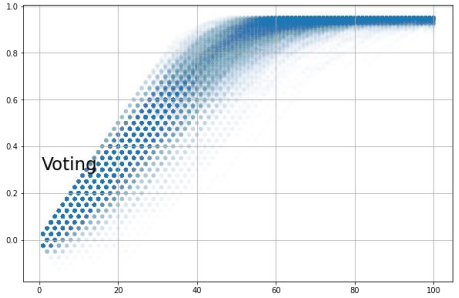
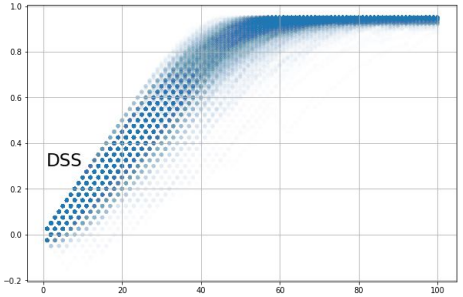


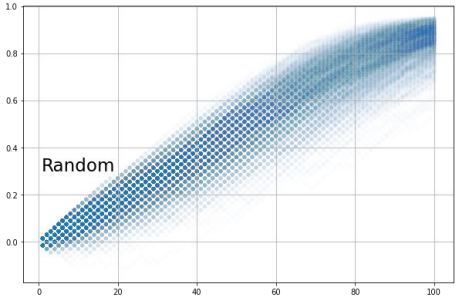


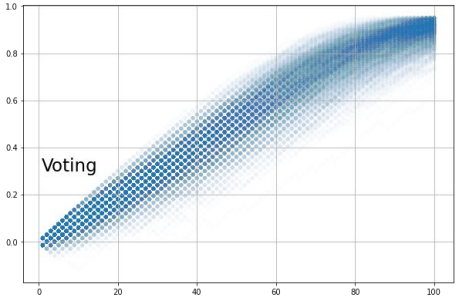


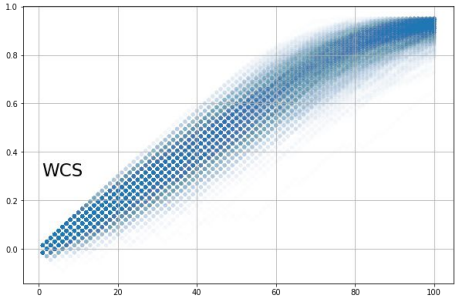
Results: what may slow convergence? - individual variance

Parameters
iterations = 1000
steps = 100
c ~ N(1,1)
group sizes = 3
population = 10
rate of bias change = 0.05
start bias = 0
min bias = -1
max bias = 1

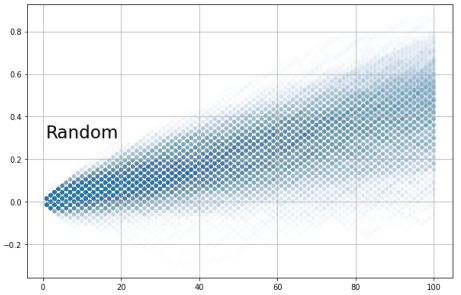
variance = 1

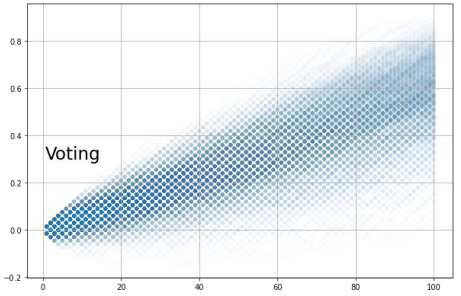


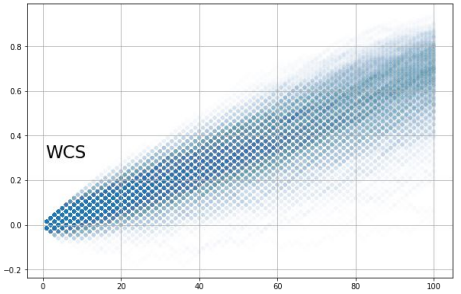




variance = 3



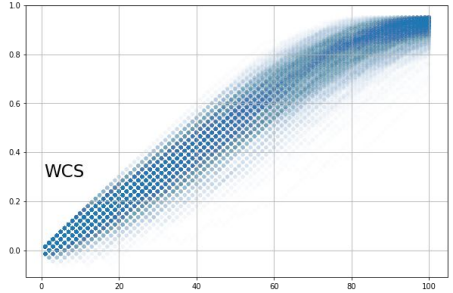


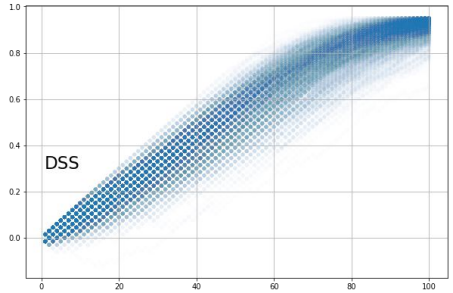


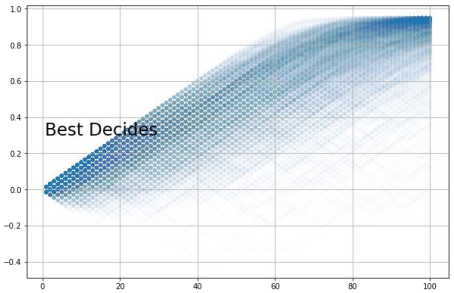
Results: what may slow convergence? - stimuli dispersion

Parameters
iterations = 1000
steps = 100
variance = 1
group sizes = 3
population = 10
rate of bias change = 0.05
start bias = 0
min bias = -1
max bias = 1

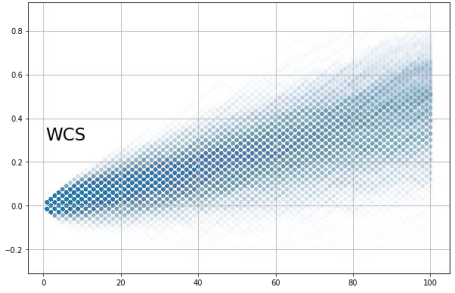
c ~ N(1,1)

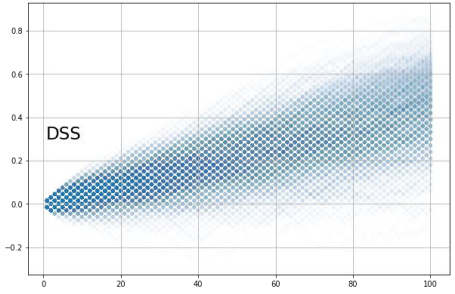


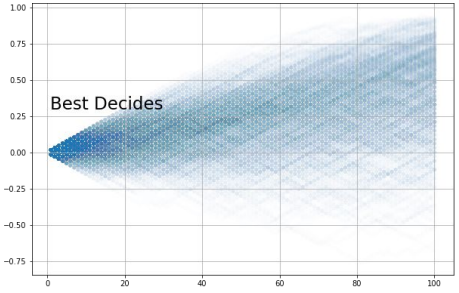




c ~ N(1,3)







So what have we learned?

Summary

Results of our simulation show that:

- Speed of the information sharing in the population:
  - is similar in all models
  - is most disperse in the model ‘Best Decides’
- The ‘wisdom of the crowd’ is present, as:
  - mean bias in population drifts towards positive values
  - number of right decision is growing, both in individual and group decisions

Summary

- Larger groups ⇨ faster convergence
- The group convergence is slowed down in all models by:
  - higher individual variance
  - higher stimuli dispersion
- We haven’t found any values of individual variance and stimuli dispersion that can prevent mean bias convergence

Bibliography

- Bahrami, B., Olsen, K., Latham, P. E., Roepstorff, A., Rees, G., & Frith, C. D. (2010). Optimally interacting minds. *Science*, *329*(5995), 1081-1085.

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- Migdał, P., Rączaszek-Leonardi, J., Denkiewicz, M., & Plewczynski, D. (2012). Information-sharing and aggregation models for interacting minds. *Journal of Mathematical Psychology*, *56*(6), 417-426.

Thank You

For Your attention :)