The Effects of Obfuscation on Opinion Dynamics

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I. Key Concepts : Obfuscation

Definition

Obfuscation is defined as the behaviour of an agent that *minimizes the information* of her opinion given to an observer due to the concern of *privacy* or *peer pressure*.

- ▶ Strategic ambiguity by politicians [1]
- ▶ Obfuscation in programming to make codes difficult to understand (and thus enhance security)
- ▶ Abbreviation for names on credit cards

Obfuscation vs Deception

Obfuscation is fundamentally different from *deception*.

- Obfuscation does not give out false information to *mislead* observers
- Obfuscation tries to make it difficult for onlookers to interpret the hidden opinions [2]
- The opposite of obfuscation is *transparency*

II. Key concepts : Action-Opinion Inference (AOI) model

To model obfuscation, we build on the action-opinion inference (AOI) model [3]. It assumes that agents *learn other people's opinions by observing their actions*, and their own opinions will be influenced. The AOI model utilizes *deontic logic* to model action-opinion relations : one opinion can

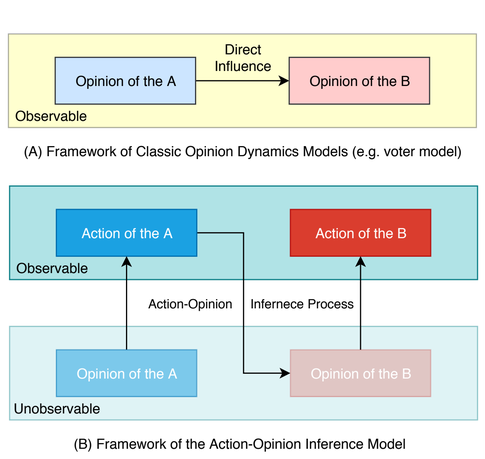
- ▶ **Oblige** ($+$) only one action ; or
- ▶ **Permit** (0) many actions ; or
- ▶ **Prohibit** ($-$) many actions.

* Each agent chooses only one action and one opinion.
* If obliging one action, the opinion must prohibit all other actions.

The relations between actions and opinions are encoded by the so-called *action-opinion matrices*. For example, in matrix S_1, opinion o_1 obliges action a_1, while prohibiting action a_2 and a_3 ; opinion o_2 permits a_1 and a_2, while prohibiting a_3.

$$S_1 = \begin{array}{c} \\ o_1 \\ o_2 \end{array} \begin{array}{c} \begin{array}{ccc} a_1 & a_2 & a_3 \end{array} \\ \begin{pmatrix} + & - & - \\ 0 & 0 & - \end{pmatrix} \end{array}$$

Agents first choose actions according to their opinions. Meanwhile, agents can observe their neighbour's actions, and infer the opinions underlying the observed actions in a Bayesian way. Then agents update their own opinions according to the inferred probability of each opinion among the neighbourhood.



(A) Framework of Classic Opinion Dynamics Models (e.g. voter model)

(B) Framework of the Action-Opinion Inference Model

FIG1. Frameworks of classic and AOI model

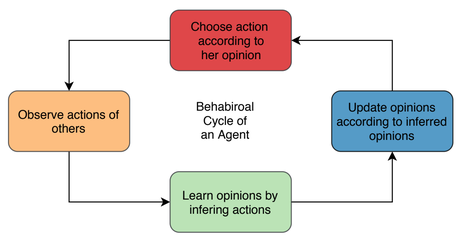


FIG2. Illustration of the model

Technical details :

1. Regular lattice
2. Von Neumann neighborhood

III. Model obfuscation using AOI model

An agent obfuscates her opinions by choosing the action that maximizes the uncertainty, measured by the Shannon entropy [2]. For each action a_j , the entropy is calculated by :

$$H_j = -\sum_{k=1}^{K} [P(o_k|a_j) log(P(o_k|a_j))] \quad (1)$$

where $P(o_k|a_j)$ is the posterior probability that an agent choosing action a_j holds opinion o_k. Therefore the behaviours of obfuscating and non-obfuscating agents are :

- ▶ **Obfuscating Agents** : choose randomly from the feasible actions that maximizes the entropy.
- ▶ **Non-obfuscating Agents** : choose among the feasible actions simply according to the action-opinion matrix.

For example, in the environment of S_1, an obfuscating agent who also believes in o_2 will choose a_1 because the entropy of a_1 is larger than that of a_2, and a non-obfuscating agent who believes in o_2 will choose between a_1 and a_2 with equal probability. Given the behaviours of both obfuscating and non-obfuscating agents, we can now *preliminarily* test the role of obfuscation in opinion dynamics in part IV and V.

IV. Hypotheses

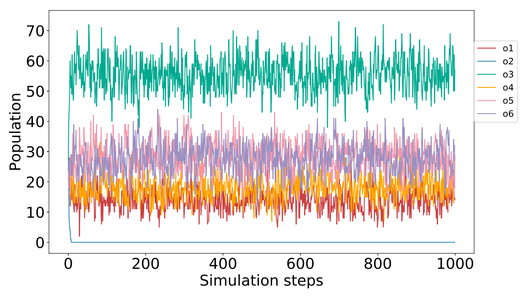
We run the simulation with different types of agents and different action-opinion matrices :

- — When there is no obfuscating agents, the results are mainly determined by the action-opinion relations. In all, no universal principles that govern the opinion dynamics can be found [3].
- — On the other hand, when everyone obfuscates in the society, we tentatively conclude the following hypotheses according to the simulation results :

- ▶ **[Hypothesis 1]** *Any opinion that prohibits the entropy-maximizing action (that is, the action with the highest entropy in the model, e.g. a_1 in S_1) will die out eventually.*
- ▶ **[Hypothesis 2]** *All the opinions that do not prohibit (i.e. permit or oblige) the entropy-maximizing action can co-exist in equilibrium.*
- ▶ **[Hypothesis 3]** *Among all the surviving opinions (as mentioned in Hypothesis 2), the average popularity of the opinion decreases with the number of actions obliged/ permitted by that opinion.*

These hypotheses will be illustrated in part V.

V. Pilot experimental results

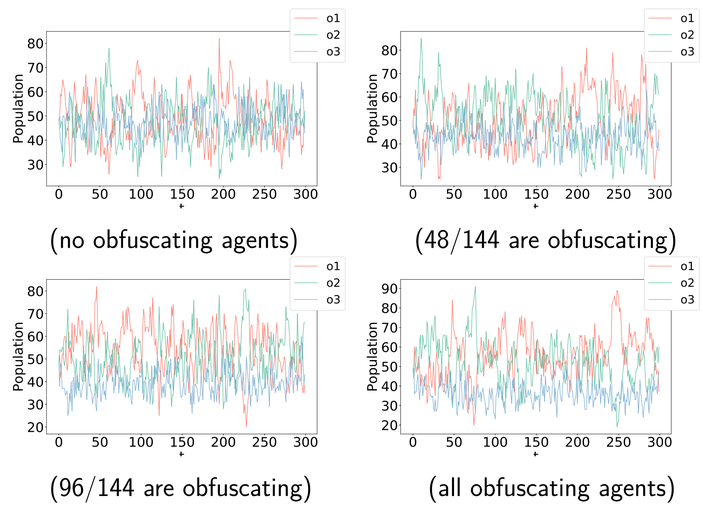


To illustrate and test the hypotheses, we run one realization of the AOI model with a population of 144 obfuscating agents. The matrix is S_2 (S_3 is for the right column) :

$$S_2 = \begin{array}{c} \\ o_1 \\ o_2 \\ o_3 \\ o_4 \\ o_5 \\ o_6 \end{array} \begin{array}{c} \begin{array}{cccc} a_1 & a_2 & a_3 & a_4 \end{array} \\ \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & - & - & 0 \\ - & + & - & - \\ - & 0 & 0 & 0 \\ - & 0 & 0 & - \\ 0 & 0 & - & - \end{pmatrix} \end{array} \quad S_3 = \begin{array}{c} \\ o_1 \\ o_2 \\ o_3 \end{array} \begin{array}{c} \begin{array}{ccc} a_1 & a_2 & a_3 \end{array} \\ \begin{pmatrix} + & - & - \\ - & + & - \\ 0 & 0 & 0 \end{pmatrix} \end{array}$$

The simulation result is shown above, from which we can verify the hypotheses proposed in the part IV :

- The entropy-maximizing action is a_2, and o_2 prohibits a_2. Eventually o_2 dies out (Hypothesis 1).
- All opinions except o_2 coexist (Hypothesis 2)
- The popularity : $o_3 > o_5 \approx o_6 > o_4 > o_1$ (Hypothesis 3).



(no obfuscating agents) (48/144 are obfuscating)

(96/144 are obfuscating) (all obfuscating agents)

The figures above are results of simulations using S_3 but with different percentages of obfuscating agents.

Results : As the percentage of obfuscating agents increases, inclusive opinions (o_3) are losing their popularity to exclusive opinions (o_1 and o_2), leading to a less diverse environment of actions and opinions.

* **Inclusive opinions** : permitting one than one actions

* **Exclusive opinions** : obliging one action and prohibiting any other actions.

References

- [1] Aragones, E., & Neeman, Z. (2000). Strategic ambiguity in electoral competition. Journal of Theoretical Politics, 12(2), 183-204.
- [2] Chorus, C.G., van Cranenburgh, S., Sandorf, E.D., Sobhani, A., & Szep, T. (2019). Obfuscation maximization for discrete choice analysis : Theory, methodology, and first empirical evidence. Working paper, Under review
- [3] Tang, T., & Chorus, C. G. (2019). Learning Opinions by Observing Actions : Simulation of Opinion Dynamics Using an Action-Opinion Inference Model. Journal of Artificial Societies & Social Simulation, 22(3).

Perspectives

- Investigate the situations with a mixed population of non-obfuscating and obfuscating agents.
- Perform large-scale ABM experiments to further confirm the three hypotheses.
- Translate these hypotheses into real-life implications and apply the findings into empirical studies.

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