Hierarchical Versus Egalitarian Control in Flocking

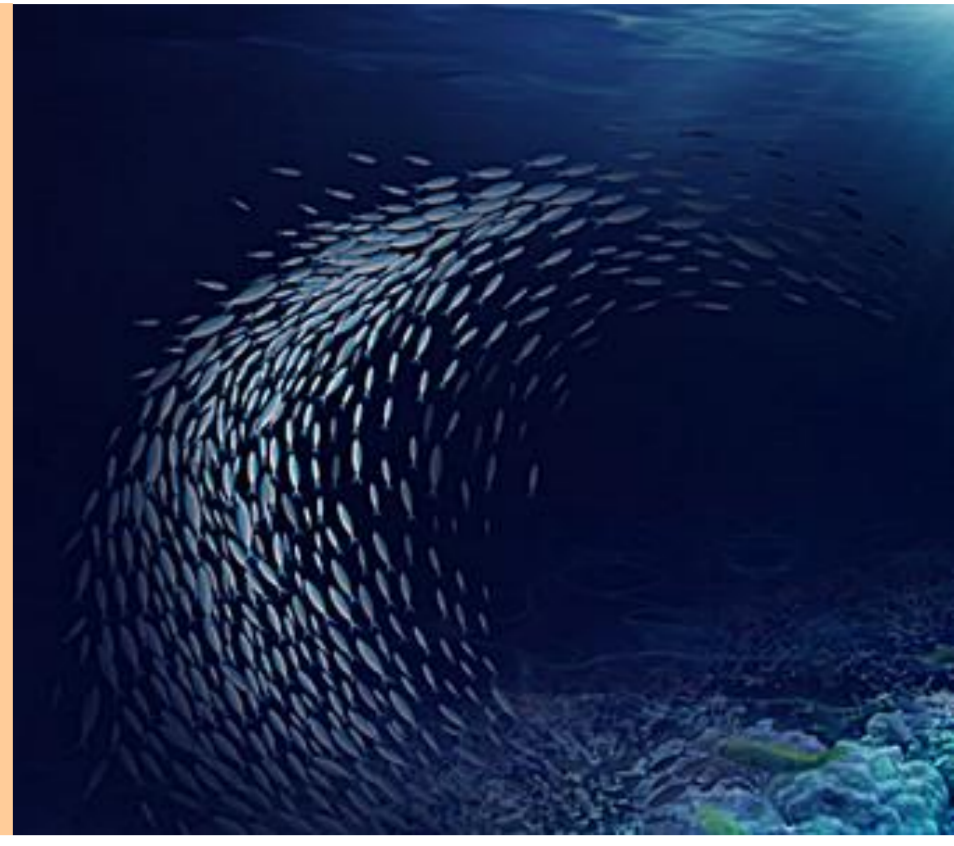Yongnan Jia & Tamás Vicsek   {yongnanjia, vicsekt}@gmail.com

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Under which condition is hierarchical strategy[1] more efficient for achieving a more coherent group flight than egalitarian strategy?

nature
FLIGHT PLANS
Airborne pecking order coordinates pigeon flocks
[2]

Research Motivation

◆ The collective behavior of individual units is organized hierarchically in nature and societies, a remarkable example being flocks of pigeons[2]. Hierarchical interaction rules are believed to be more efficient as compared to the ones operating along purely egalitarian rules.

◆ However, at the same time, large groups of thousands of birds or fish are not likely to act hierarchically.

◆ So we would like to know, when egalitarian strategies are better? Under which condition are hierarchical strategies more efficient？

Research Methods

◆ In order to explore this problem, several simple flocking models have been investigated.
- ◆ Egalitarian flocking model.
- ◆ Hierarchical-contribution flocking model.
- ◆ Shen[3] hierarchical-contribution flocking model.
- ◆ Neighbor-number flocking model.

◆ Different boundary conditions are also considered for the purpose of understanding the hierarchical rules more comprehensively.
- ◆ Closed area(rectangle-shape area).
- ◆ Free area.

Preliminary Results

◆ The behavior of each individual is decided by the average behavior of its neighbors.
◆ For egalitarian system, each individual has the same contribution to decide the desired behavior in each time step. But for hierarchical systems, different individuals have different level of contributions to the desired behavior of each individual. And these contributions mostly satisfy log-normal distribution.
◆ Each individual unit aims at moving coherently with its neighbors while avoiding collision with each other.

Flock Model within Closed Area

◆ In this case, each individual moves in a rectangle area. We assume that a repelling wall force acts when the individual comes close enough to the wall.
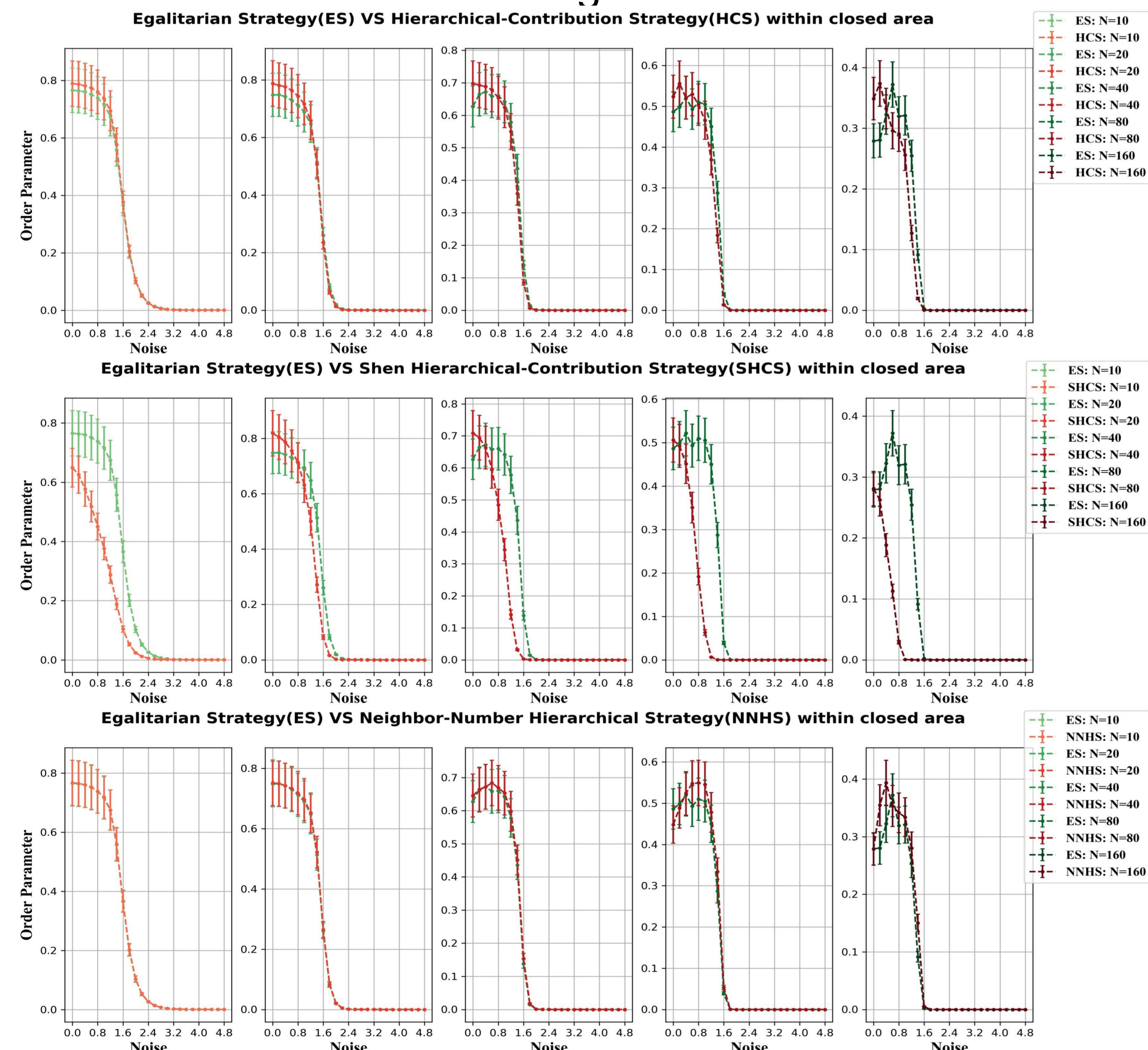
Flock Model in Free Area

◆ There is no area limitation. But in order to force them to form a collective behavior together, another attraction force will be added to the boundary individuals[4].
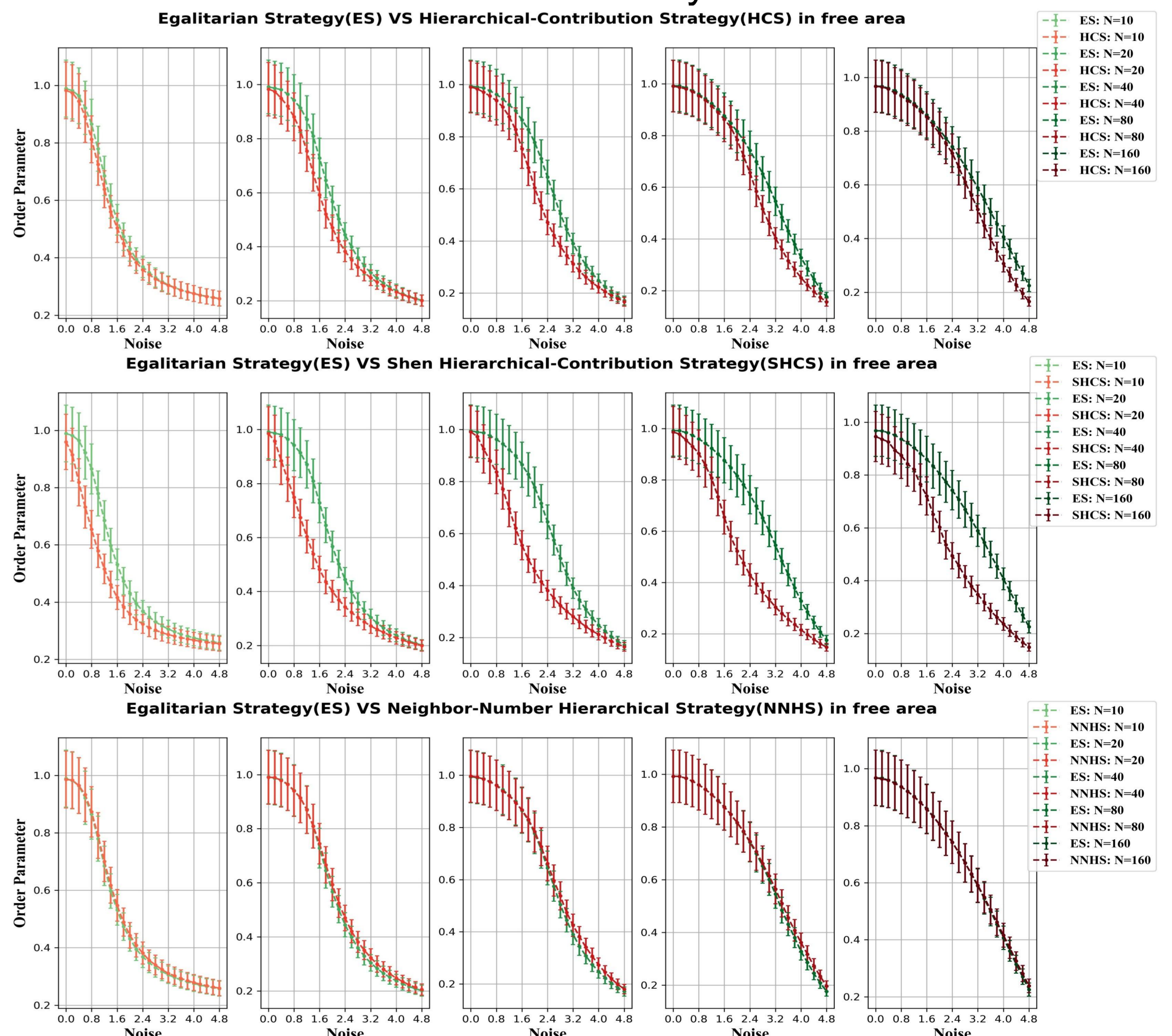
Conclusions

◆ For the types of hierarchies we considered surprisingly, the egalitarian rules for all group sizes and given noise values result in a more ordered flock.
◆ Taking into account the roles of informed agents or an underlying directed hierarchical network of interactions may change the above conclusion.

References
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[3] Jackie Shen. Cucker-smale flocking under hierarchical leadership. Society for Industrial and Applied Mathematics. 68(3): 694–719, 2006.
[4] D J G Pearce and M S Turner, Density regulation in strictly metric-free swarms. New Journal of Physics. 16(8): 082002, 2014.