SMALL BIASES ON APPRECIATION THAT LEAD TO SUBSTANTIAL AND HARMFUL EFFECT OF SEGREGATION IN TASK CENTERED GROUPS

AN AGENT BASED SIMULATION OF DISCOURSE PATTERN FORMATION

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BACKGROUND

- Discourse and communication patterns in small groups seem to be connected to successful task performance or good learning outcomes
- Beneficial patterns are usually bidirectional mutuality: reciprocity in turn taking in discourse and responses (Barron 2003; van Boxtel et al. 2000; Hogan et al. 1999; Stahl et al. 2014)
- Discourse patterns reflect how group members evaluate and appreciate each other (Bonito 2000; 2002)
- Empirical studies have found that strongly reciprocated dyadic and triadic interaction patterns are characteristic to successful and high achieving groups (Bonito 2000; Hogan et al. 1999; Stahl et al. 2014)
- Isolation and marginalization seems to be more common in groups of five or larger (Bonito 2000; 2002; Janssen et al. 2007)

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AGENT-BASED MODEL (ABM) OF DISCOURSE PATTERN FORMATION

- We simulate how *sensitivity to response* and *cooperation* affect the formation of discourse patterns in small group
- The model assumes that the agents' decision to interact and participate in a discussion depends on two properties; activity and discursivity
  - Activity: activity to participate in a discussion (inherent property)
  - Discursivity is directly proportional to realized and externalized discourse events (property linking two agents)
- Sensitivity to response is assumed to affect both activities and discursivities through pair-wise comparisons
  - If an agent *i* finds that its activity is lower than its peer *j*'s discursivity towards it, then *i* tends to increase its activity because it tries to compete for floor in discussion.

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DECISION PROBABILITIES

- Interaction model D where agent *i* randomly selects partner *j* to interact with
- Interaction may lead to change in agent's state (activity and discursivity) but it depends on agents activities and discursivitites
- In addition, a second peer *k* may also be part of interaction. The second peer *k* is included only collalaterally. Triadic collateral model T promotes the formation of patterns consisting three partners
- Probability to change state is a probabilistic decision (factors A and B affect the choice). We assign utilities $U_A(i,j)$ and $U_B(i,j)$ which may both depend on states of agents *i* and *j*
- Probability that agent *i* adopts a new state: $p_{ij} = \frac{exp\left[U_A/\sigma\right]}{exp\left[U_A/\sigma\right]+exp\left[U_B/\sigma\right]} = \frac{1}{1+exp\left[-\delta_{ij}/\sigma\right]}$ (Laciana & Oteixa-Aguirre 2014; Sîrbu et al. 2013)

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EVOLUTION OF ACTIVITIES AND DISCURSIVITIES

- The update rules for agent's *i* activity κ_{ii} and discursivity κ_{ij} in the dyadic model (D) and in the triadic collateral model (T), where agent *i* also holds the discursivity κ_{ik} towards agent *k*

$$
\begin{aligned}
\kappa_{ii} &\leftarrow \kappa_{ii} + \pi_0 [\Delta\kappa_{ii}] \kappa_{ii}(1-\kappa_{ii}) \\
\kappa_{ij} &\leftarrow \kappa_{ij} + \pi_0 [{}_{\alpha}\Delta\kappa_{ij} + {}_{\lambda}\Delta\kappa_{ij}] \kappa_{ij}(1-\kappa_{ij}) \\
\kappa_{ik} &\leftarrow \kappa_{ik} + \pi_0 [{}_{T}\Delta\kappa_{ik}] \kappa_{ik}(1-\kappa_{ik})
\end{aligned}
$$

Parameter π_0 is the overall sensitivity of agents to changing their activities and discursivities.

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SIMULATIONS AND PARAMETERS

- Simulations are carried out by selecting stochastically the agents that interact (two agents for the dyadic model D and three agents for the triadic collateral model T)

Parameter	Symbol	Role	Values
Sensitivity to responsivity	α	Sensitivity in competitive comparisons	$\alpha \in [0,1]$, step 0.2
Cooperativity	λ	Sensitivity in cooperation	$\lambda = 0.0, 0.1, 0.3$
Diversity in competition	σ_α	Tolerance to diversity in responsivity	$\sigma_\alpha = 0.1, 0.2, 0.3$
Diversity in cooperation	σ_λ	Tolerance to diversity in cooperativity	$\sigma_\lambda = 0.25$

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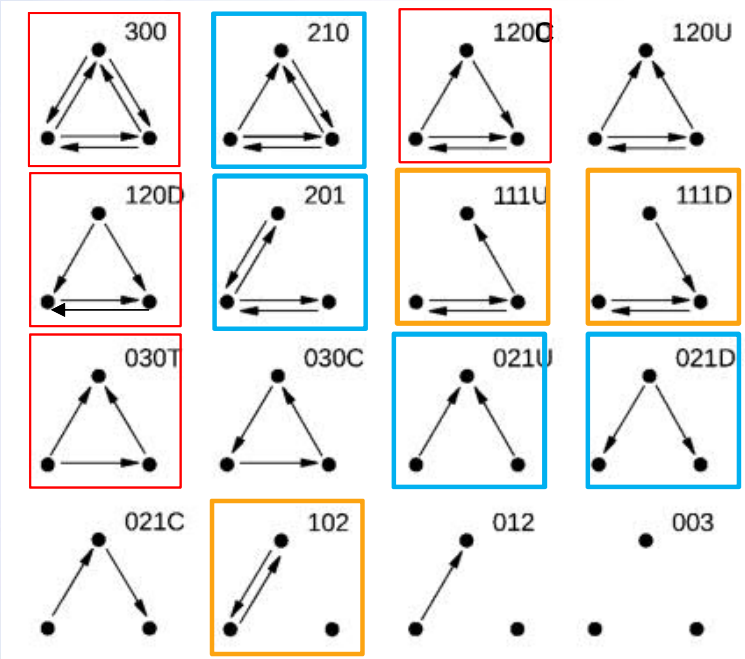
DISCOURSE PATTERNS



16 triadic patterns (Moody 1998)

- Triadic patterns (red): all three agents are connected to each other in different ways
  - egalitarian triad (300), collateral triad (120D), broker triad (120U), cyclically connected triad (120C), transitive triad (030T)
- Dyadic patterns (orange): a reciprocated dyad is the most dominant structural element
  - egalitarian dyad (102), collateral dyad (111U), broker dyad (111D)
- Leadership patterns (blue): one agent gains a special position as leader
  - endorsed leader (021U), broker leader (021D), dyadic leader (201), triadic leader (210)

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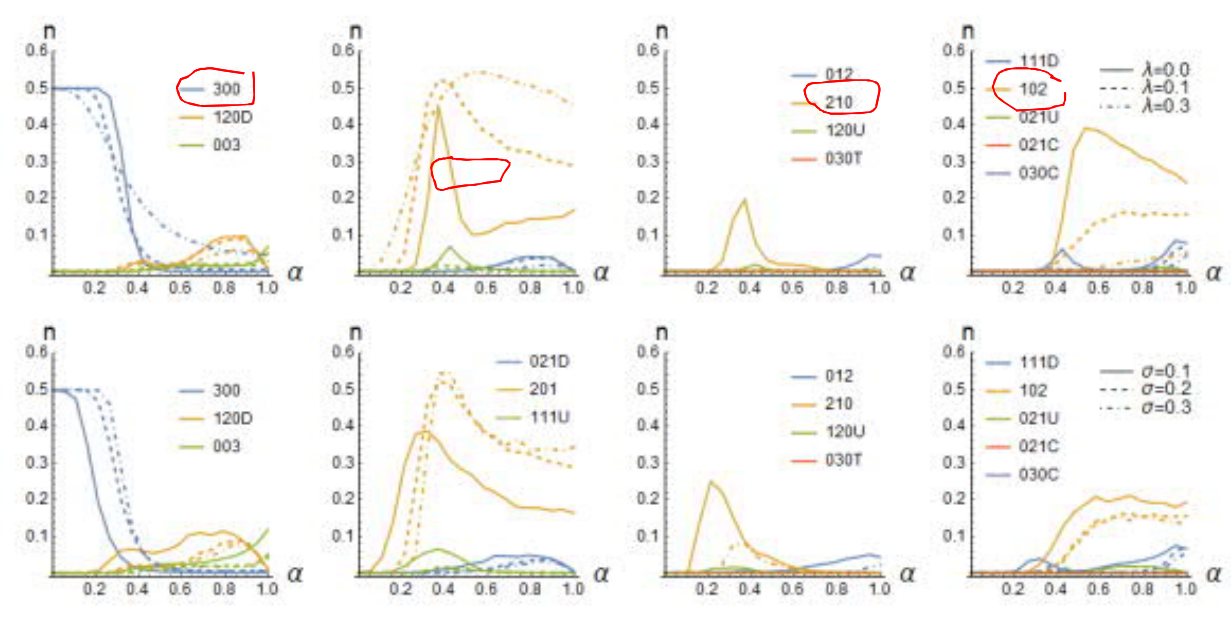
RESULTS: GROUPS OF 4 AGENTS



The effect in responsivity to no cooperation or low diversity is on increase the dyadic leadership patterns (201) while the number of dyads (102) decrease.

- The relative abundance *n* of discourse patterns in G4 as a function of responsivity α.
- Upper panel shows results for diversity $\sigma = 0.20$ and for cooperativities $\lambda = 0.0, 0.1$ and 0.3.
- Lower panel the results are for $\lambda = 0.3$ with $\sigma = 0.05, 0.10, 0.20$ and 0.30.

- The effects of responsivity and cooperativity are prominent in G4 with dyadic interactions (model D)
- For G4 the most dominant patterns for low responsivity ($\alpha < 0.4$) are fully connected egalitarian triads (300), while for intermediated responsivity $0.3 < \alpha < 0.6$ the dyadic leadership patterns (201) are dominant.

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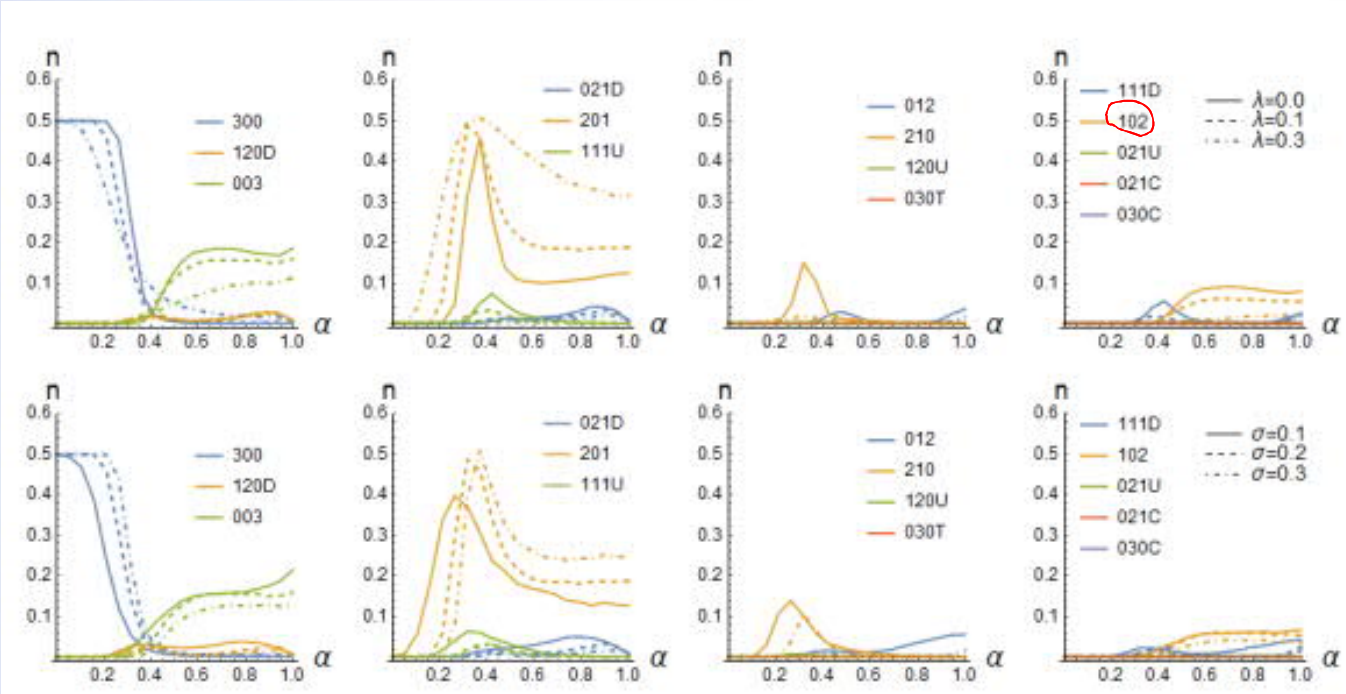
RESULTS: GROUPS OF 5 AGENTS



- The relative abundance *n* of discourse patterns in G5 as a function of sensitivity α.
- Upper panel shows results for diversity $\sigma = 0.20$ and for cooperativities $\lambda = 0.0, 0.1$ and 0.3.
- Lower panel the results are for $\lambda = 0.3$ with $\sigma = 0.05, 0.10, 0.20$ and 0.30.

- The effects of responsivity and cooperativity are also prominent in G5 with dyadic interactions (model D)
- In G5 the abundance of dyads (102) is significantly lower and abundance isolates significantly higher than in G4 with corresponding parameters
  - Bigger group enhances the tendency for isolation and drop-outs.

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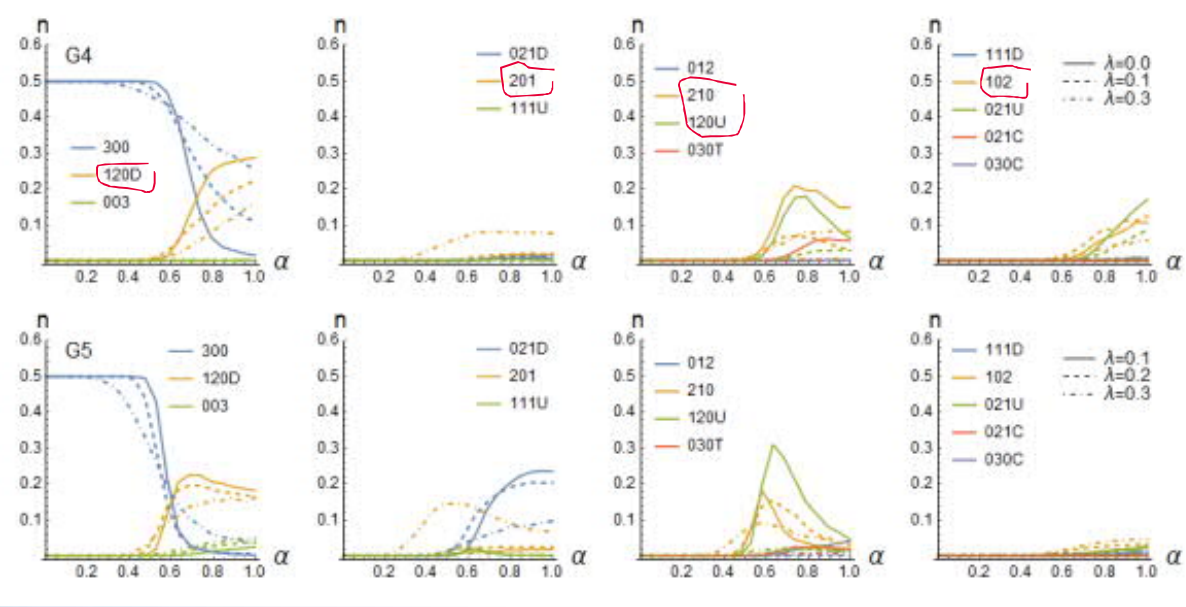
RESULTS: COLLATERALITY



- The relative abundance *n* of discourse patterns in G4 and G5 in the triadic collateral interaction model T as a function of sensitivity α.
- Upper panel shows results for diversity $\sigma = 0.20$ and for cooperativities $\lambda = 0.0, 0.1 \text{ and } 0.3$.
- Lower panel the results are for $\lambda = 0.3$ with $\sigma = 0.05, 0.10, 0.20 \text{ and } 0.30$.

- Inclusion of collaterality increases the abundance of triadic leaders (210) and collateral and broker triads (120D and 120U), while abundances of dyads (102) and dyadic leaders (201) are decreased in comparison to model D.

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DISCUSSION AND CONCLUSIONS

- The results show how delicately the discourse patterns depend on responsivity, how the competition of gaining better discursivity (floor in discourse) shapes the patterns, and how by raising the sensitivity to responsivity the tendency to reciprocated dyadic patterns is raised.

- Highly discursive agents have the tendency to strengthen their mutual ties and ignore their less discursive peers, thus forming tightly connected dyads.

- Very subtle bias-effects, weak signals of feedback, may have tremendous effect when the same signals and feedback are repeated, eventually leading to strong and irreversible segregation of groups

For more details, see:
Koponen, IT & Nousiainen, M (2018). An Agent-Based Model of Discourse Pattern Formation in Small Groups of Competing and Cooperating Members. *Journal of Artificial Societies and Social Simulation*, *21*(2). DOI: 10.18564/jasss.3648

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Koponen, IT & Nousiainen, M (2016). Formation of reciprocated appreciation patterns in small groups: An agent-based model. *Complex Adaptive Systems Modeling*, 4(24). DOI:10.1186/s40294-016-0035-6