

# Group Intelligence in Social Robots

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Researcher at LARSYS-ITI



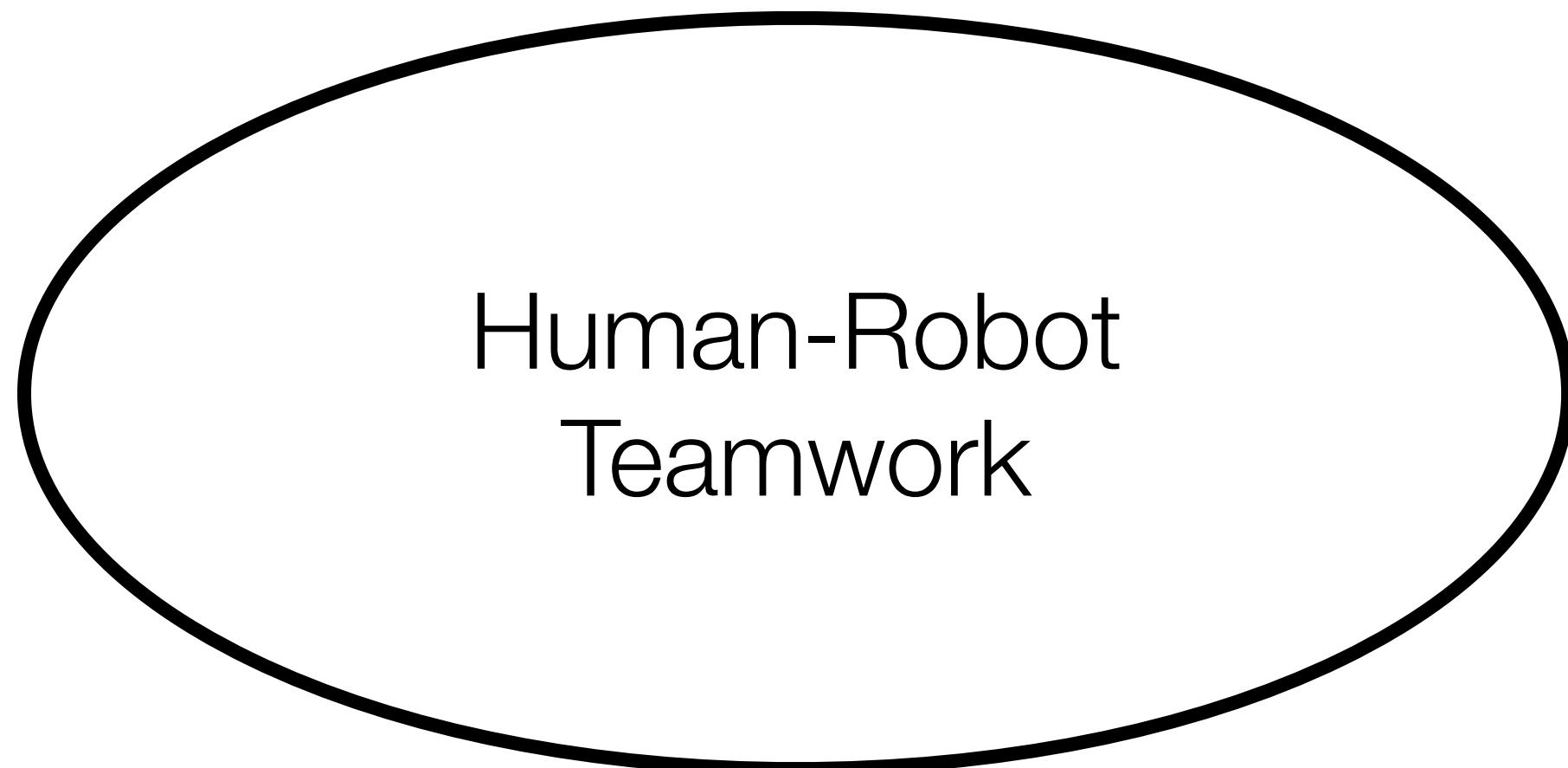
23/11/2022 - Media Innovation Lab @ RU University

# Motivation



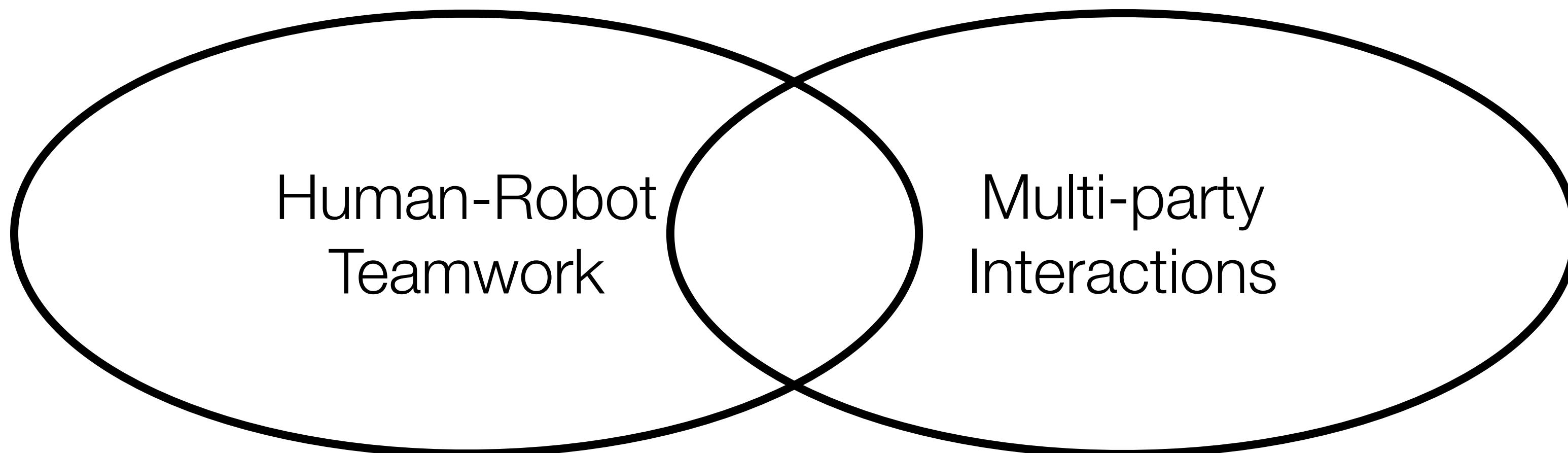
# Teamwork

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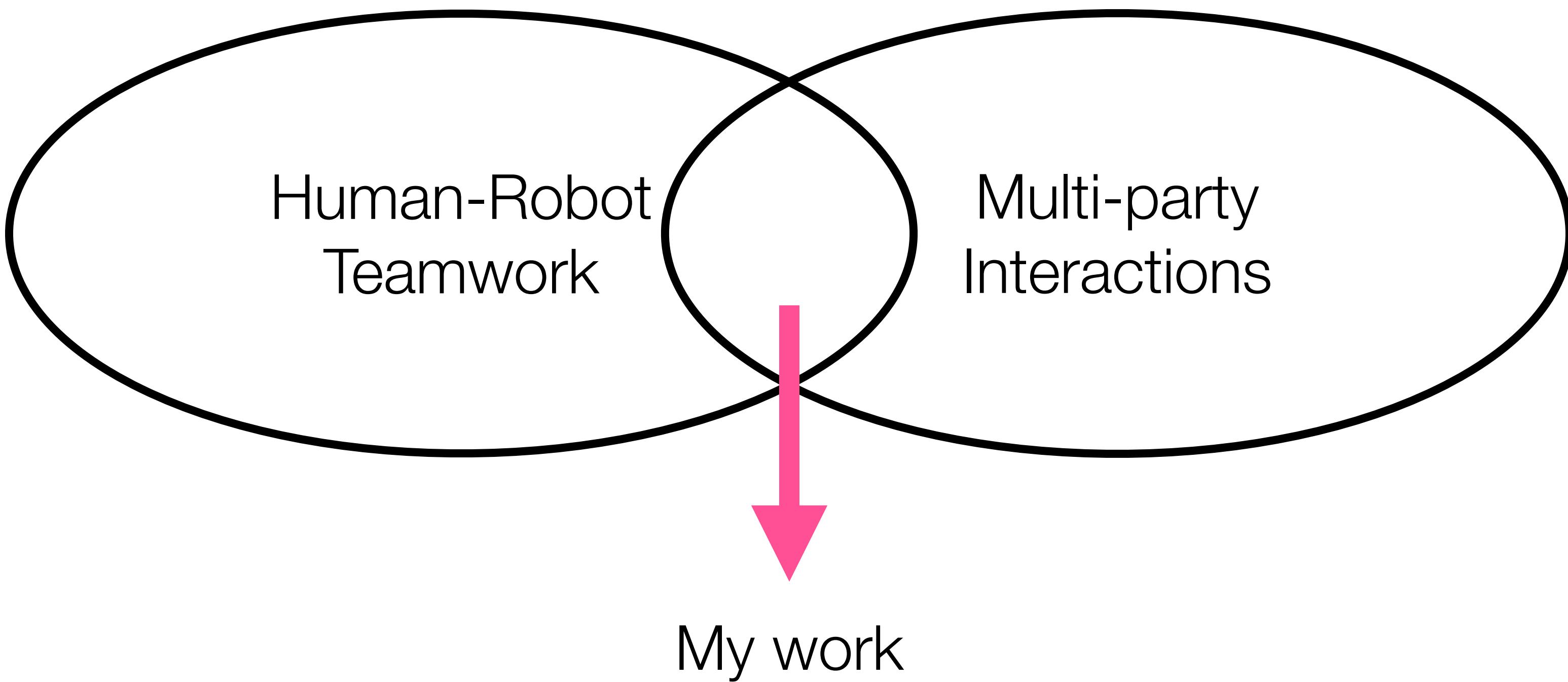
# Teamwork & Multi-party

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# Novelty

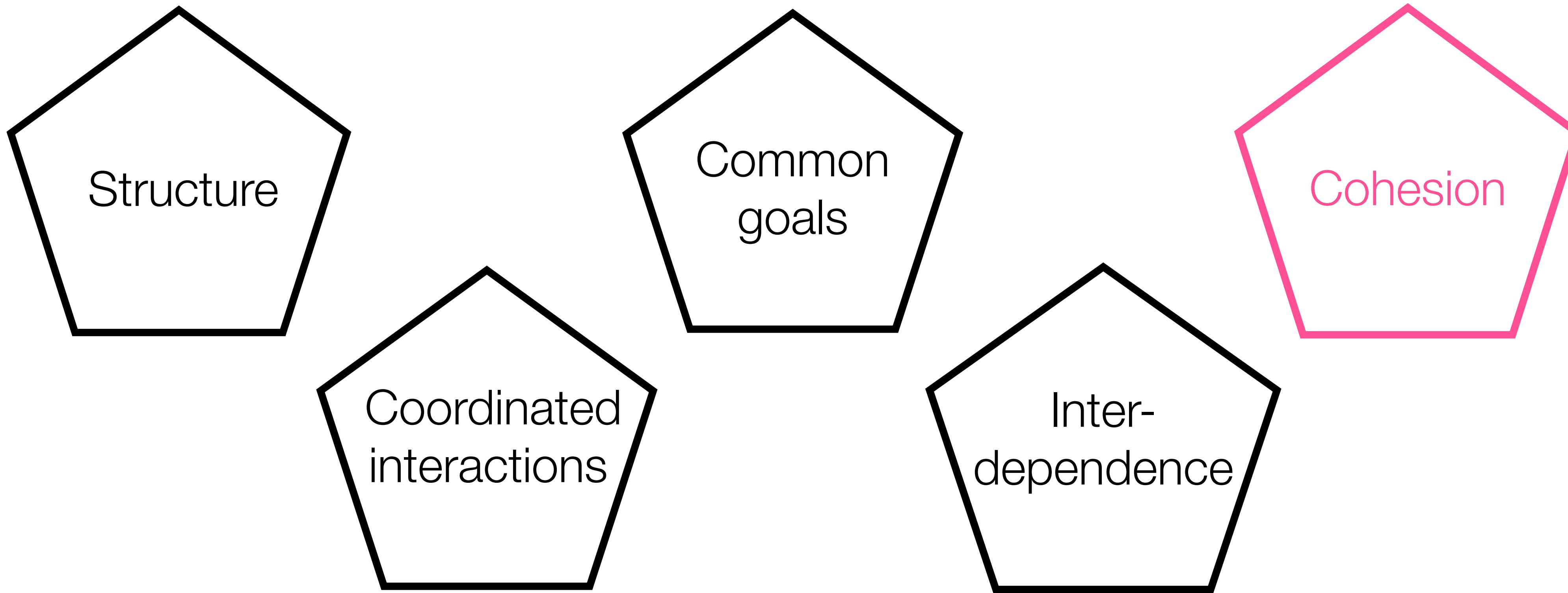
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# What is a Team?

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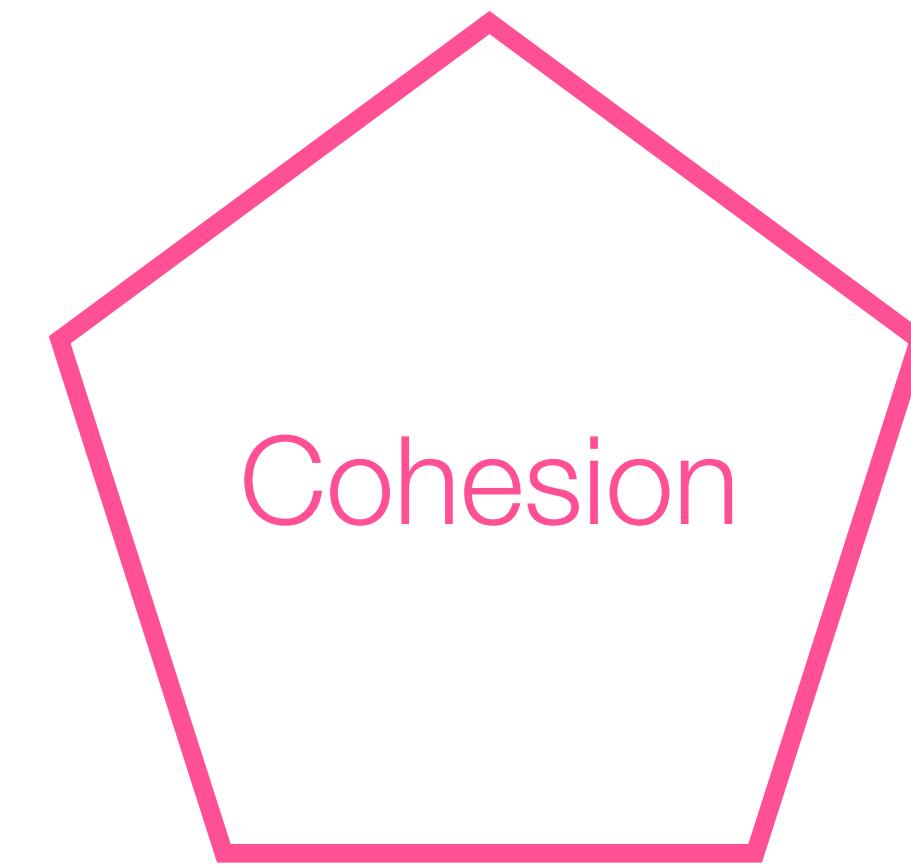
“unified, cohesive group”



# What is Cohesion?

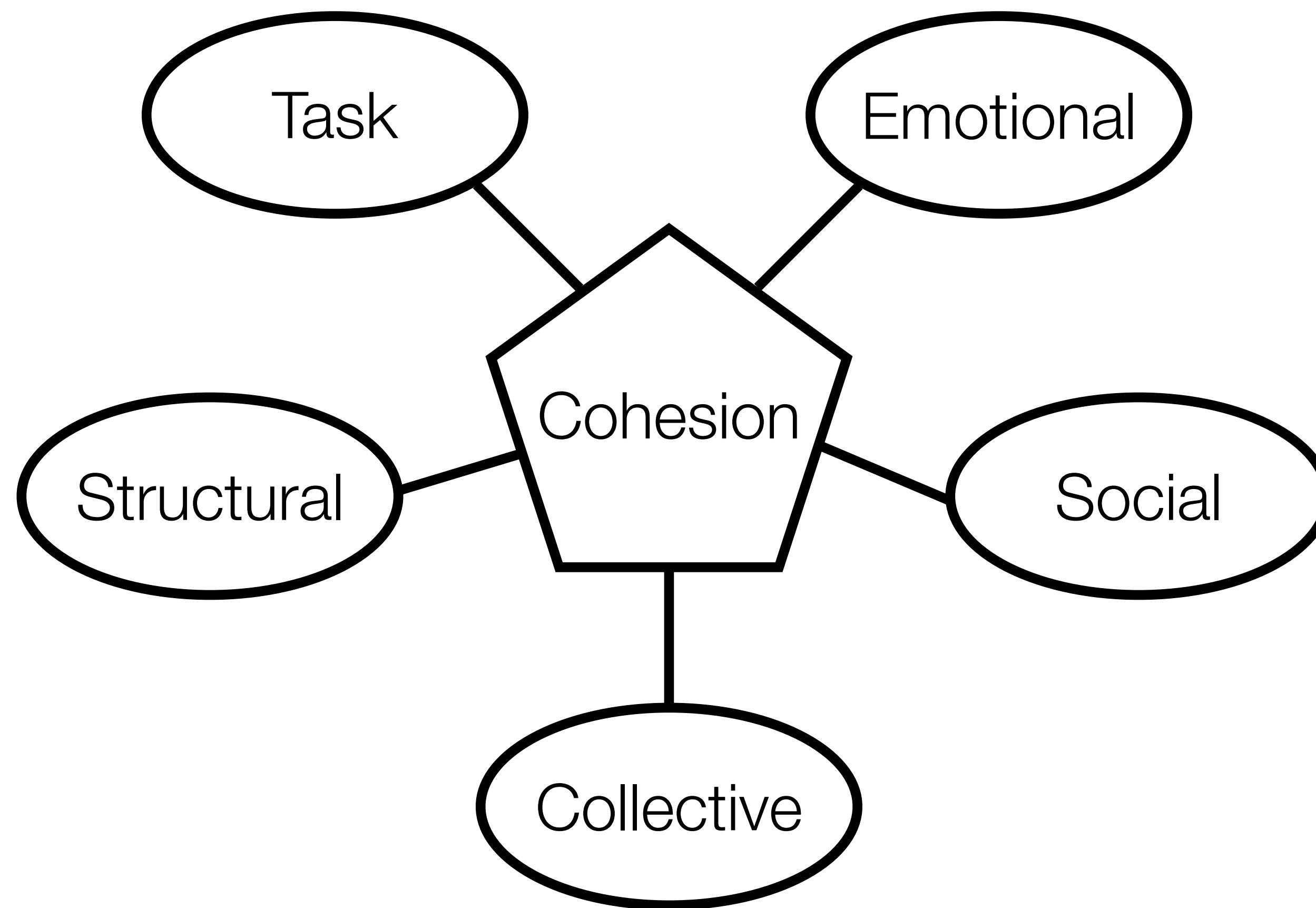
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“a shared sense of unity by all group members”



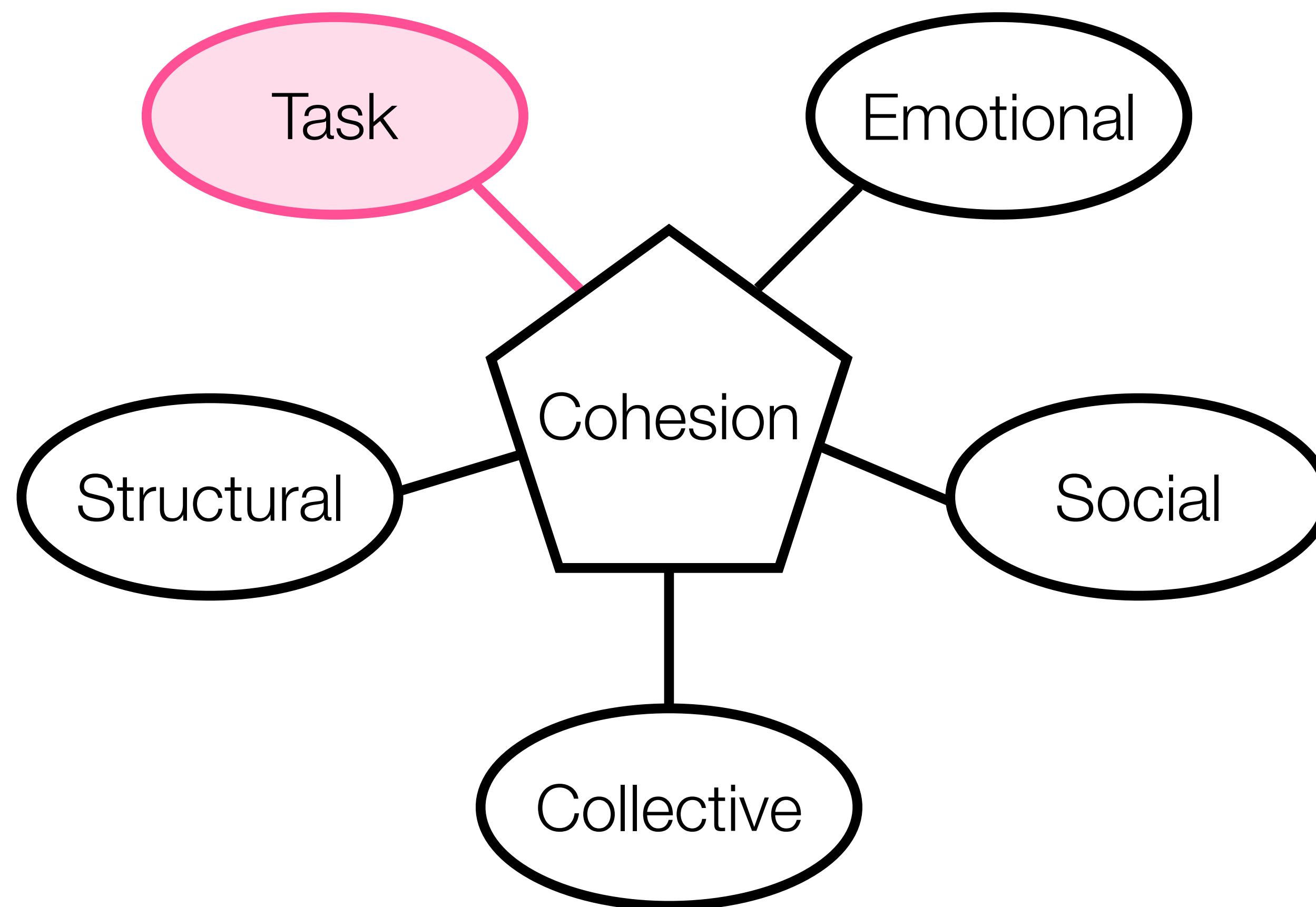
# What is Cohesion?

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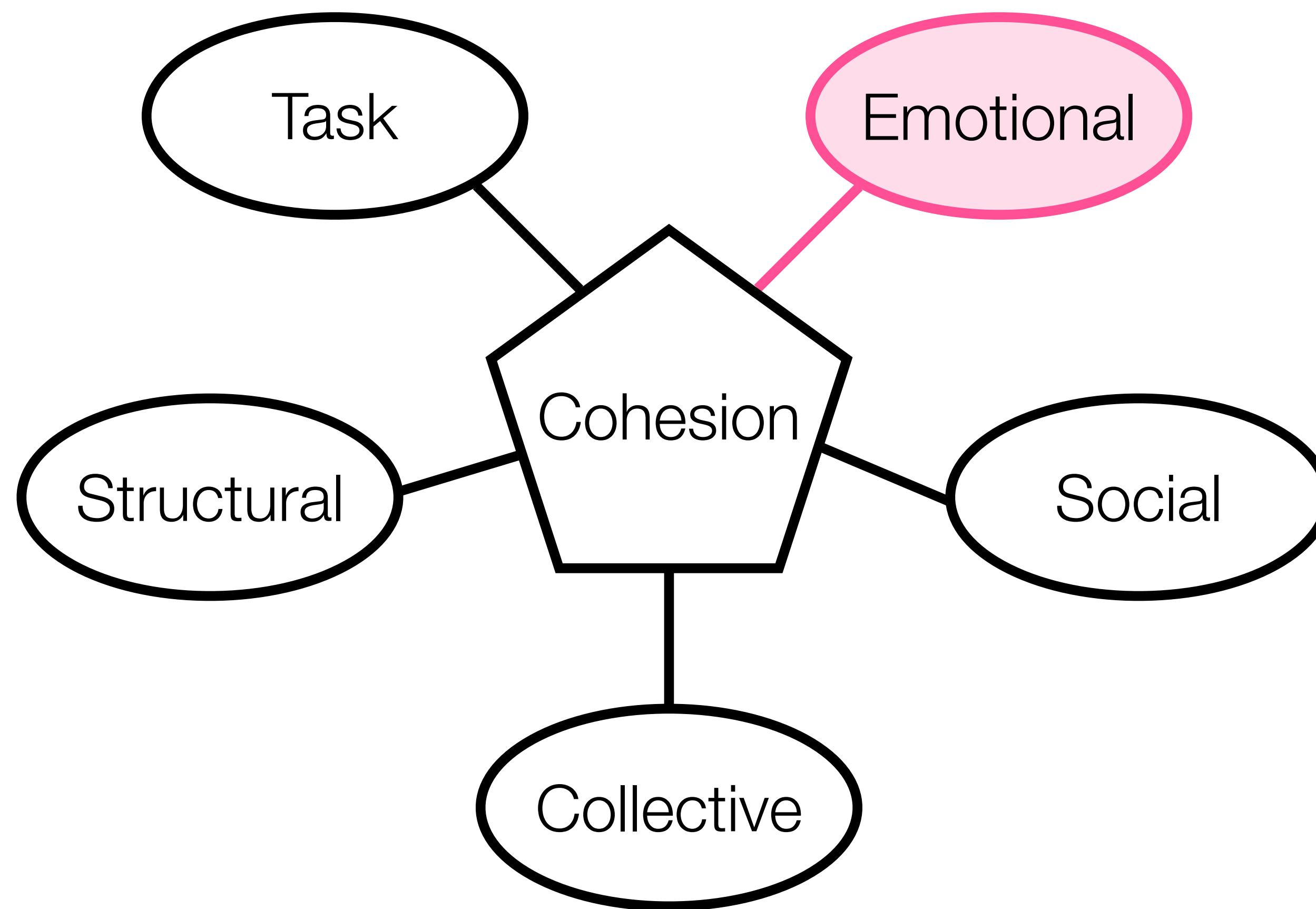
# What is Task Cohesion?

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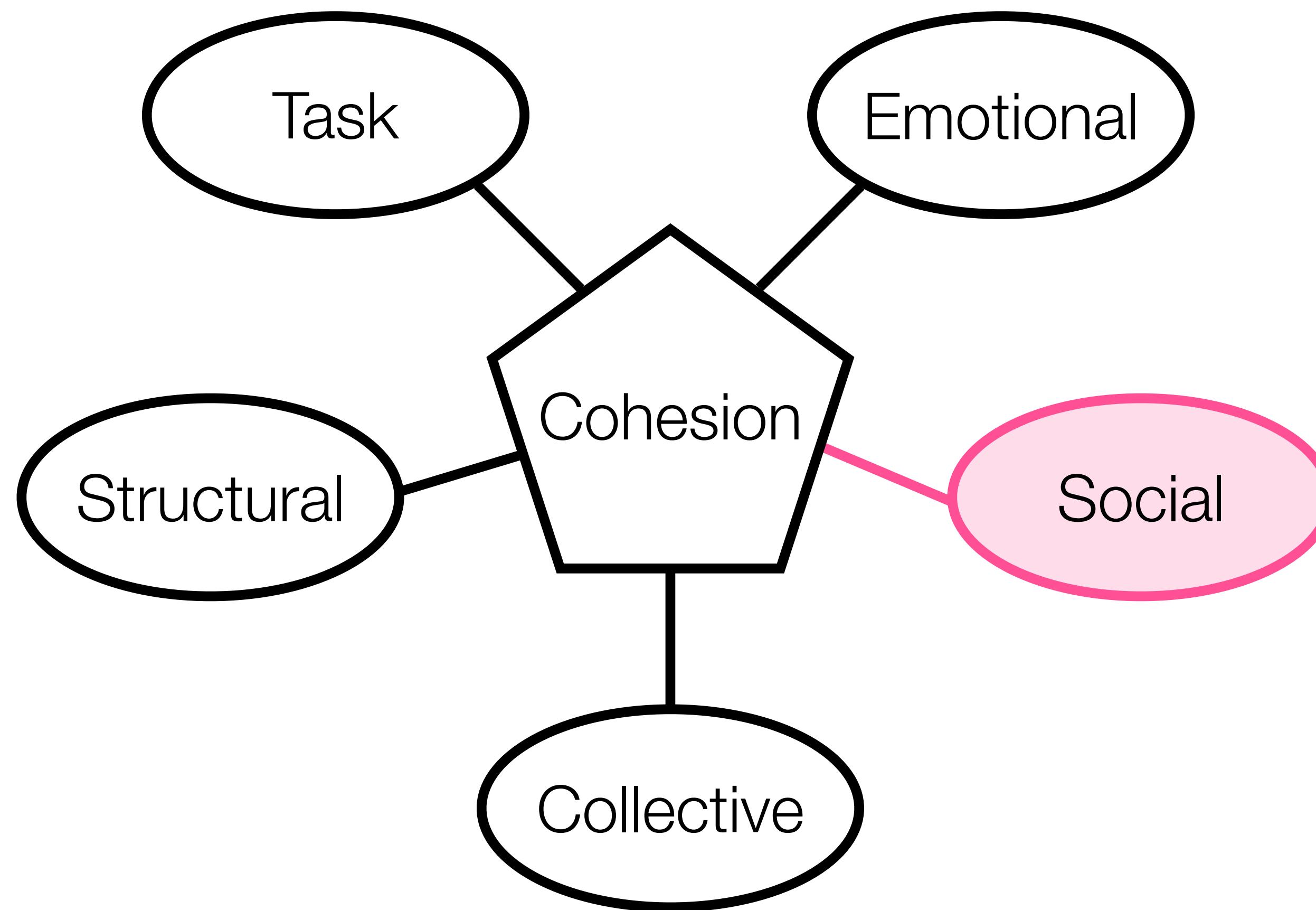
# What is Emotional Cohesion?

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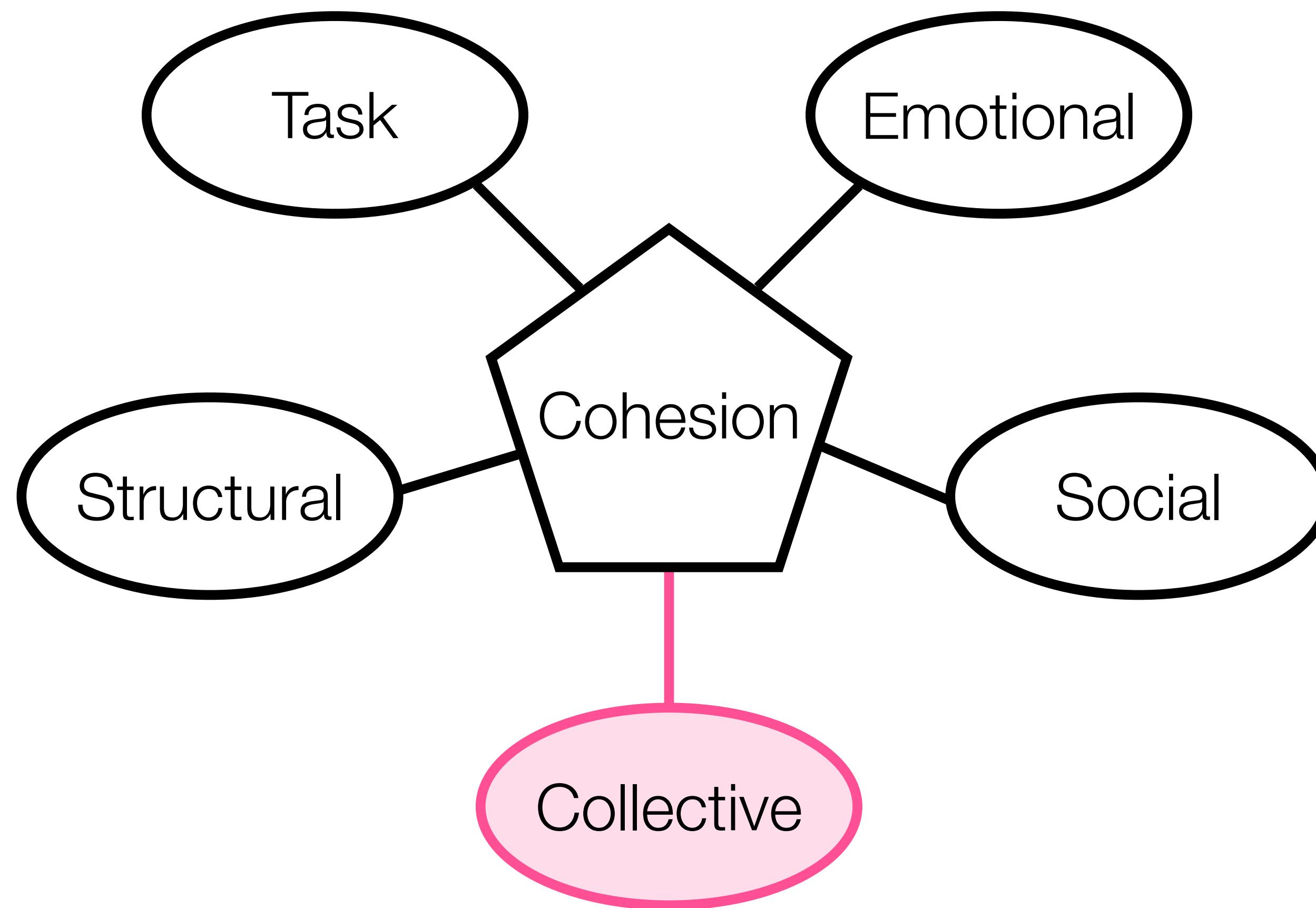
# What is Social Cohesion?

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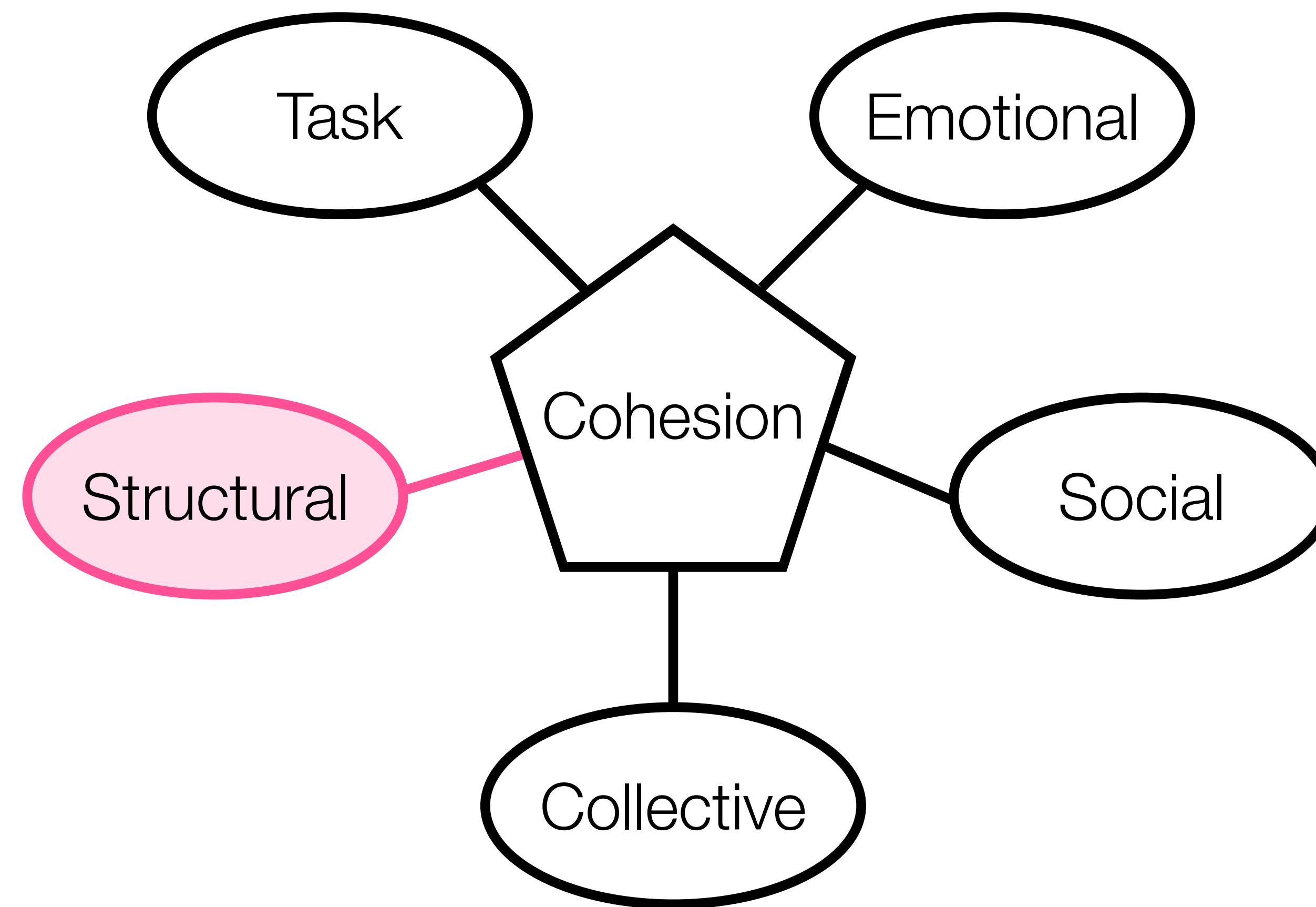
# What is Collective Cohesion?

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# What is Structural Cohesion?

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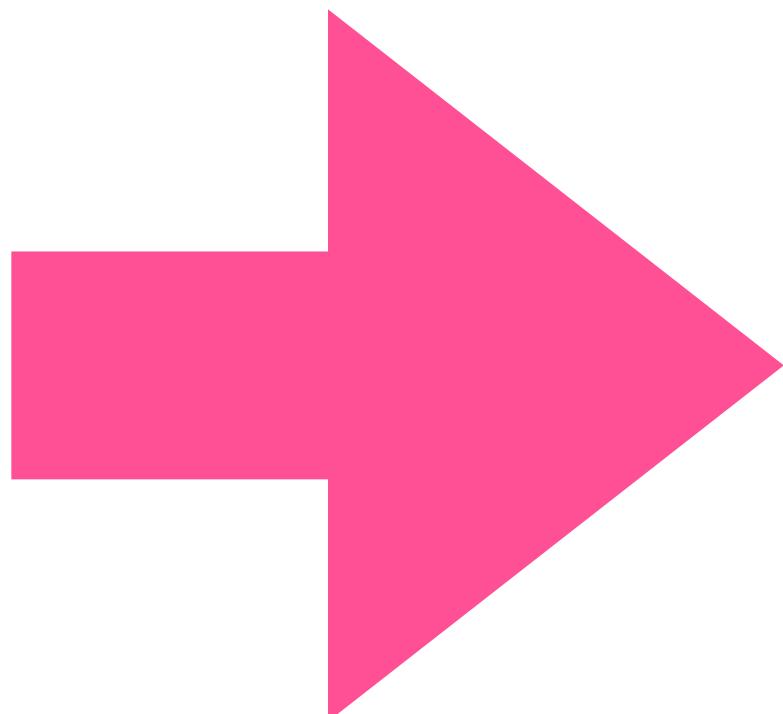


# Research Problem

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*How can we endow a robotic teammate with  
social capabilities to improve the **cohesive alliance**  
in a multi-party setting with humans?*

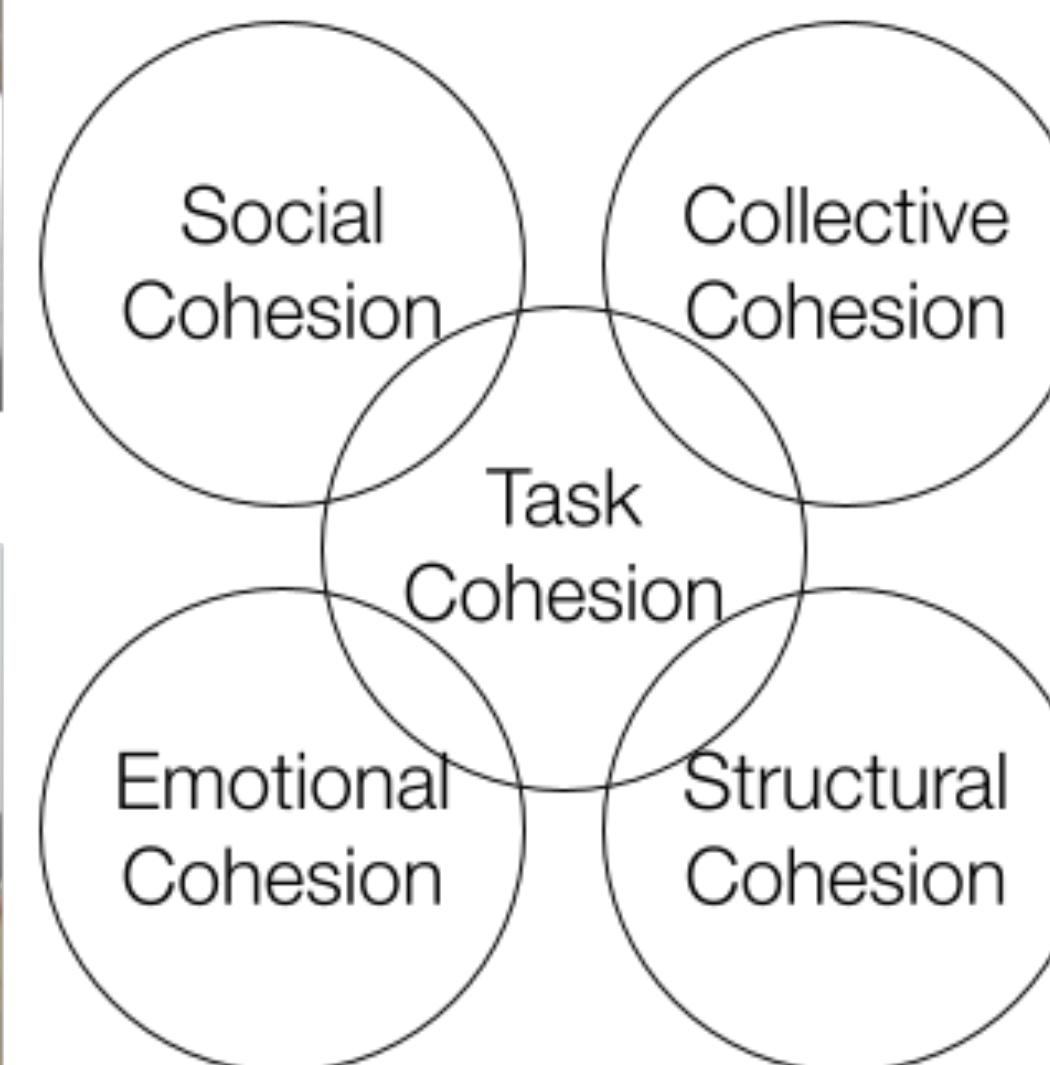
# Contributions



Membership Preferences



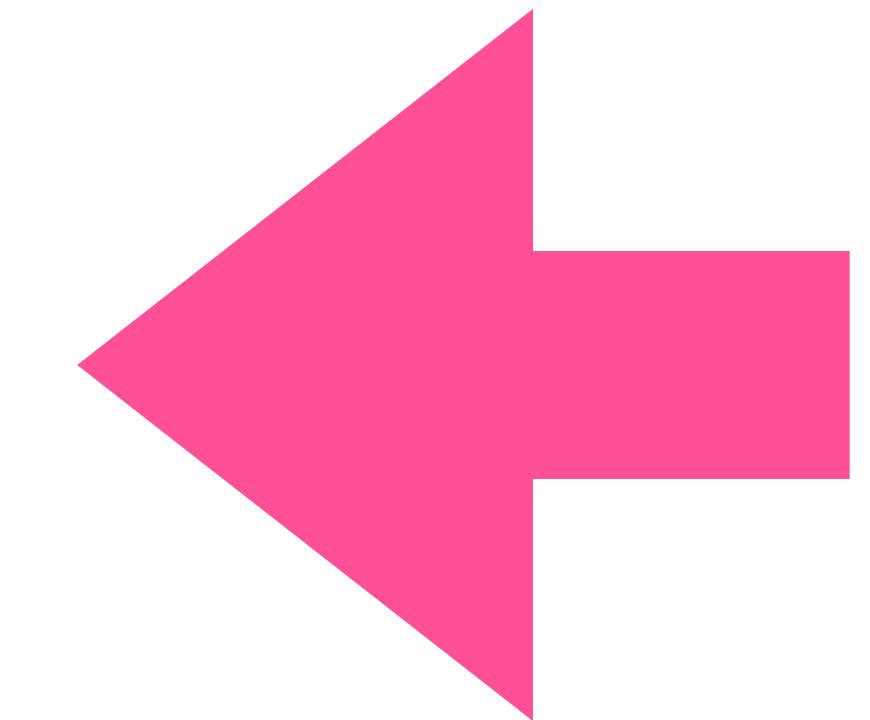
Group-based Emotions



Prosociality



Multi-party Gaze



Collective  
Cohesion



# Prosociality in human-robot teams

# Project Goal & Research Questions

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Collective Cohesion

# Project Goal & Research Questions

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## Collective Cohesion

- How do people perceive prosocial and selfish actions of robotic teammates?

# Project Goal & Research Questions

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## Collective Cohesion

- How do people perceive prosocial and selfish actions of robotic teammates?
- Can the perception of those robots be affected by the outcome of team?

# Project Goal & Research Questions

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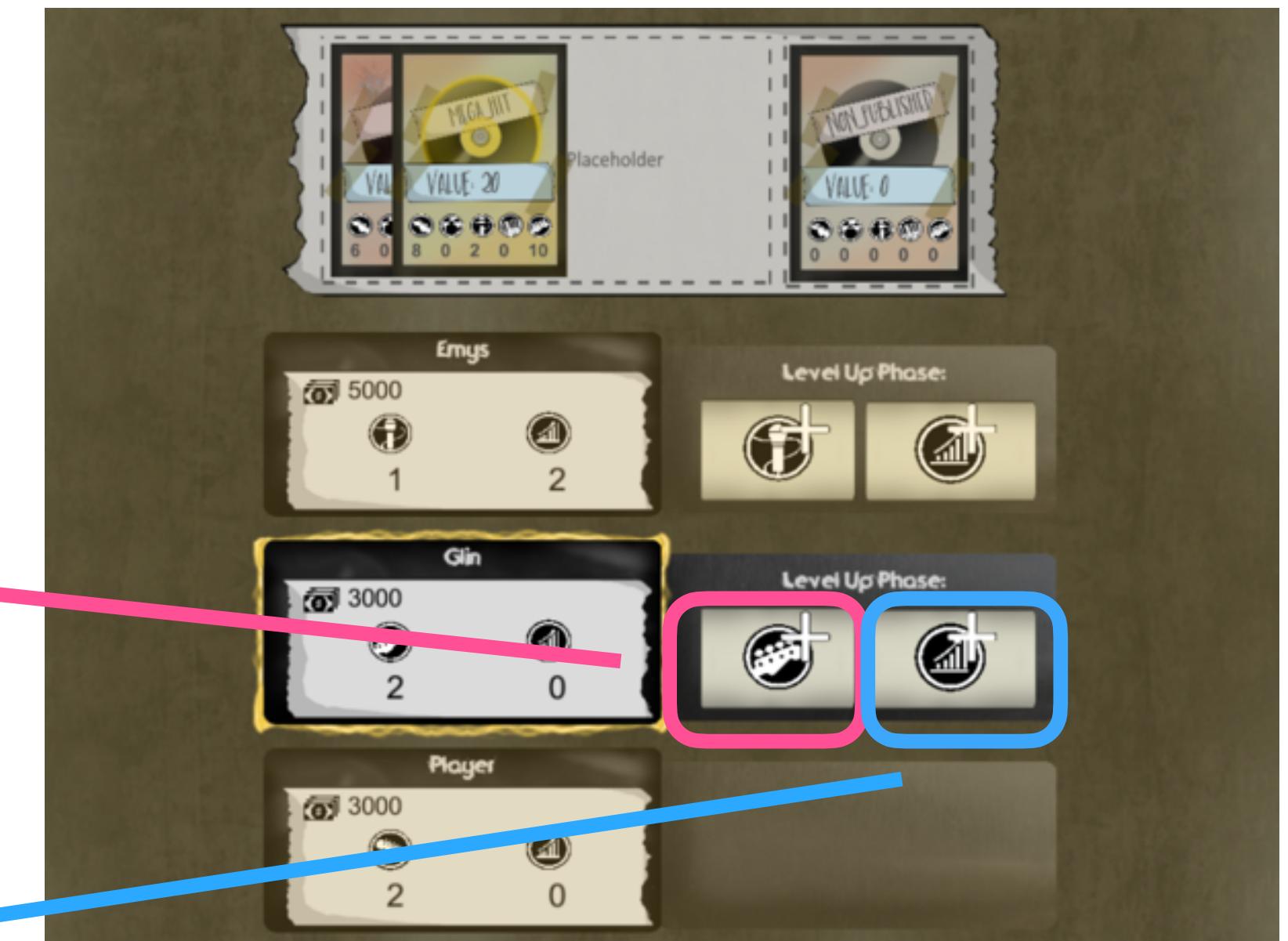
## Collective Cohesion

- How do people perceive prosocial and selfish actions of robotic teammates?
- Can the perception of those robots be affected by the outcome of team?
- Does the outcome of the team affect people's cohesion?

# User Study

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- *For The Record* - Threshold game with uncertain returns
  - Common Goal - “play for instrument”  
- **to cooperate**
  - Individual Goal - “play for marketing”  
- **to defect**



# User Study

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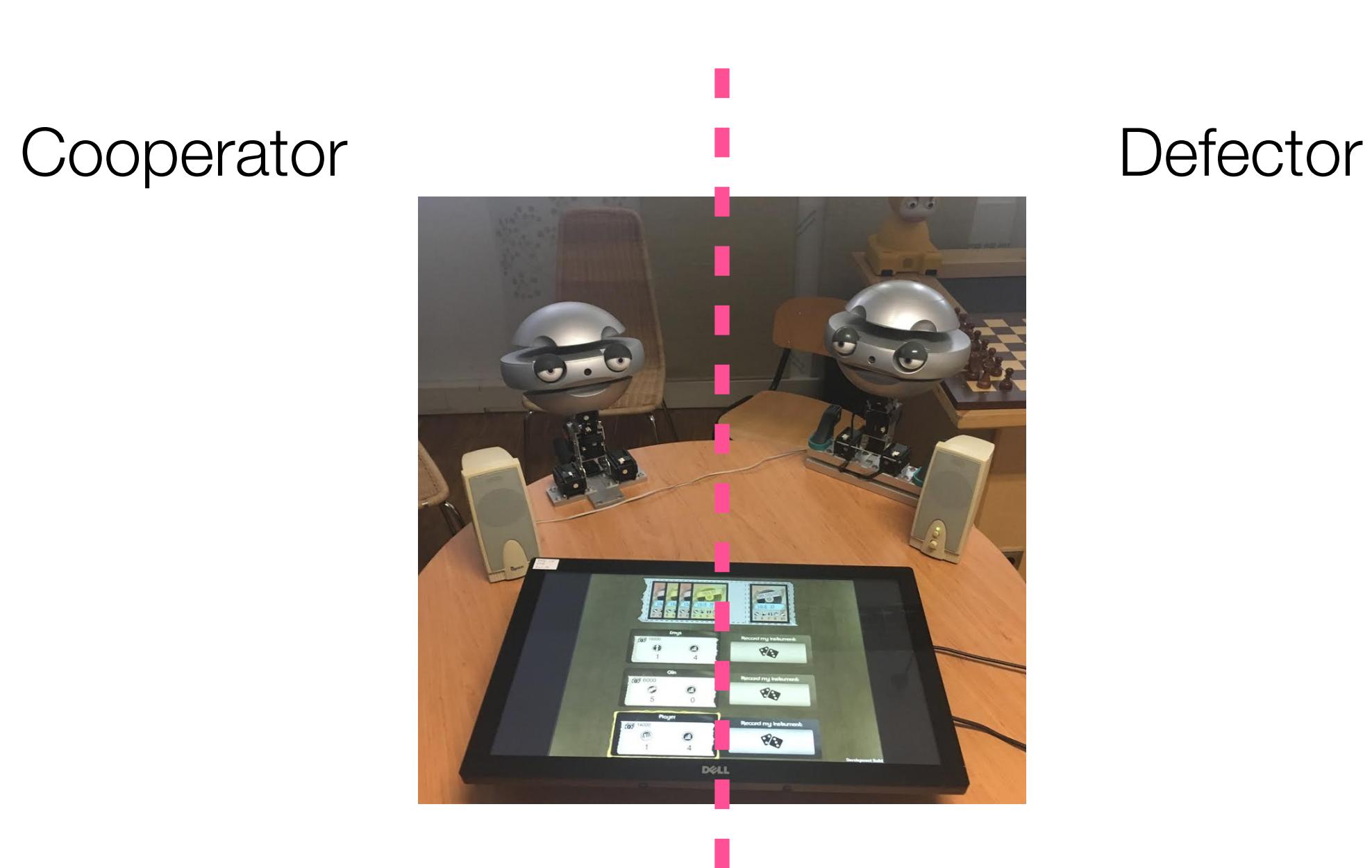
- Team of 3
  - 2 autonomous robots
  - 1 person
- 70 participants (large corporation)



# Experimental Design

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- Mixed experimental design
- Within-subjects variable - **strategy of the robots**



# Experimental Design

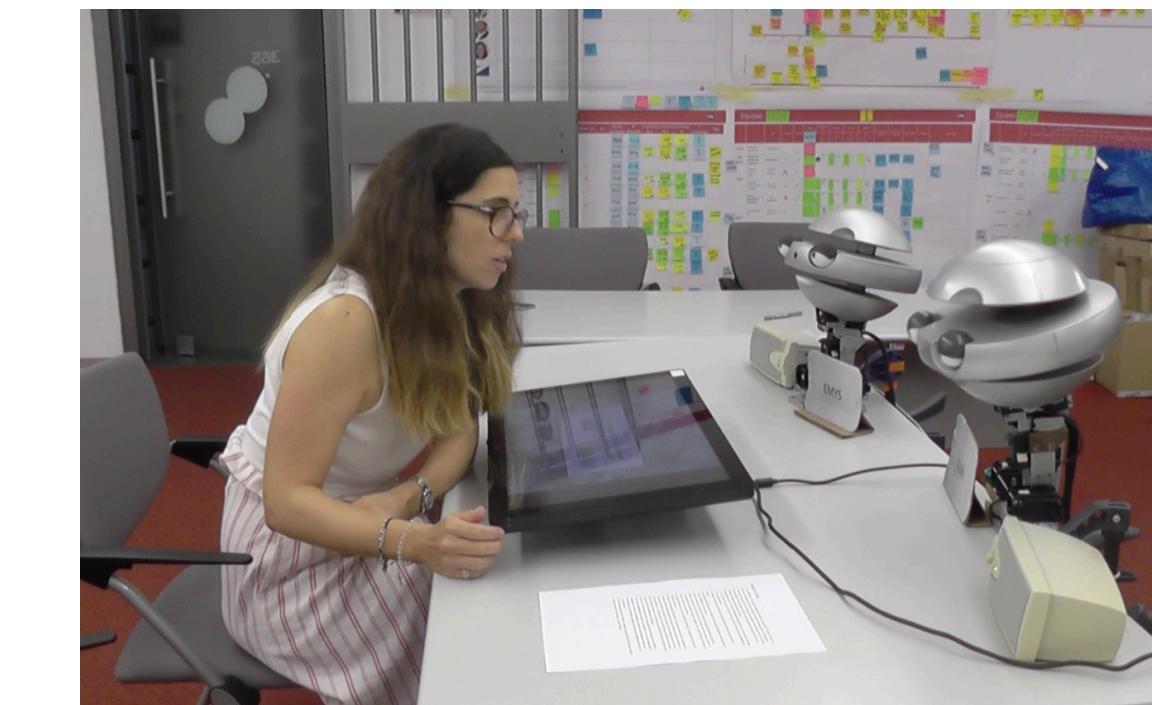
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- Mixed experimental design
- Within-subjects variable - **strategy of the robots**
- Between-subjects variable - **game result**

Winning



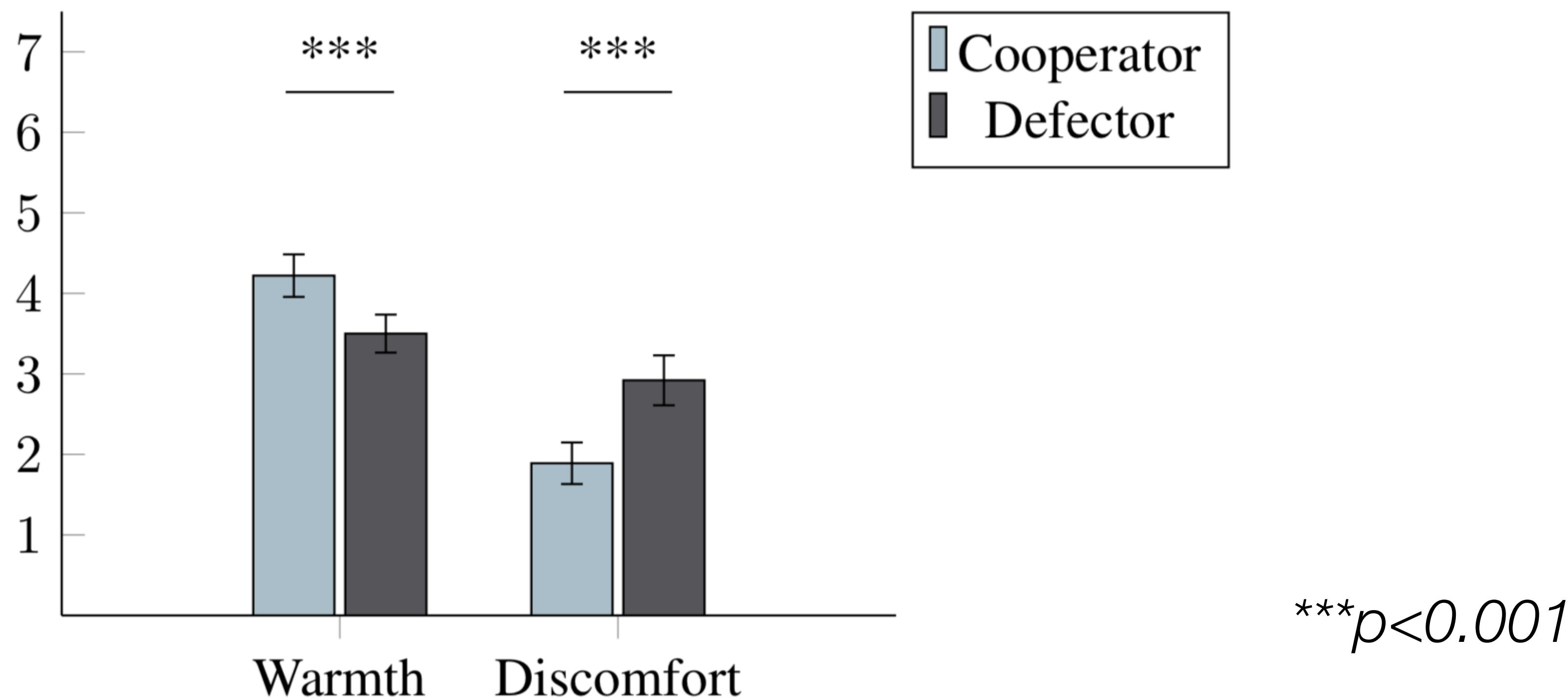
Losing





# How do people perceive prosocial and selfish actions?

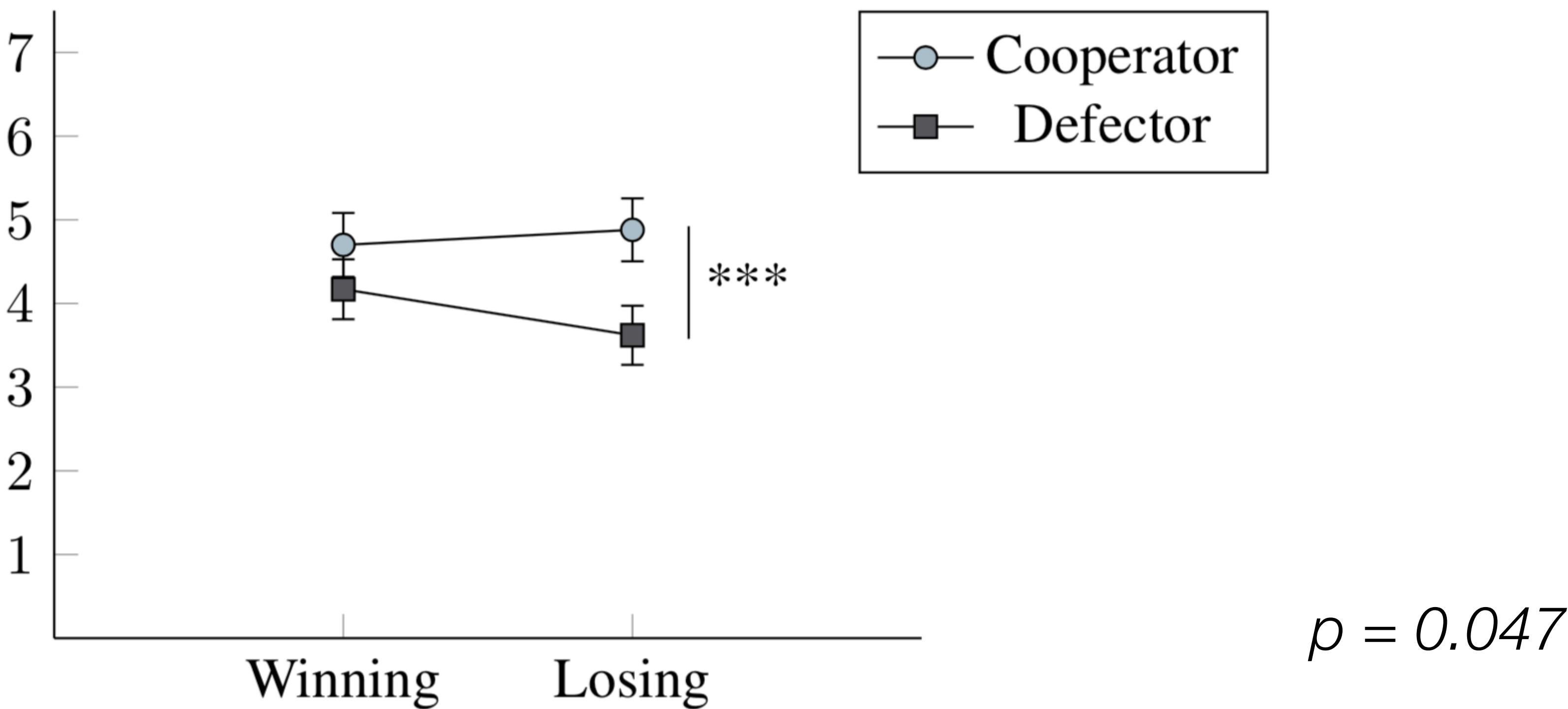
## Perceived Warmth and Discomfort (RoSAS)



Carpinella, C. M., Wyman, A. B., Perez, M. A., & Stroessner, S. J. (2017, March). The robotic social attributes scale (rosas) development and validation. In Proceedings of the 2017 ACM/IEEE International Conference on human-robot interaction (pp. 254-262).

# Can those perceptions be affected by the outcome?

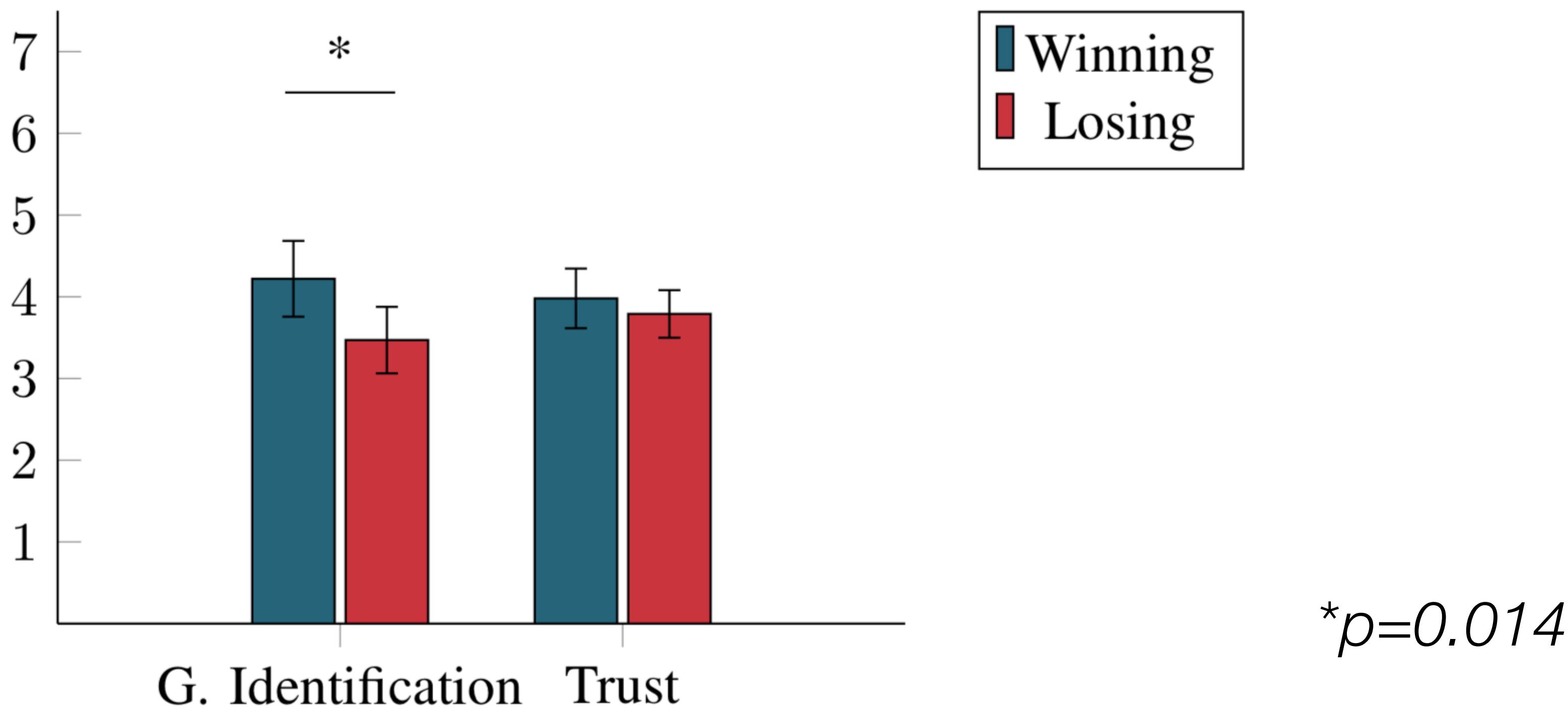
Perceived Competence (RoSAS)



Carpinella, C. M., Wyman, A. B., Perez, M. A., & Stroessner, S. J. (2017, March). The robotic social attributes scale (rosas) development and validation. In Proceedings of the 2017 ACM/IEEE International Conference on human-robot interaction (pp. 254-262).

# Does the outcome affect people's cohesion?

## Group measures

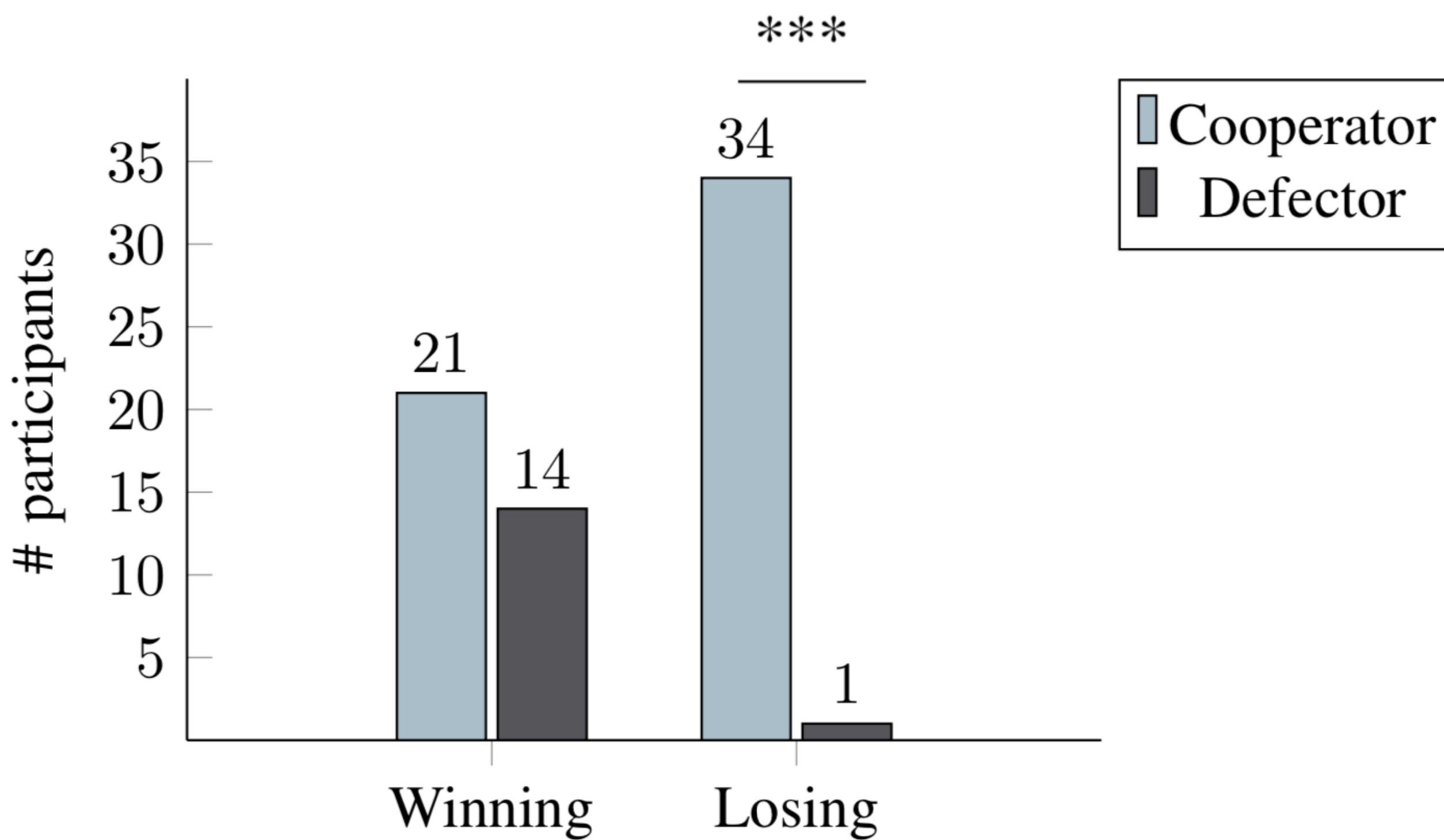


C. W. Leach, M. Van Zomeren, S. Zebel, M. L. Vliek, S. F. Pennekamp, B. Doosje, J. W. Ouwerkerk, and R. Spears, "Group-level self-definition and self-investment: a hierarchical (multicomponent) model of in-group identification." *Journal of personality and social psychology*, vol. 95, no. 1, p. 144, 2008

K. Allen and R. Bergin, "Exploring trust, group satisfaction, and performance in geographically dispersed and co-located university technology commercialization teams," in *In Proceedings of the NCIIA 8th Annual Meeting: Education that Works*, 2004, pp. 18–20.

# Does the outcome affect people's cohesion?

Preference for a hypothetical future game



\*\*\* $p<0.001$

# Take-away Message

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The collective cohesion portrayed by the robots affects people's perceptions.

The outcome of the game can influence people's reported collective cohesion.

Positive outcomes can “forgive” selfish behaviours...

**Correia, F.**, Mascarenhas, S. F., Gomes, S., Arriaga, P., Leite, I., Prada, R., Melo, F. S. & Paiva, A. (2019, March). Exploring prosociality in human-robot teams. In 2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 143-151). IEEE. [HRI'19]



Emotional  
Cohesion

A model of Group-  
based Emotions

# Project Goal & Research Questions

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Emotional Cohesion

# Project Goal & Research Questions

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## Emotional Cohesion

- How can a robot express group feelings?

# Project Goal & Research Questions

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## Emotional Cohesion

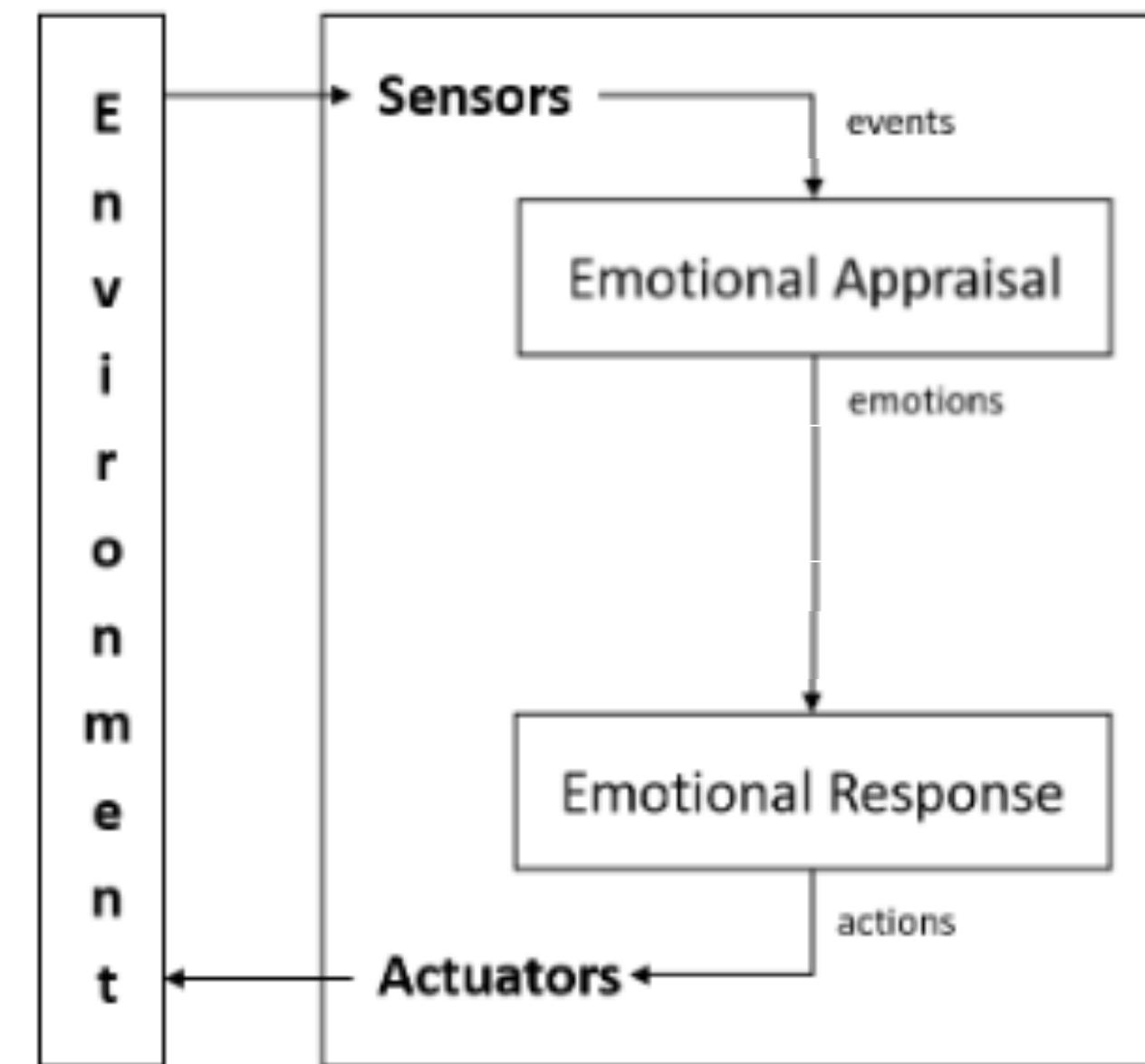
- How can a robot express group feelings?
- Does the expression of group feelings by the robot increase people's cohesion?

# What are Group-based Emotions?



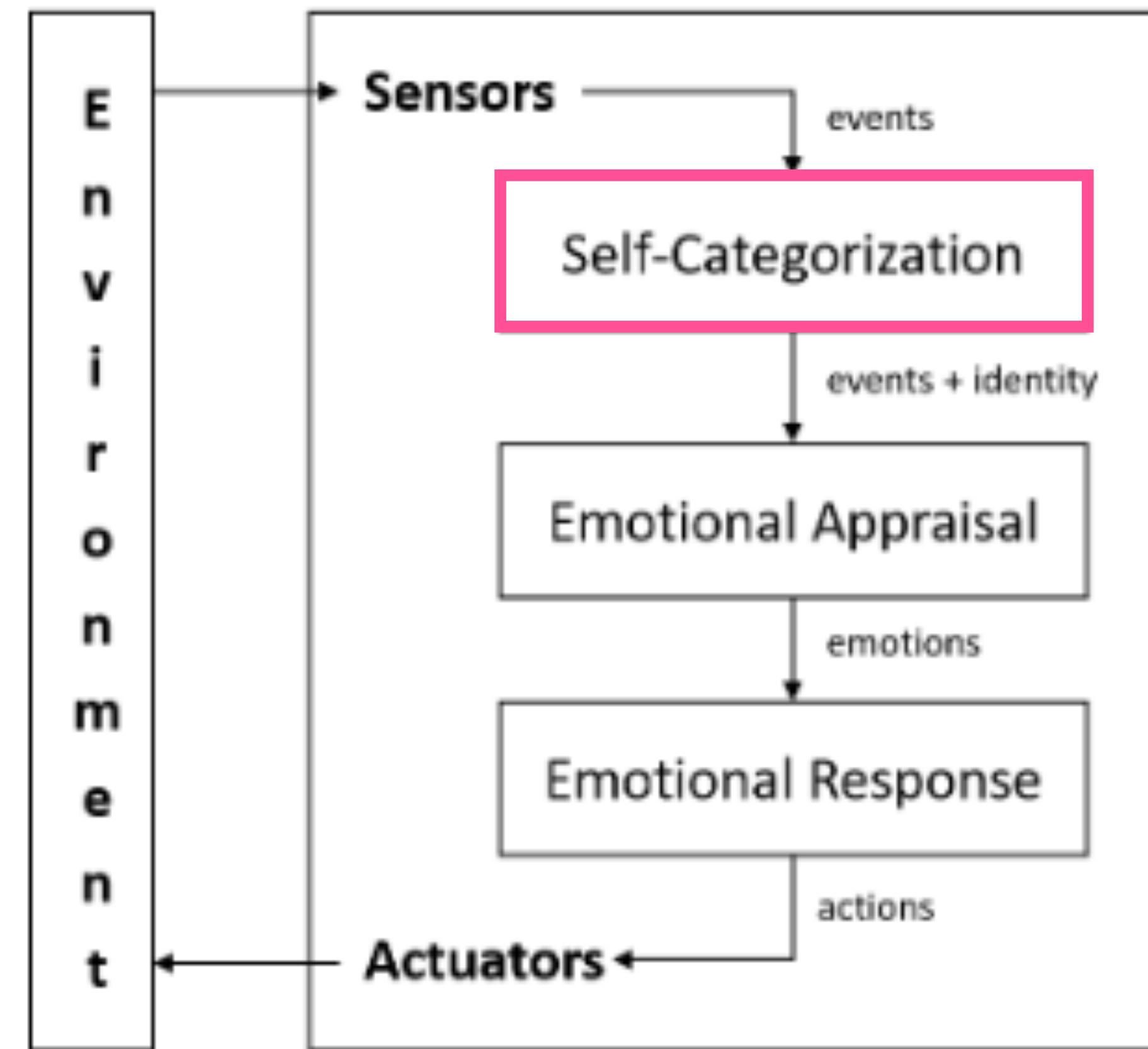
# How can a robot express group feelings?

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**Current models for generation of emotions  
do not allow for Group-based Emotions!**

# A model of Group-based Emotions



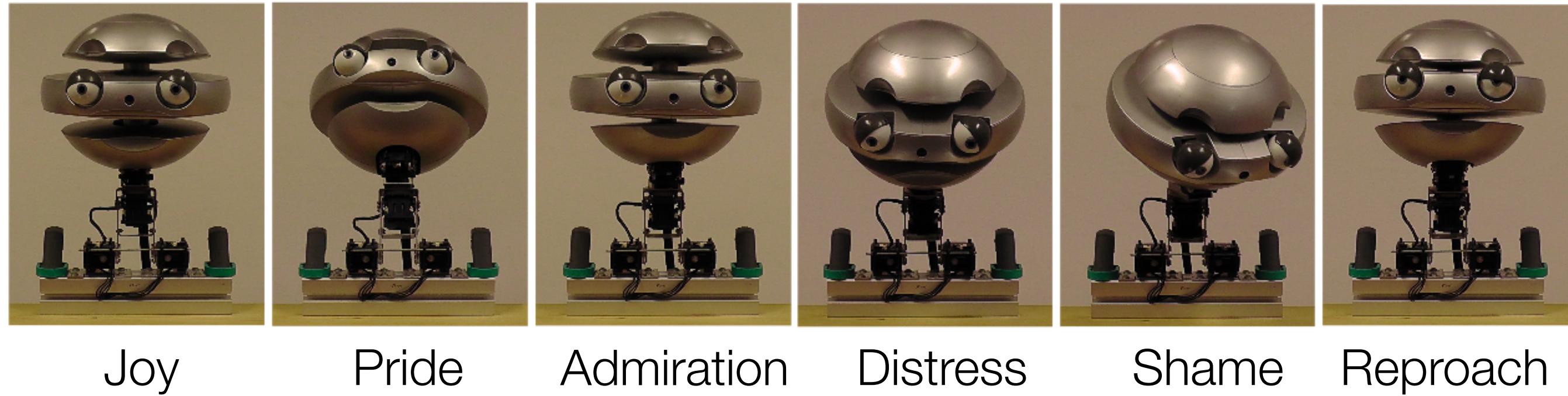
# User Study

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- Card game
- 2 autonomous robots
  - 1 with group-based emotions
  - 1 with individual-based emotions



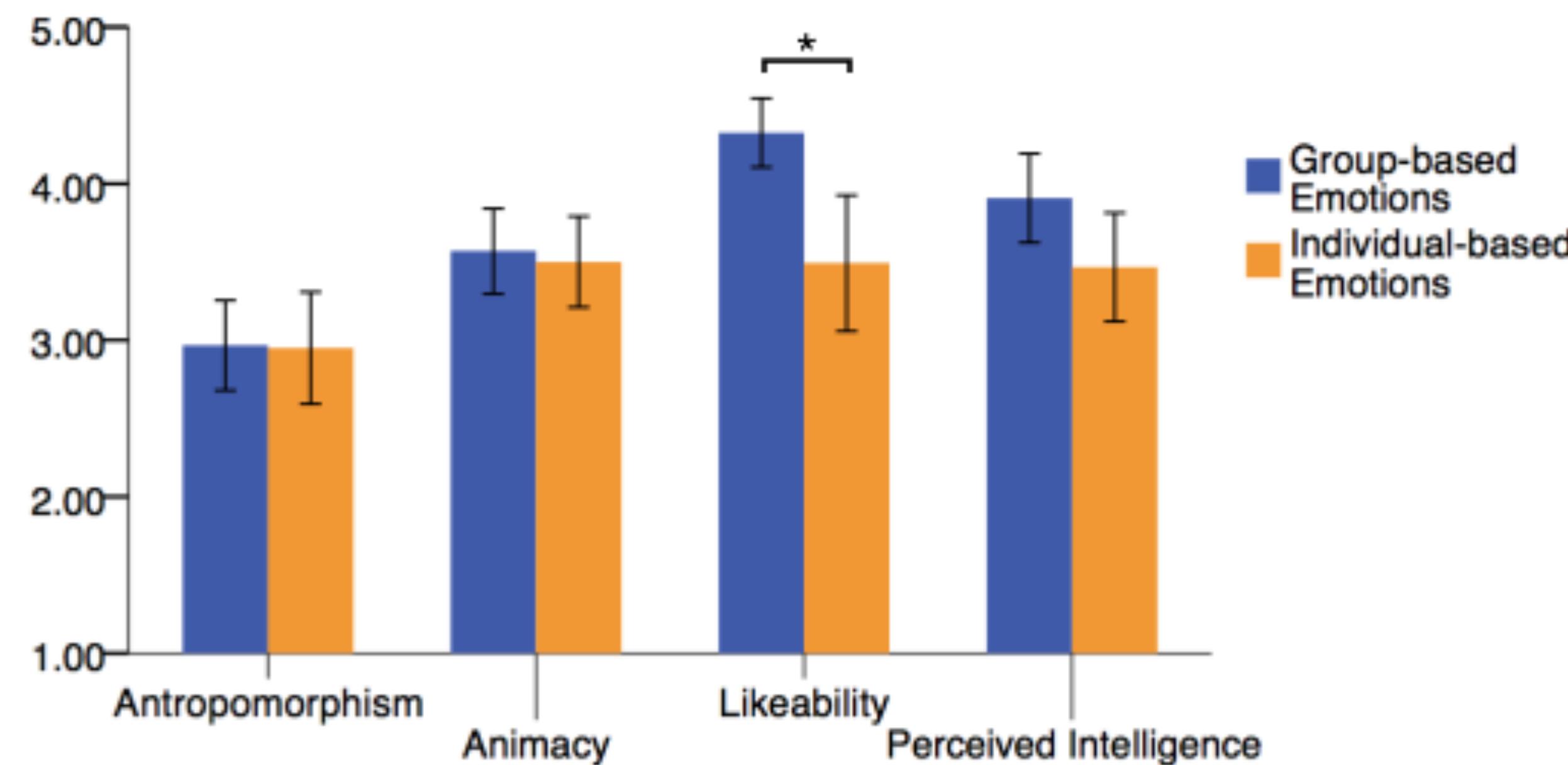
# User Study - Manipulation



|                         | Robot that expresses individual-based emotions |                               |       |       | Robot that expresses group-based emotions |          |                  |                                  |
|-------------------------|--|-------------------------------|-------|-------|---|----------|------------------|----------------------------------|
|                         | Admiration                                     | Reproach                      | Pride | Shame | Admiration                                | Reproach | Pride            | Shame                            |
| Partner increased score | I am impressed with your move!                 | —                             | —     | —     | —   | —        | We are the best! | —                                |
| Partner decreased score | —  | With that move, I cannot win. | —     | —     | —   | —        | —                | We were not so good this time... |

# How do people perceive a robot that expresses group feelings?

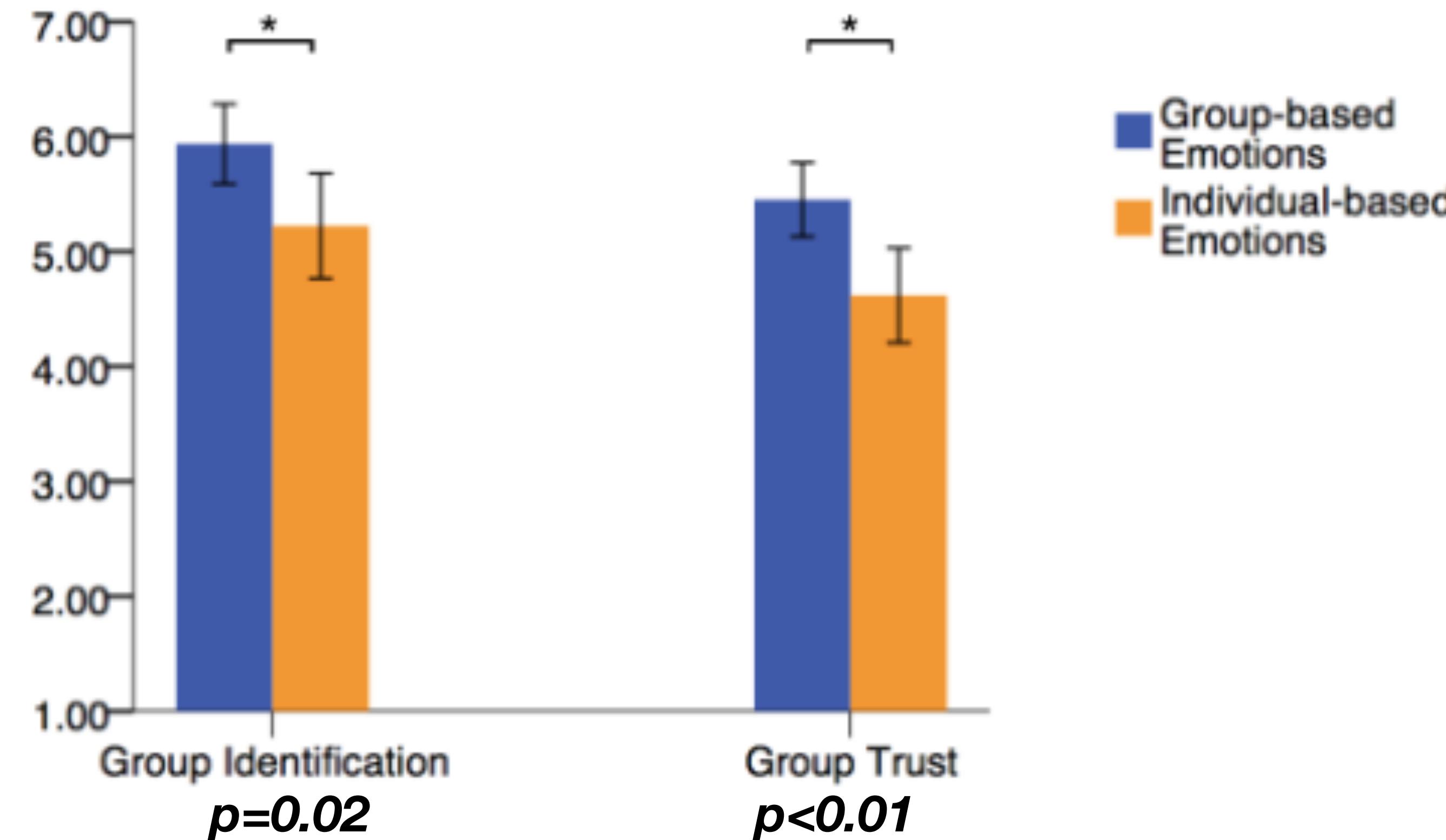
## Social attributes (Godspeed)



$p=0.07$     $p=0.79$     **$p<0.01$**     $p=0.80$

# Does the expression of group feelings increase people's cohesion?

## Group measures



C. W. Leach, M. Van Zomeren, S. Zebel, M. L. Vliek, S. F. Pennekamp, B. Doosje, J. W. Ouwerkerk, and R. Spears, "Group-level self-definition and self-investment: a hierarchical (multicomponent) model of in-group identification." *Journal of personality and social psychology*, vol. 95, no. 1, p. 144, 2008

K. Allen and R. Bergin, "Exploring trust, group satisfaction, and performance in geographically dispersed and co-located university technology commercialization teams," in *In Proceedings of the NCIIA 8th Annual Meeting: Education that Works*, 2004, pp. 18–20.

# Take-away Message

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Robotic teammates can express emotional cohesion through the group-based emotions and, it turn, foster collective cohesion.

# Conclusions

# Research Problem (Revisited)

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*How can we endow a robotic teammate with  
social capabilities to improve the cohesive alliance  
in a multi-party setting with humans?*

# Research Problem (Answered)

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*The cohesive alliance can be established and supported when the social capabilities of robotic teammates consider a “shared sense of unity with the group”.*

# Research Problem (Answered)

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*The cohesive alliance can be established and supported when the social capabilities of robotic teammates consider attractions (social), identification (collective), feelings (emotional), gaze communication (structural).*

# Contributions

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C1. Computational mechanisms to develop autonomous social behaviour for robotic teammates in multi-party settings

*How can we endow a robotic teammate with social capabilities to improve the cohesive alliance in a multi-party setting with humans?*

# Contributions

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C2. Evaluation of people's behaviours and perceptions towards a mixed human-robot group

*How can we endow a robotic teammate with social capabilities **to improve the cohesive alliance in a multi-party setting with humans?***

# Contributions

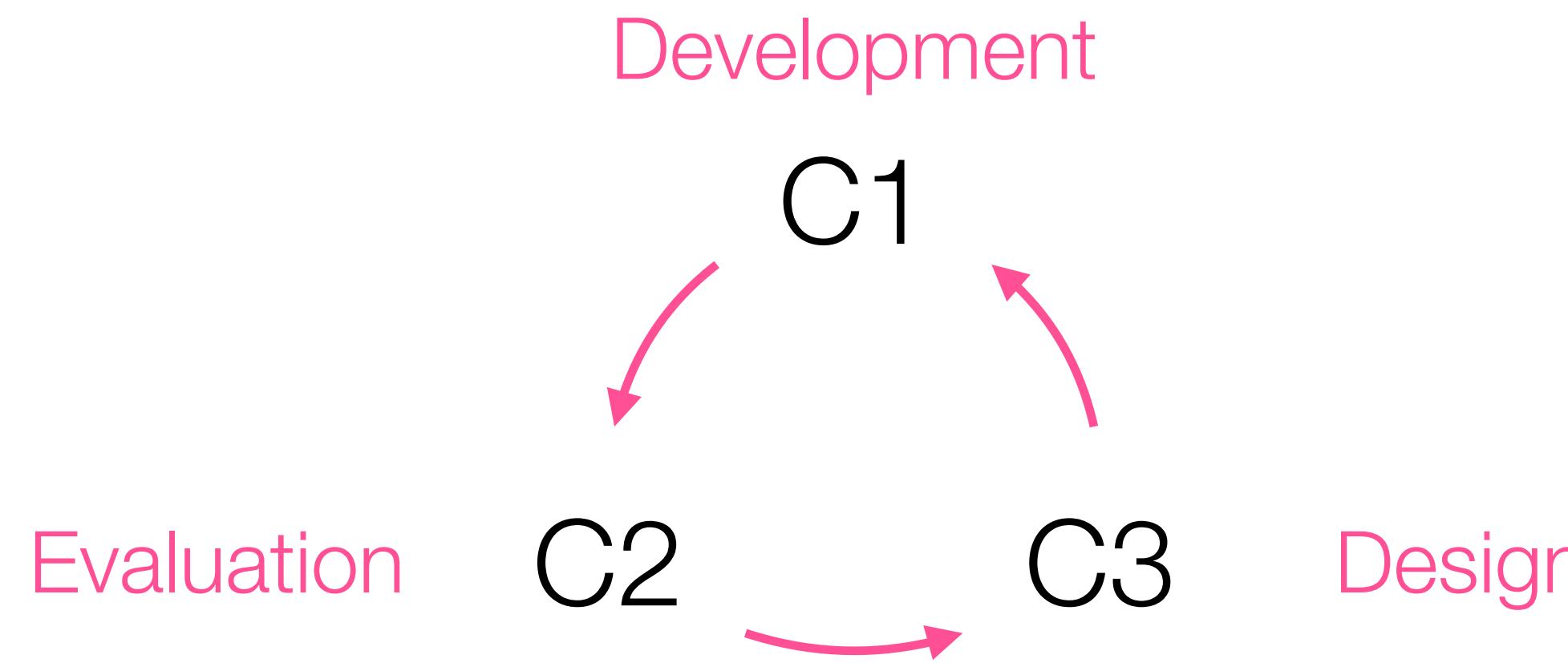
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C3. Understanding relevant group processes  
in mixed-groups of humans and robots

*How can we endow a robotic teammate with  
[which] social capabilities to improve the cohesive alliance  
in a multi-party setting with humans?*

# Contributions

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*How can we endow a robotic teammate with social capabilities to improve the cohesive alliance in a multi-party setting with humans?*

# Future directions for H-R Teamwork in Multi-party

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- *Different group sizes and human-robot configurations*
- *Different embodiments or anthropomorphic features*
- *Autonomous perception of group patterns*

Thank you!

Question?