Robotic Autonomy in Teamwork Settings

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Interactive Technologies Institute
LARSyS

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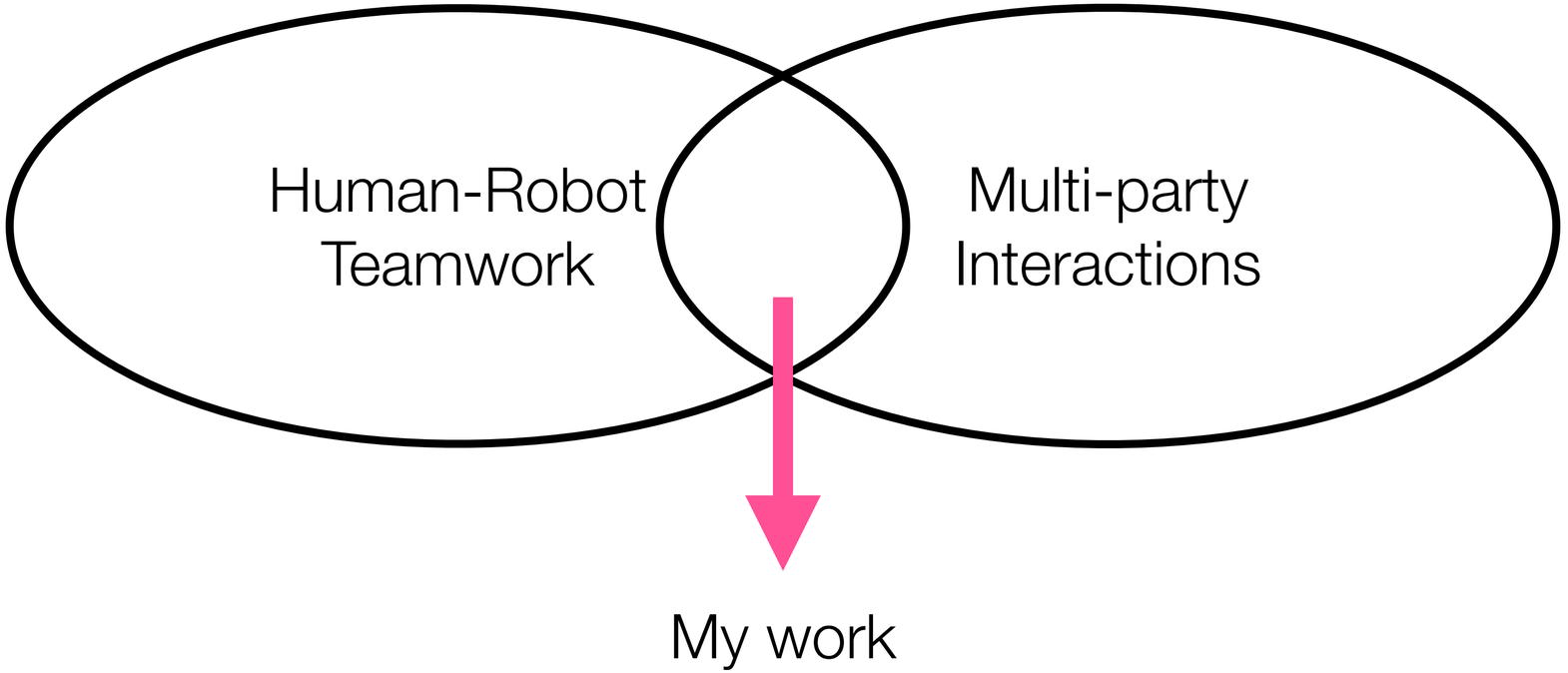
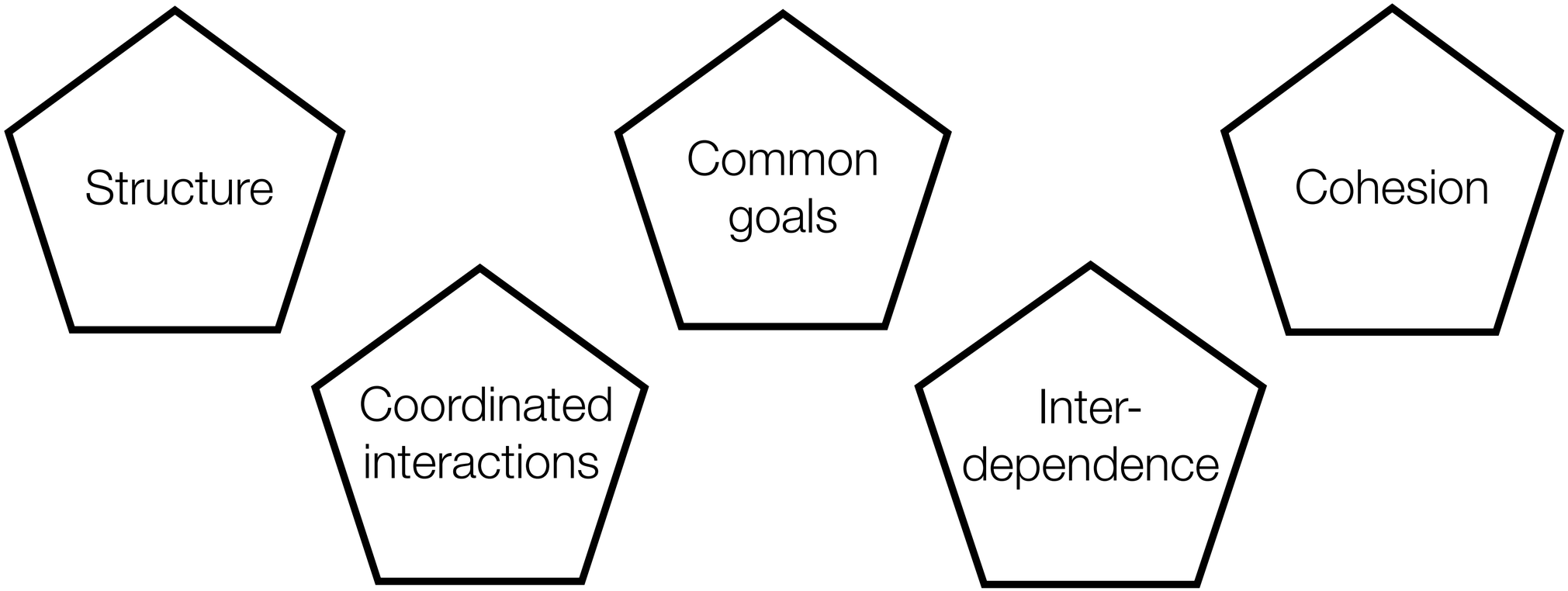
Motivation

Contributions



What is a Team?

"unified, cohesive group"



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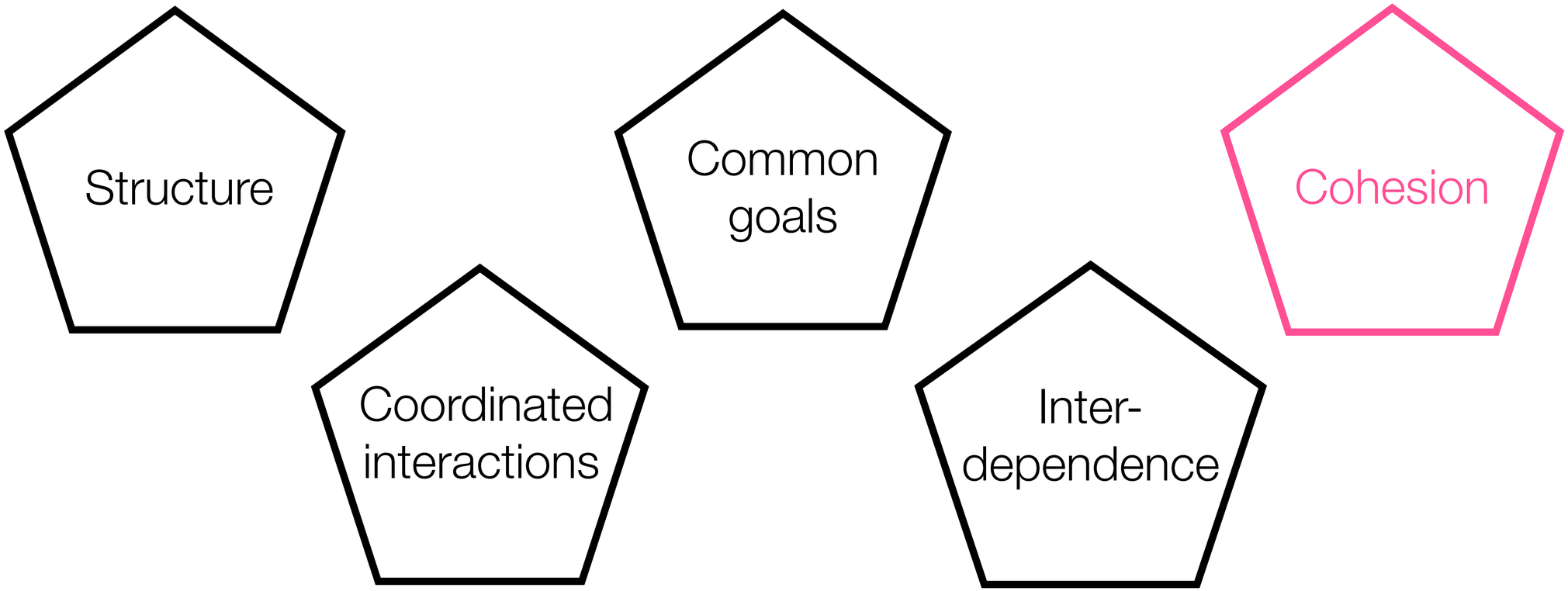

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What is Cohesion?

“a shared sense of unity by all group members”

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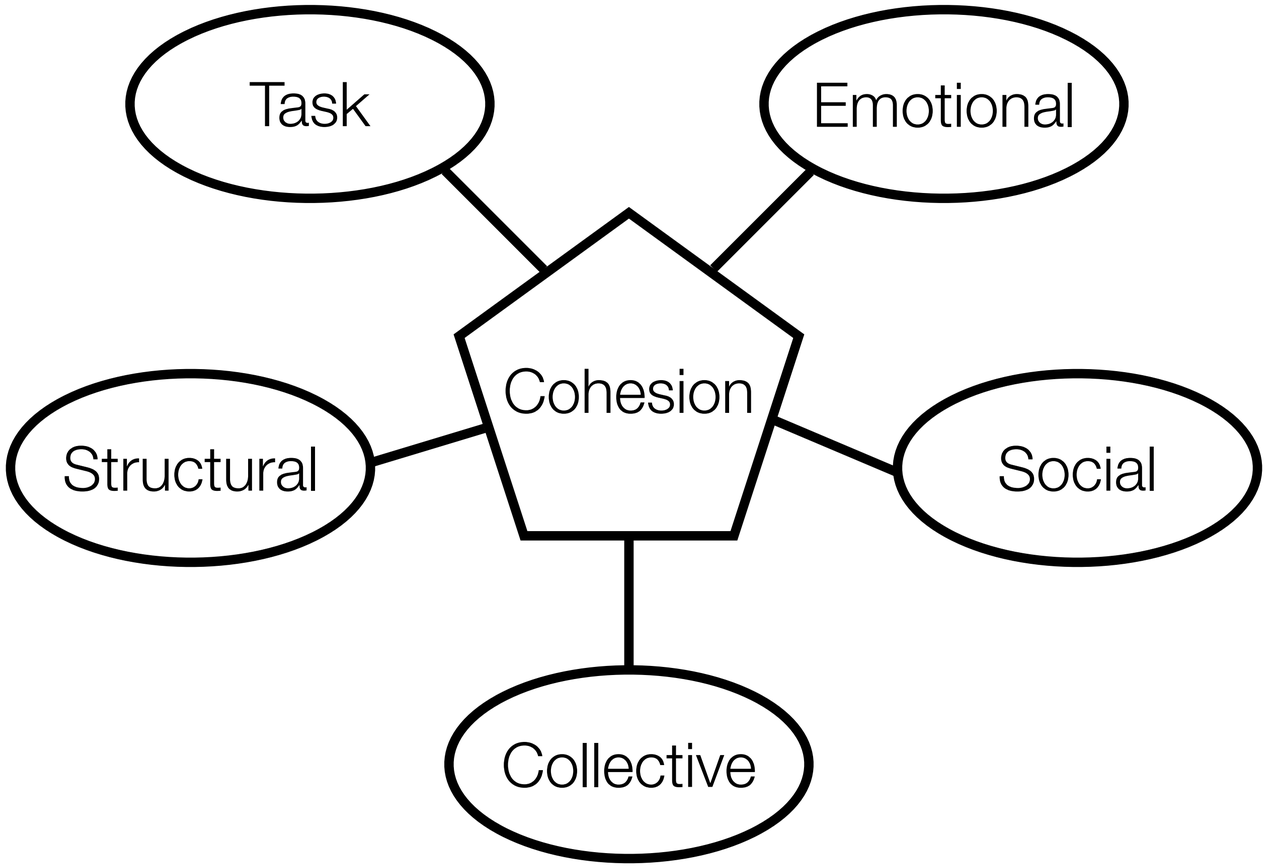

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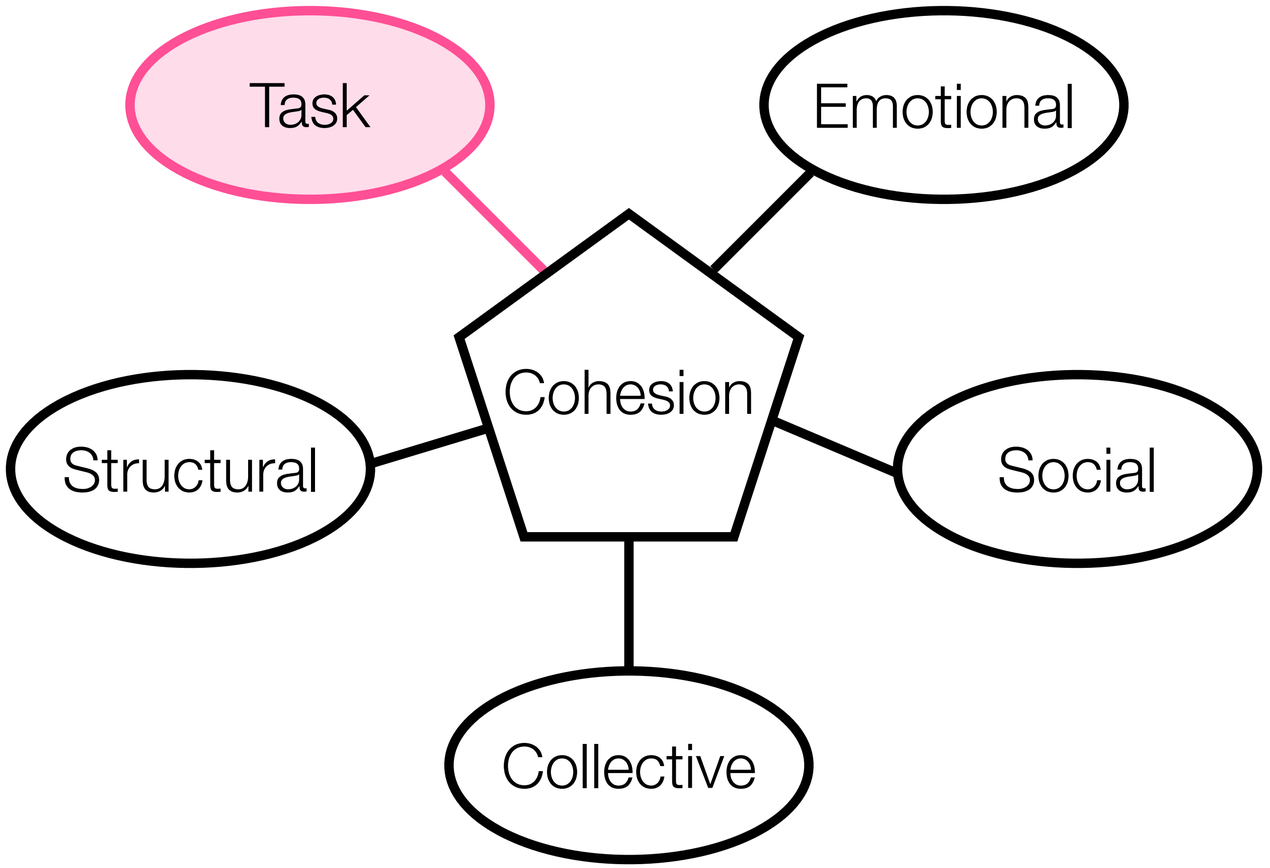
What is Task Cohesion?



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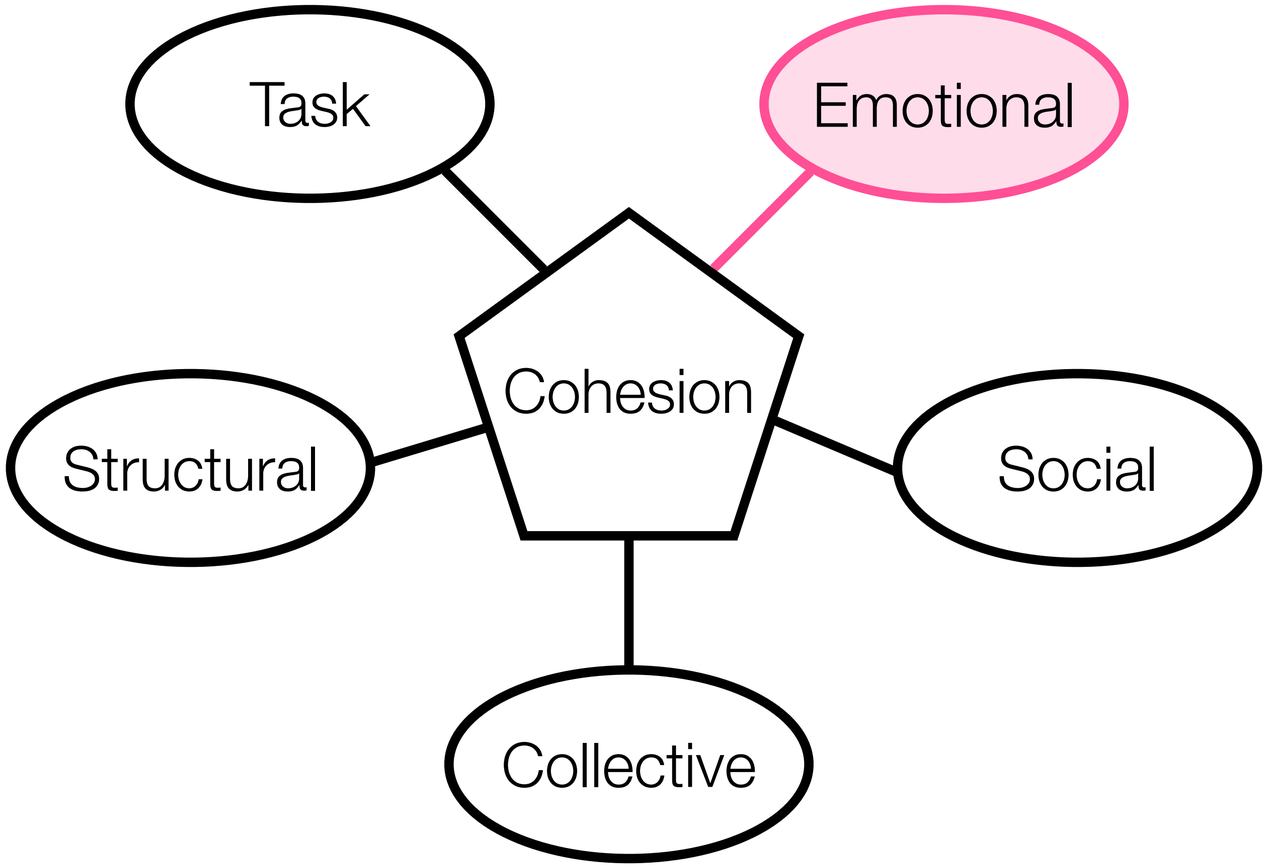
What is Emotional Cohesion?



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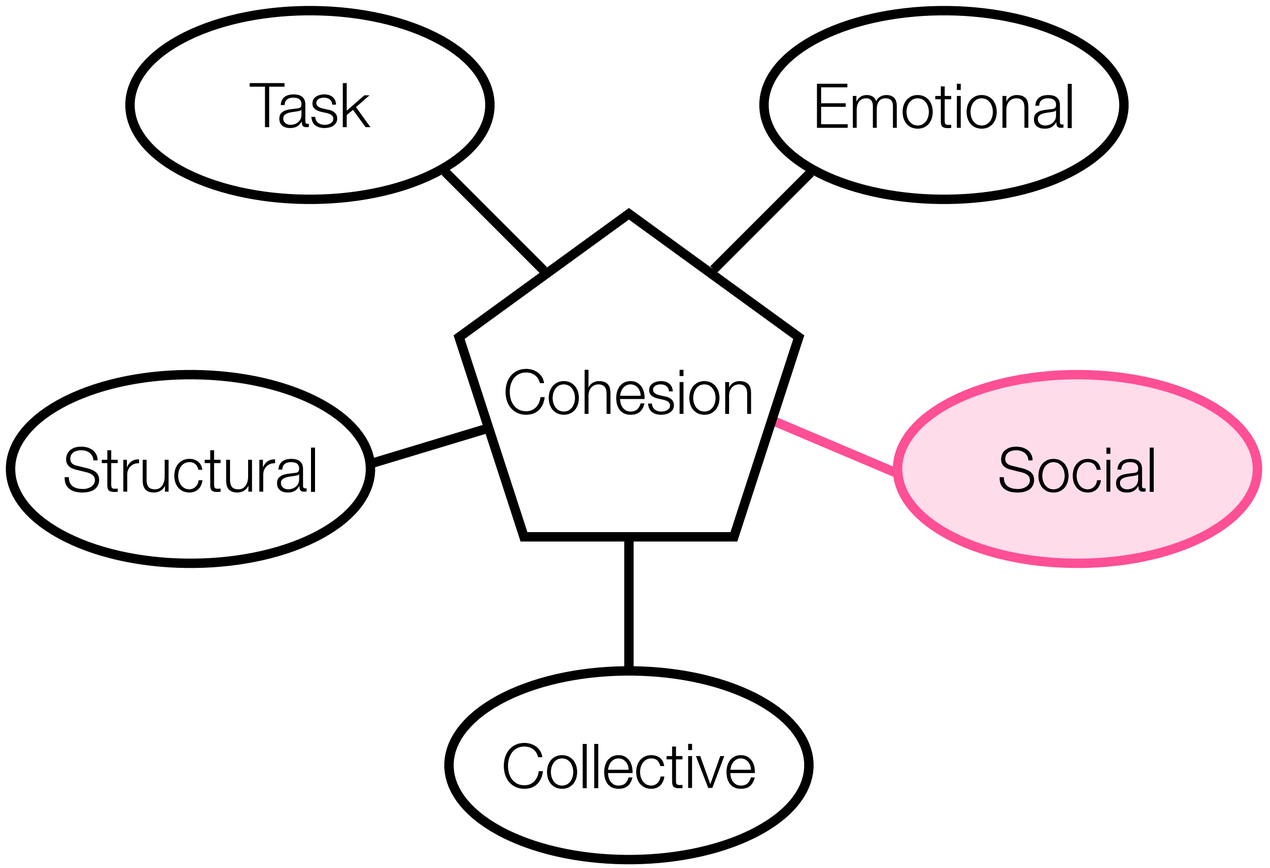

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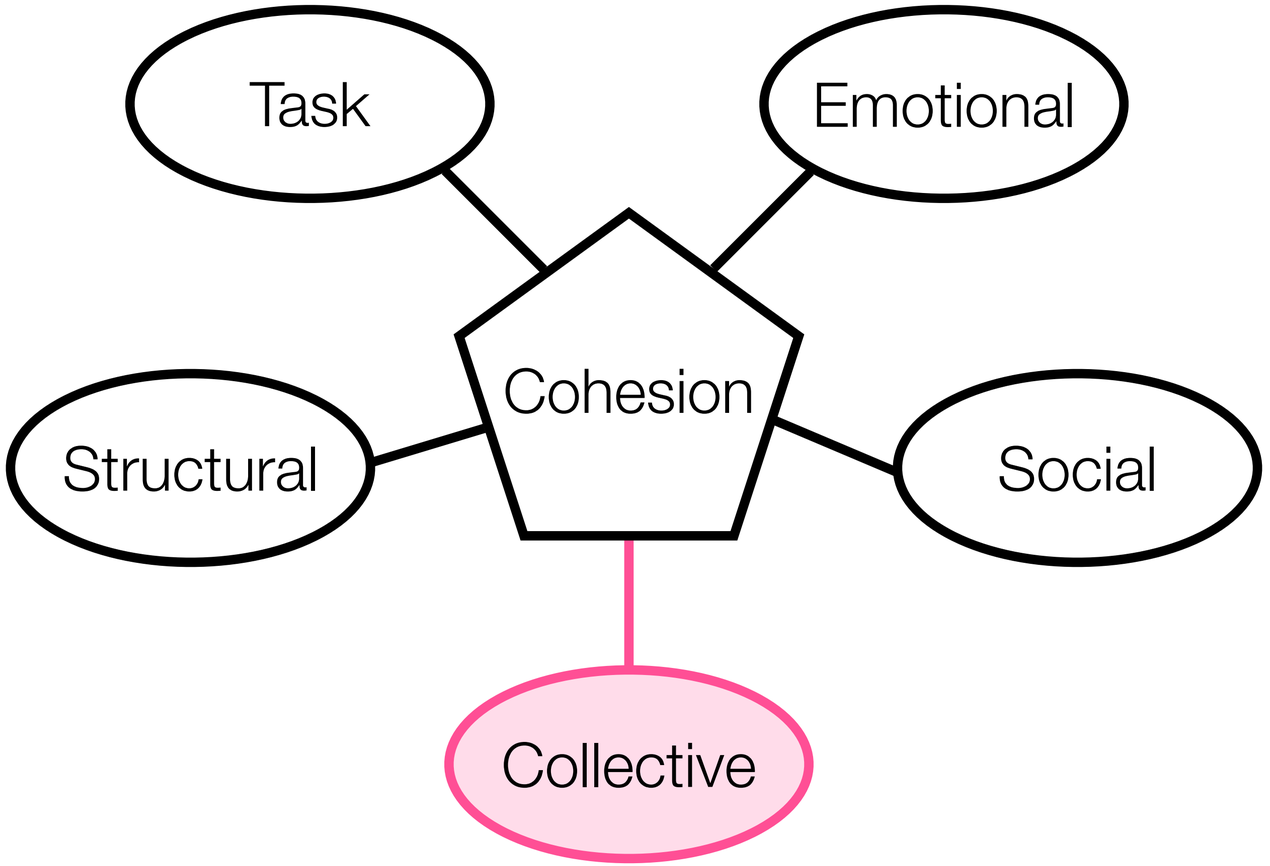

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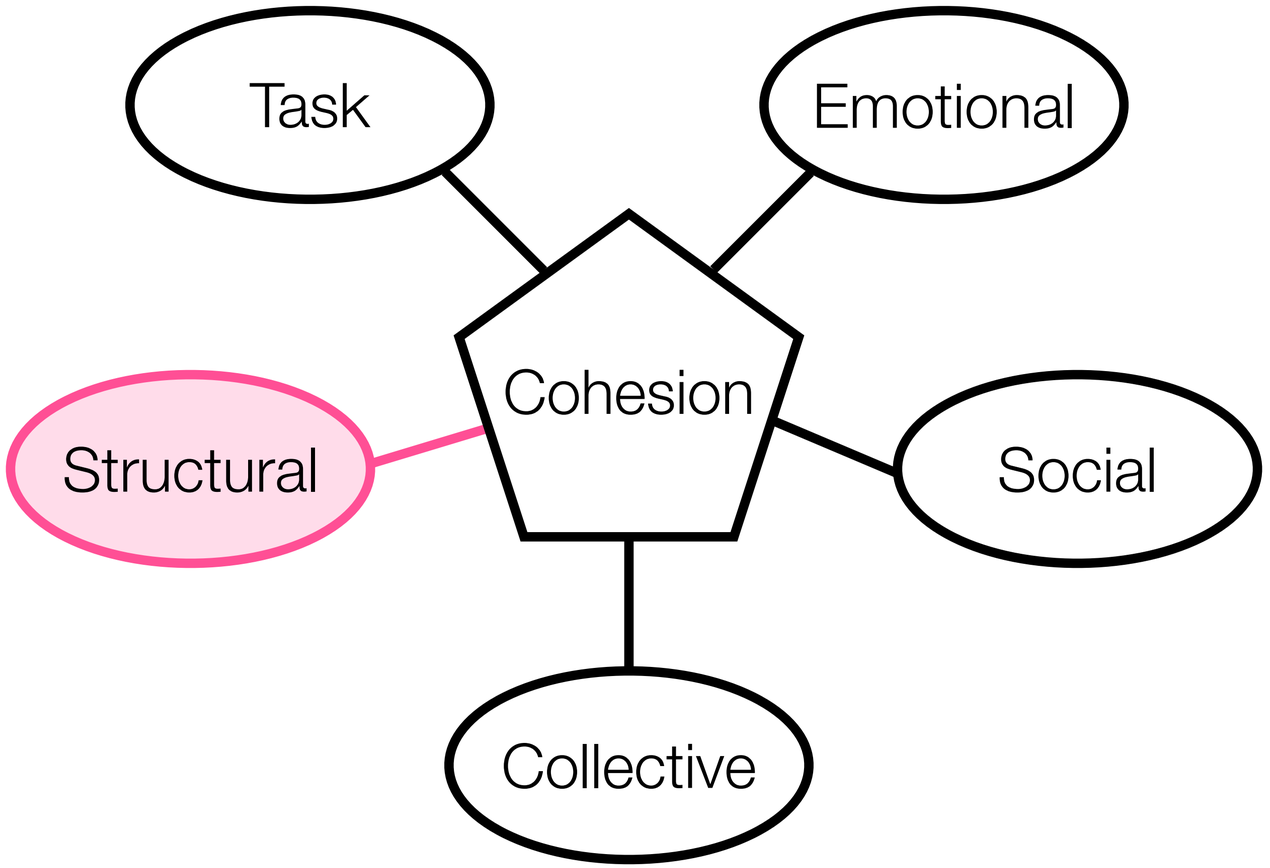
What is Structural Cohesion?



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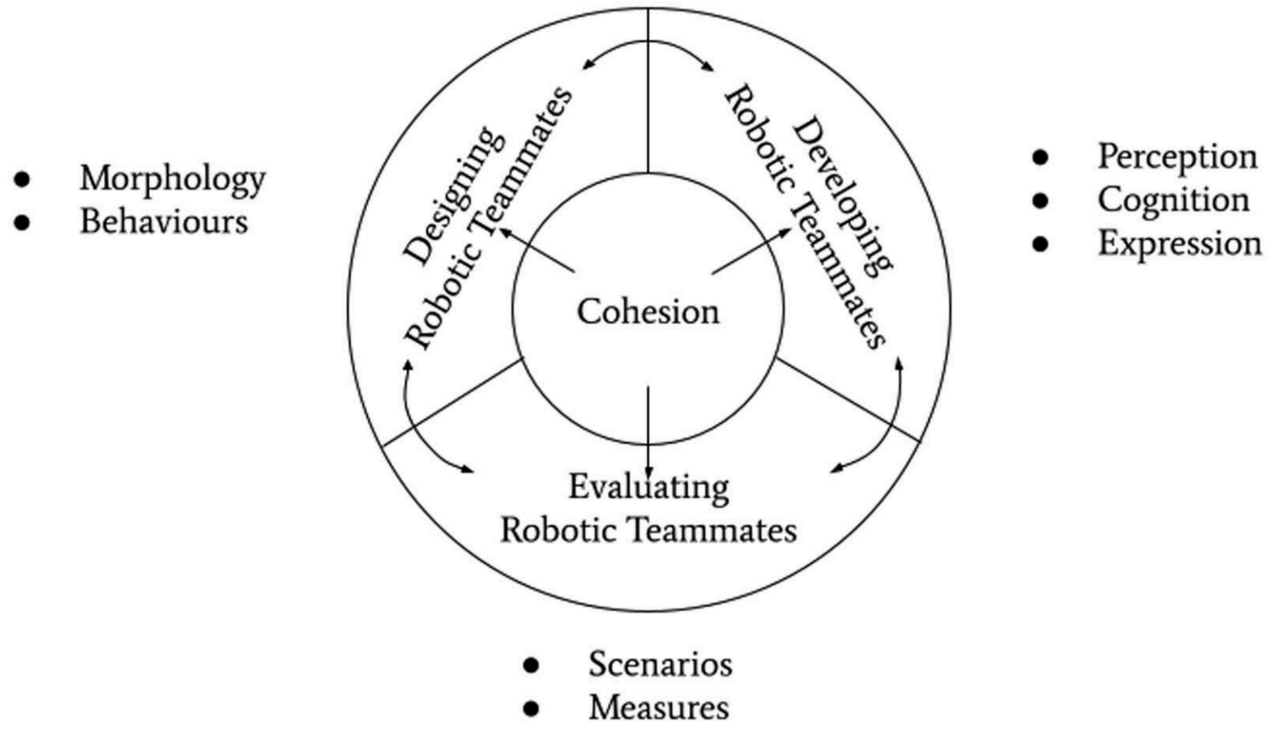
Cohesion as a Framework to create Robotic Teammates



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Cohesion as a Framework to create Robotic Teammates

Stage	Collective cohesion	Emotional cohesion	Social cohesion	Structural cohesion	Task cohesion
Designing robotic teammates	- Behaviors that portray belongingness to the team - Physical characteristics or accessories that signal belongingness	- Behaviors that express group feelings	- Behaviors that foster attraction between teammates	- Behaviors that acknowledge roles, norms, and relationships in the team	- Behaviors that comply and endorse the common goals
Developing robotic teammates	- Perceive social cues of association and dissociation on teammates - Interpret and reason about belongingness - Express association (and dissociation)	- Perceive emotional cues on teammates - Interpret and reason about group feelings - Express emotional cues	- Perceive liking and disliking cues on teammates Interpret and reason about membership preferences and rejections - Express liking (and disliking) cues	- Perceive social cues with structural information - Recognize and reason about roles, norms, and relationships - Express cues with structural information	- Perceive social cues related to the task accomplishment - Reason about individual and group goals in the task - Express social cues to endorse common goals or task accomplishment
Evaluating robotic teammates	- Measures of belongingness or identification	- Measures of group emotional state	- Measures of attraction or preferences	- Measures of roles (e.g., leadership)	- Measures of trust or fluency

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Gaze behaviours in Multi-party Settings

Project Goal & Research Questions

Structural Cohesion

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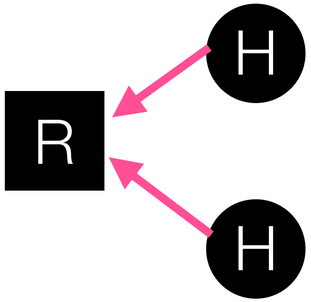
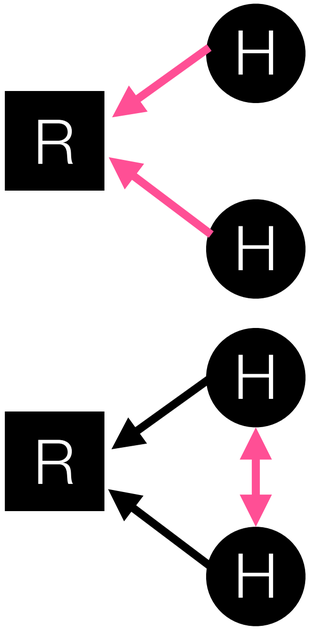
  - Should a robotic teammate perceive communicative acts only towards itself?



Project Goal & Research Questions

Structural Cohesion

- What is the degree of connectivity that a robotic teammate should consider in its perceptive skills?
  - Should a robotic teammate perceive communicative acts only towards itself?
  - Or should it also perceive communicative acts between other pairs of team members?



Project Goal & Research Questions

Structural Cohesion

- Is the gaze responsiveness of a robotic teammate able to enhance the perceived teamwork of its human-robot team?

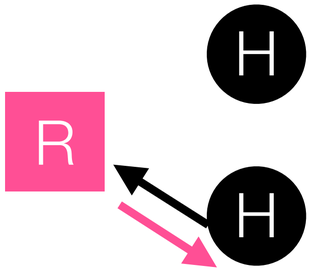
Gaze Behaviour in a Multi-party setting

Attentive Gaze

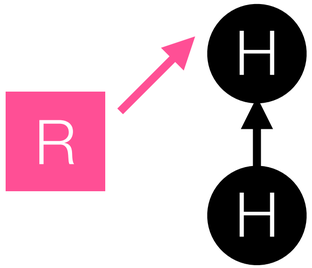
Responding Gaze

Gaze Behaviour in a Multi-party setting

Attentive Gaze



- If the teammate *X* looks at the *Robot*, the robot will return the gaze so that “eyes would meet” (attempt to establish *mutual gaze*).



- If the new gaze target of a teammate *X* is *Y* ≠ *Robot*, it gazes at target *Y* (attempt to establish *joint attention*).

Responding Gaze

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Responding Gaze

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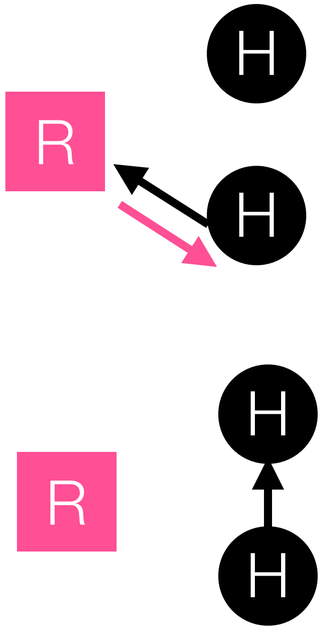
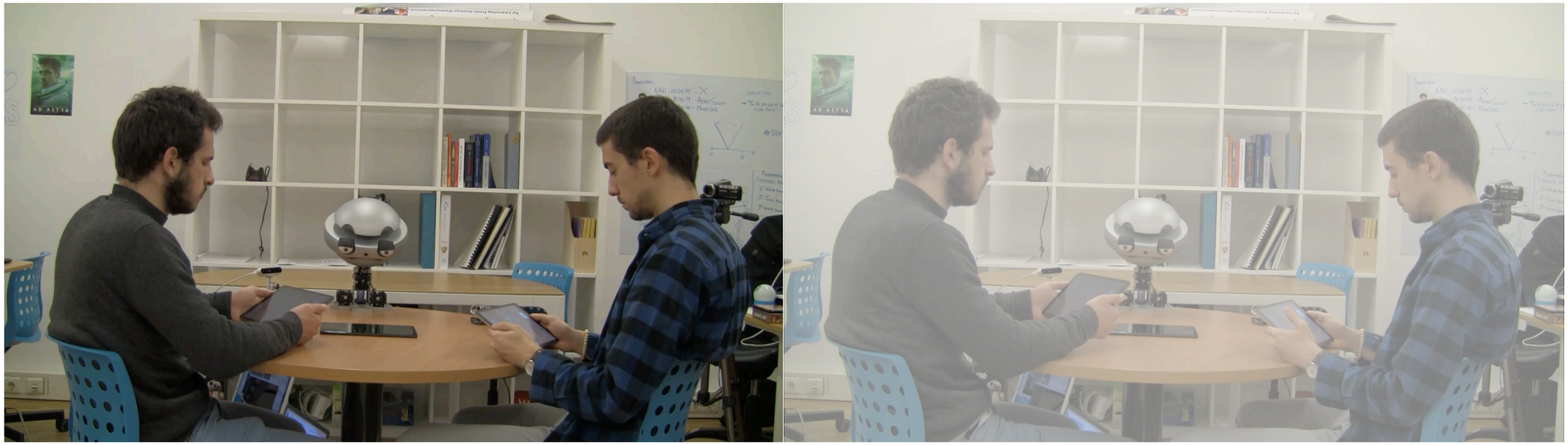
- If the new gaze target of a teammate *X* is *Y* ≠ *Robot*, it gazes back at target *Screen*.



Gaze Behaviour in a Multi-party setting

Attentive Gaze

Responding Gaze



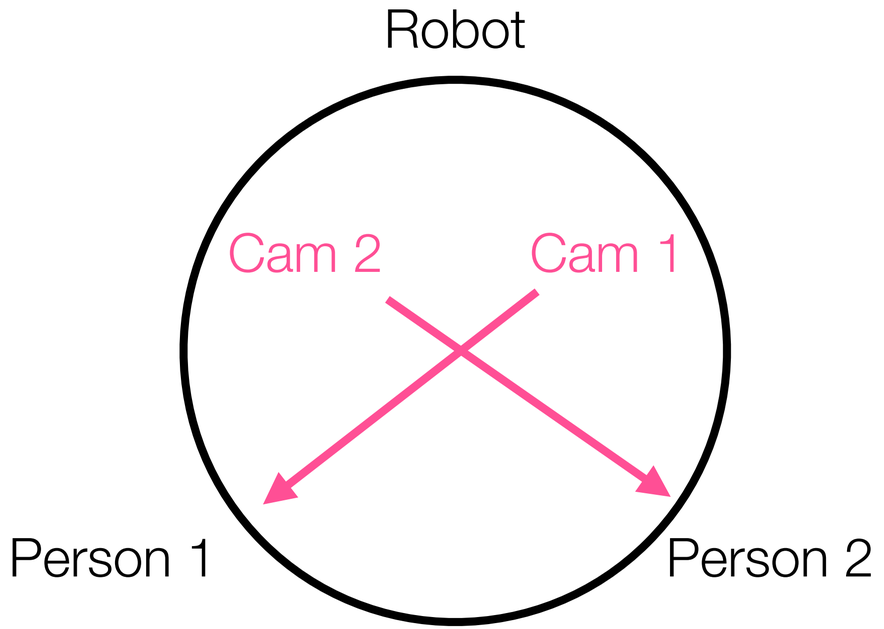
Gaze Behaviour in a Multi-party setting

Attentive Gaze

Responding Gaze

Development autonomous robot

- Reactive behaviour according to the heuristics
- Gaze detection (OpenFace)
  - Dedicated per person



Scripted interactions

- 10 scripted interactions for human behaviour

Video recordings with autonomous robot

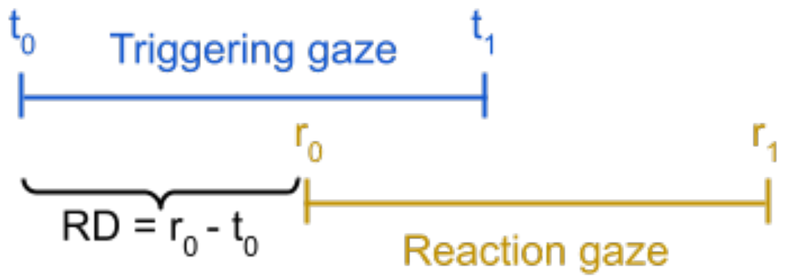
- 2 independent variables
  - Gaze responsiveness of the robot
  - Reaction Delay

Video recordings with autonomous robot

- 2 independent variables
  - **Gaze responsiveness of the robot**
    - Attentive Gaze
    - Responding Gaze
    - Control (no response)
  - Reaction Delay

Video recordings with autonomous robot

- 2 independent variables
  - Gaze responsiveness of the robot
  - **Reaction Delay**
    - Long Delay (~1.46 s)
    - Short Delay (~0.70 s)
    - Control (no delay)



Video recordings with autonomous robot

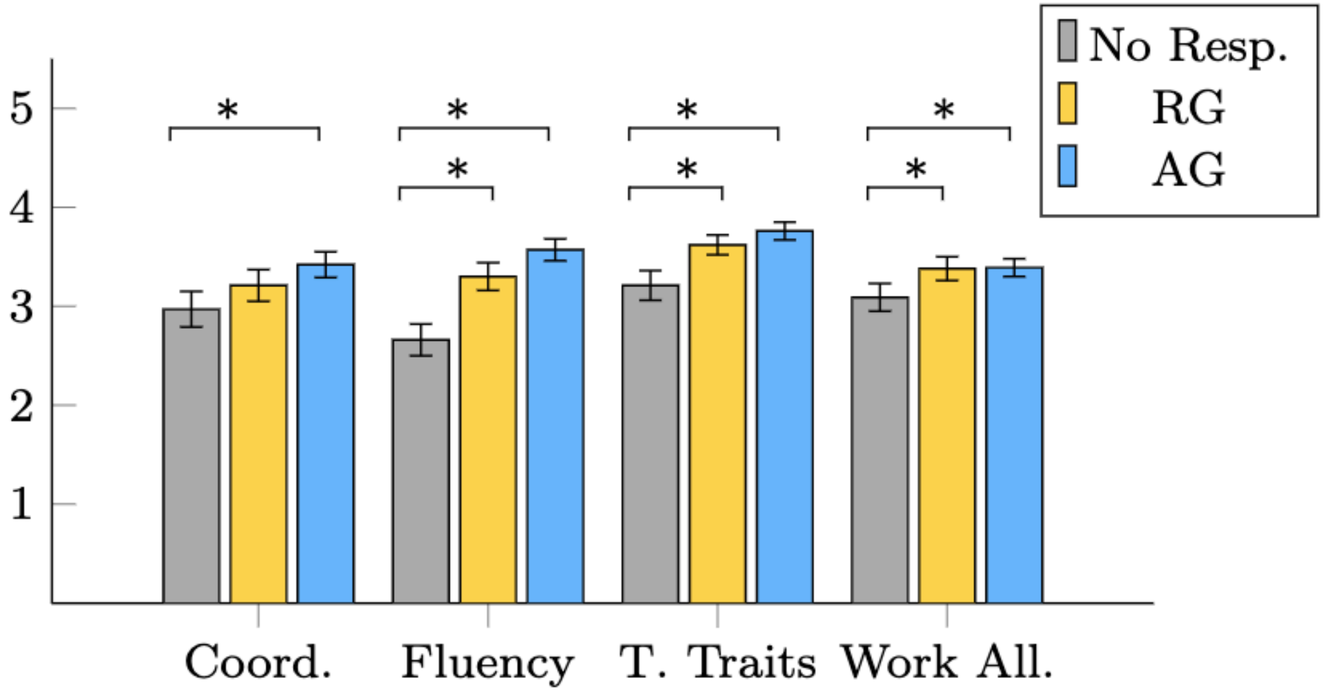
- 6 conditions:

Condition	Gaze Responsiveness	Reaction Delay
No Response	None	
RG+LD	Responding Gazes (RG)	Long Delay (LD)
RG+SD		Short Delay (SD)
AG+LD	Attentive Gazes (AG)	Long Delay (LD)
AG+SD		Short Delay (SD)
In Sync		No Delay

User Study

- Prolific third-person evaluation in a between-subjects design
- (6 x 10) 60 small videos [4-6] seconds
- 289 valid participants that rated 5 random videos each
- 1445 video evaluations
- Each video was rated by 24 people (avg.)

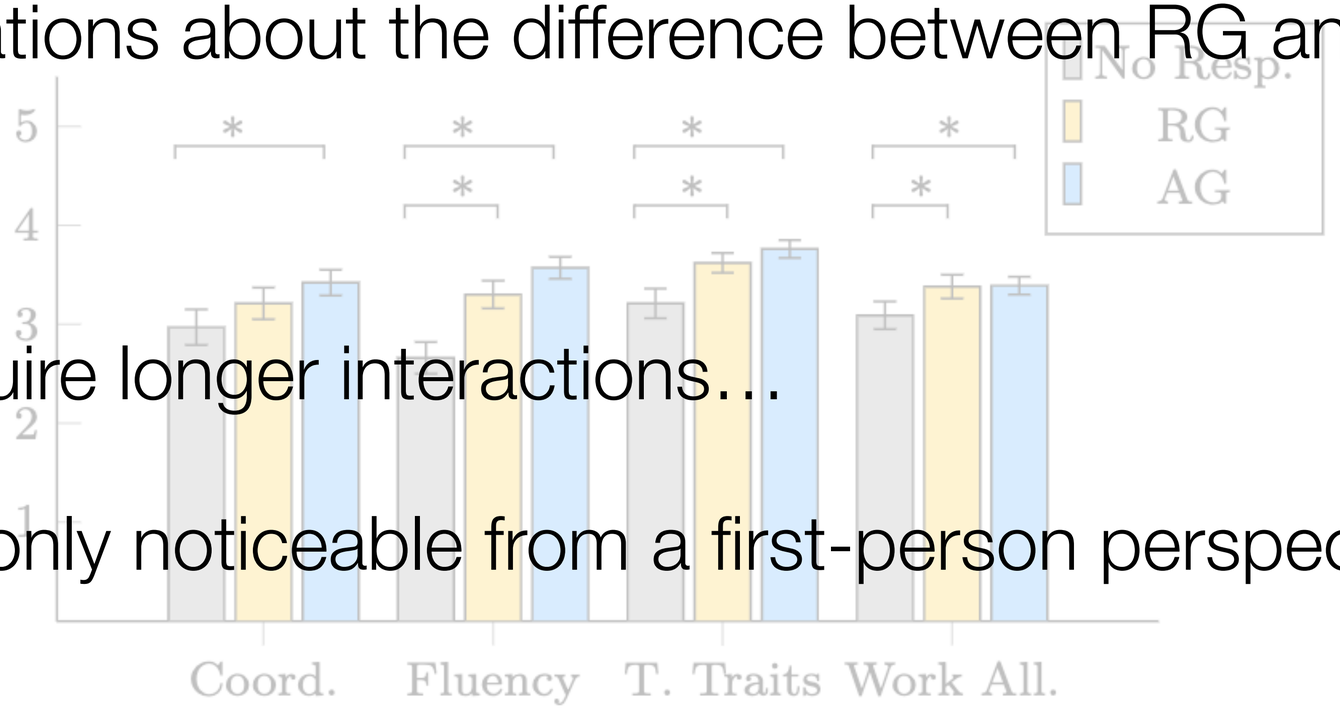
Does gaze responsiveness influence perceived teamwork?



Hoffman, Guy. "Evaluating fluency in human–robot collaboration." IEEE Transactions on Human-Machine Systems 49.3 (2019): 209-218.

Does gaze responsiveness influence perceived teamwork?

Our speculations about the difference between RG and AG:



- Might require longer interactions…
- Might be only noticeable from a first-person perspective

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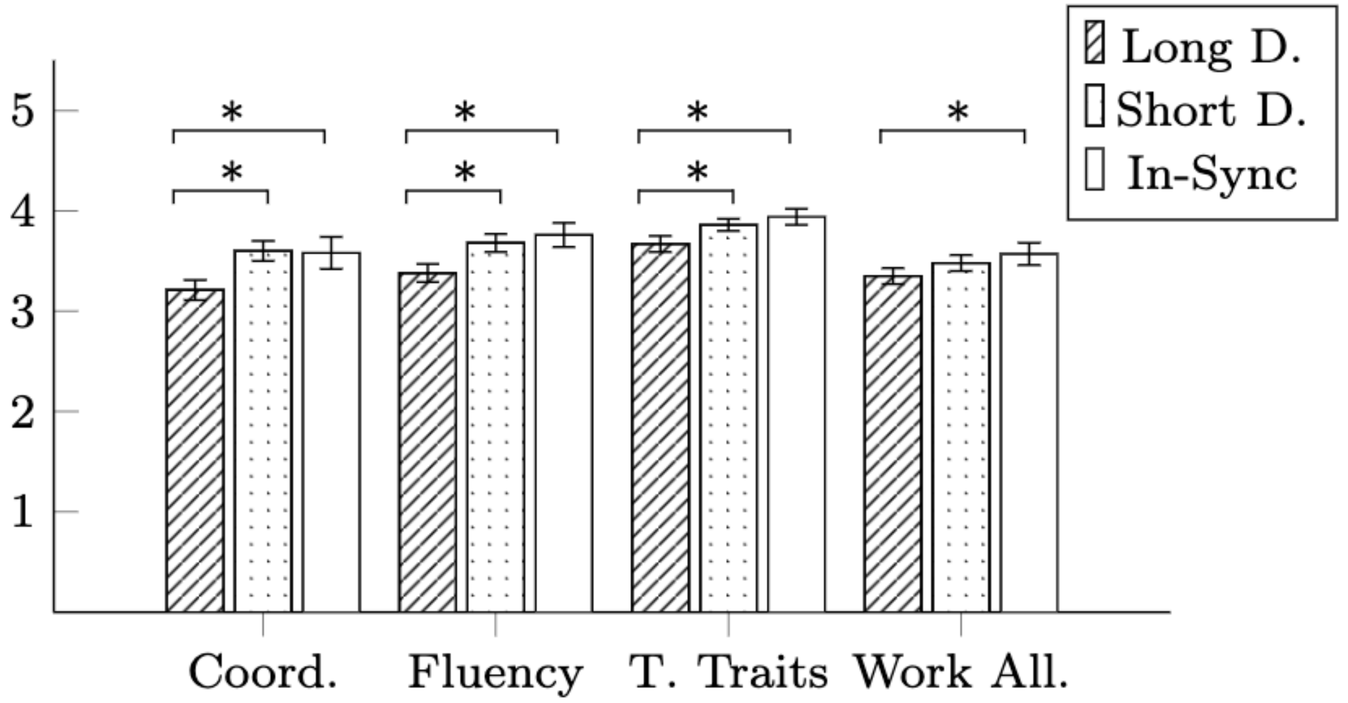
Does reaction delay influence perceived teamwork?



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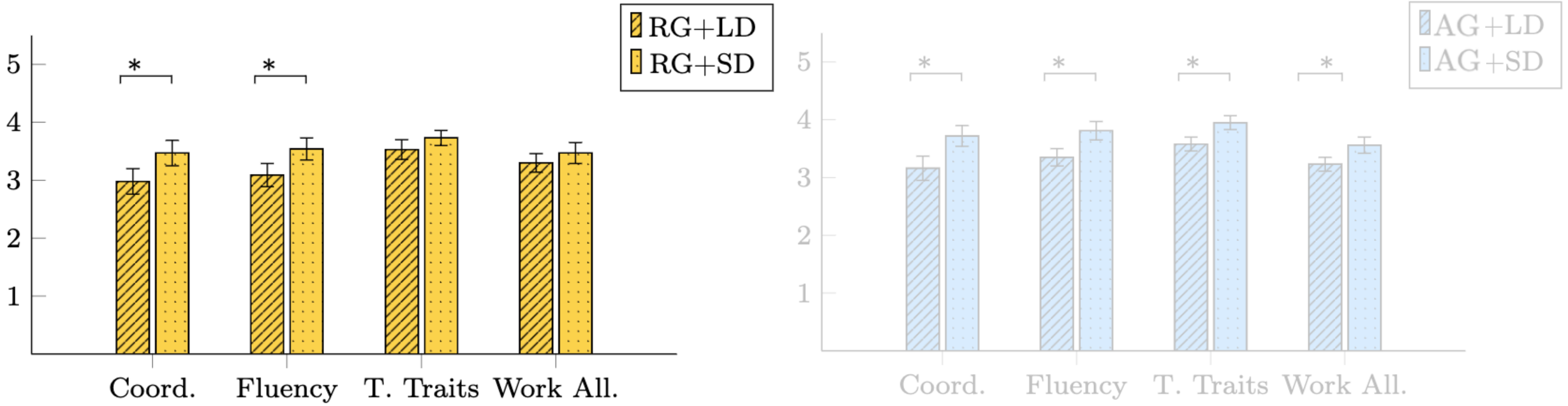
Can the reaction delay affect how each strategy of gaze responsiveness is perceived?



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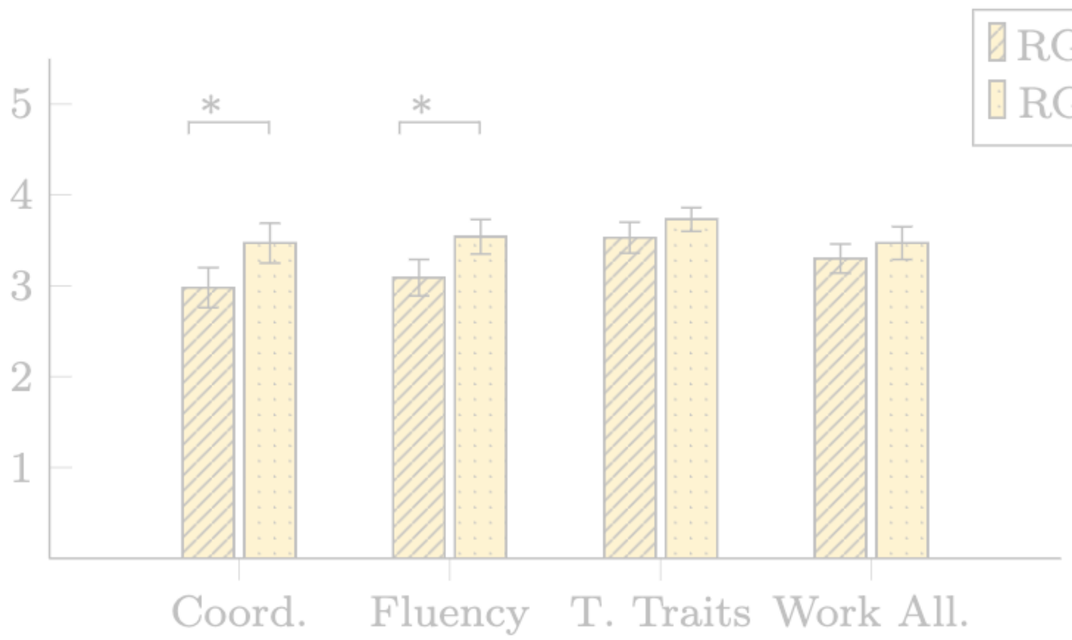
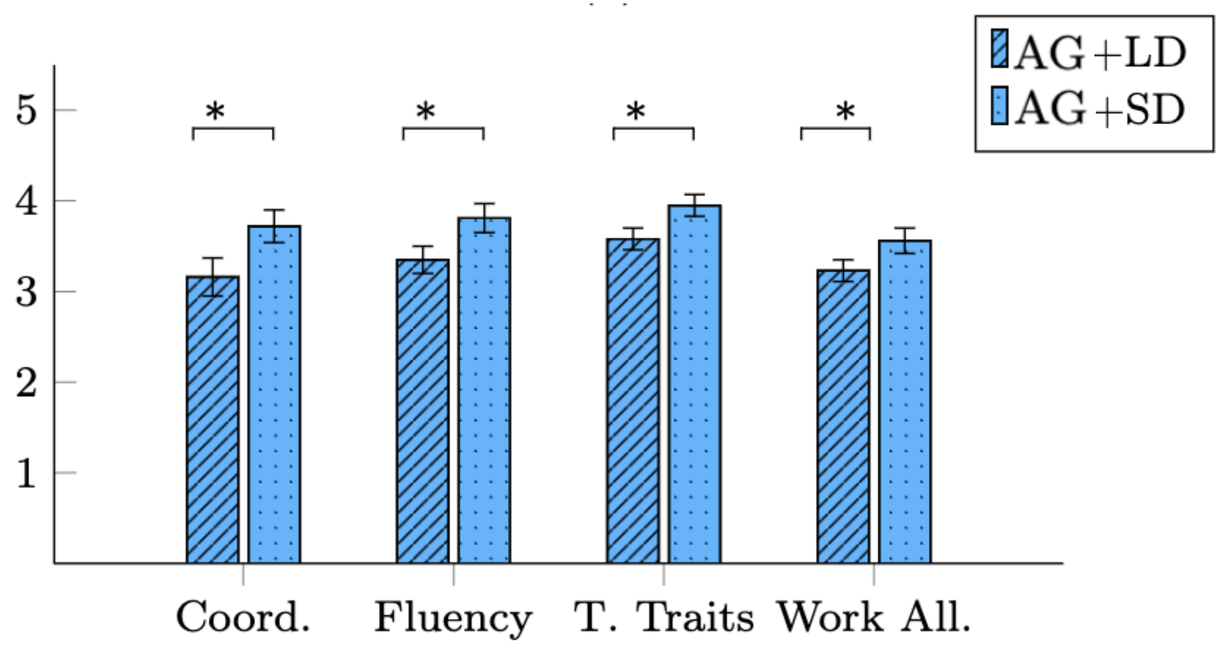




Take-away Message

In a multiparty setting, gaze responsiveness can positively affect the perception of teamwork.

When employing responsive strategies, considering the reaction delay is extremely relevant.

Correia, F., Campos, J., Melo, F. S., & Paiva, A. (2023). **Robotic Gaze Responsiveness in Multiparty Teamwork**. *International Journal of Social Robotics*, *15*(1), 27-36

Inclusive Conversations among Mixed-Visual Ability Children

Challenges in small group discussions

- Children with Visual Impairments (VI) are passive in small group discussions and uncomfortable to expose their ideas

Goal

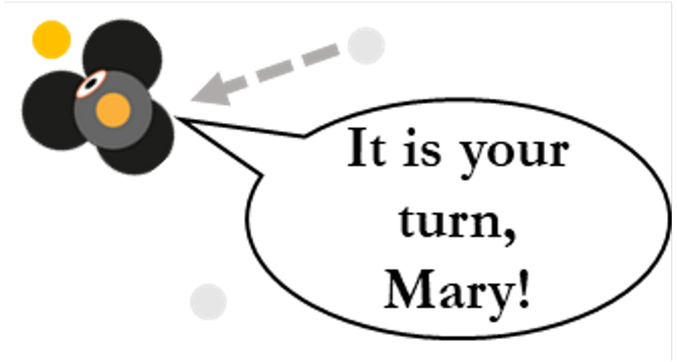
To foster **inclusion** in a meaningful **classroom activity** (i.e., small group conversations) in which children with and without visual impairment **share the same technology**

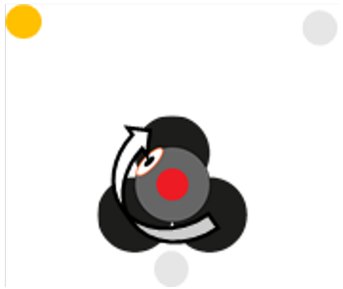
Inclusibo

- A mediator robot encourages group members to **contribute equally** to the conversation while **acknowledging individual** participation

Inclusibo

- **Encourage Behaviour**





- A mediator robot encourages group members to **contribute equally** to the conversation while **acknowledging individual** participation

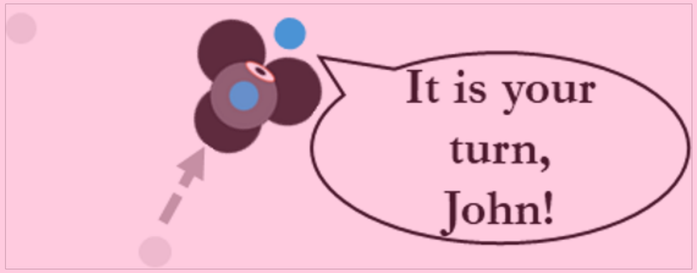
- **Gaze Behaviour**

Accessible Behaviours

- it encourages the least active members and values their contribution using **multisensory** feedback

Two Mediating Strategies

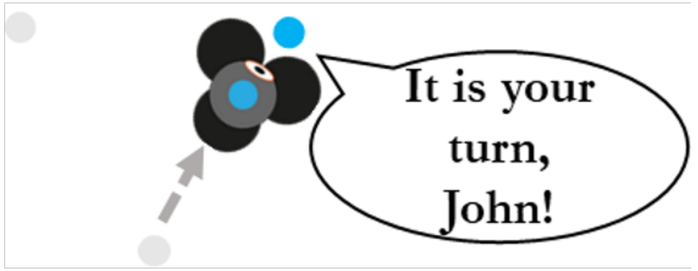
Directive Strategy



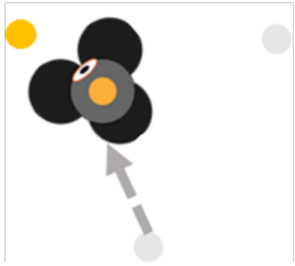
encourage (15s)

gaze the speaker

Organic Strategy



encourage (60s)



move closer to the speaker

Two Mediating Strategies

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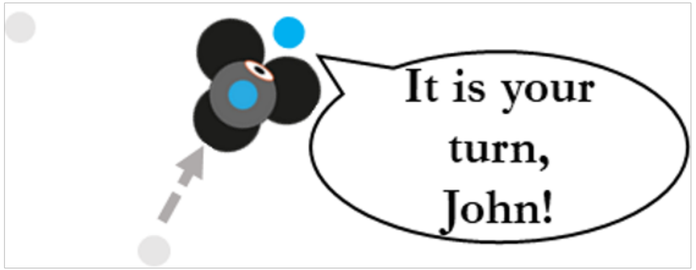

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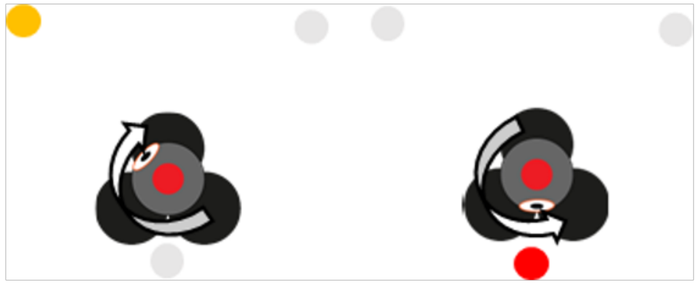

gaze the speaker

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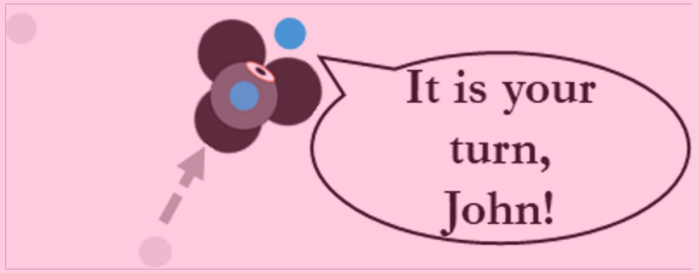


encourage (60s)

move closer to the speaker

User Study

- Decision-making activity (groups of 3)
- 78 children (26 with VI, 52 without VI)
- Age 6-14
- 3 conditions within-subjects:
    - Baseline
    - Organic
    - Directive

Research Questions

- What are the behavioural differences and similarities between VI and sighted children in a conversational task?
- Can a mediator robot foster inclusion in mixed-visual ability group conversations?
- How does a robot influence group dynamics in small-group conversations?

Measures

Individual

- accepting ideas
- speaking time
- generating ideas
- speaking turns
- engagement
- praise and being praised
- gaze the robot
- gaze the group

Group

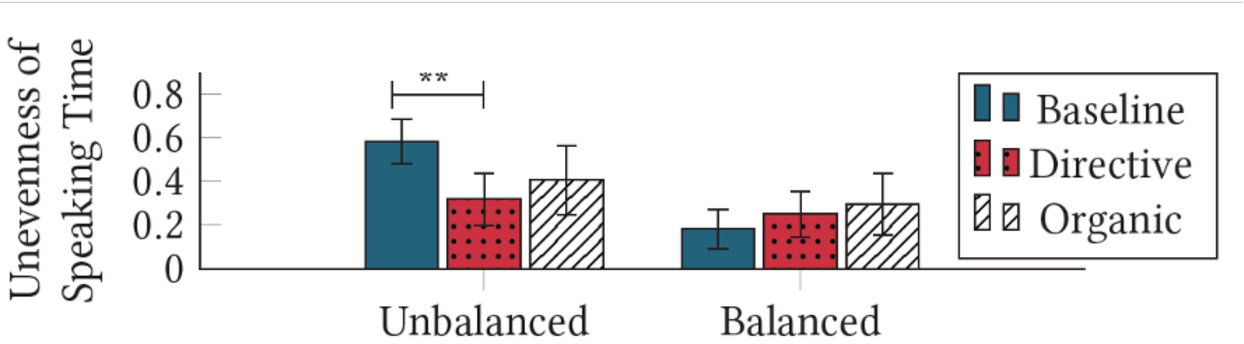
- accepting ideas
- speaking time
- performance time
- obedience

Subjective

- being heard
- robot related questions
- recall behaviours; perceived utility and fairness, preference
- inclusion-exclusion continuum
- give their opinion

Unevenness of Speaking Time

- unbalanced groups speaking time was significantly more even in **directive** condition



Children’s Perceptions of Inclusion

- Children perceive being more heard with **organic** mediating strategy

Take-away Message

The robot's actions using proximity and naming were crucial for an inclusive conversation.

Gazing differences depending on their visual ability.

Striking a balance between directive feedback and perceived inclusion goes beyond balancing participation.

Neto, I., Correia, F., Rocha, F., Piedade, P., Paiva, A., & Nicolau, H. (2023, March). **The Robot Made Us Hear Each Other: Fostering Inclusive Conversations among Mixed-Visual Ability Children**. In Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (pp. 13-23).




Thank you!



filipacorreia@tecnico.ulisboa.pt

Questions?