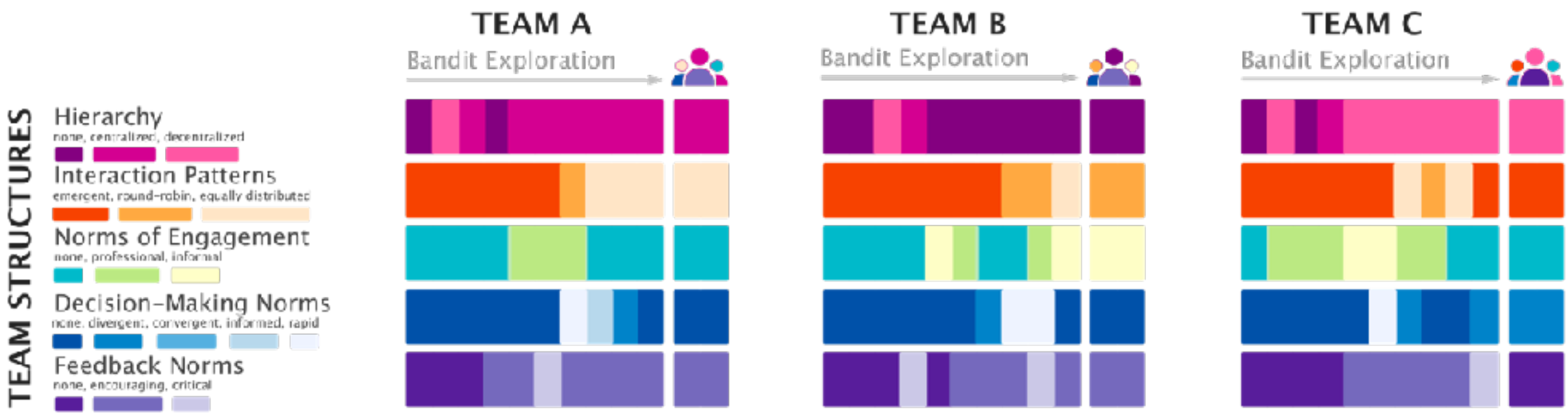
In Search of the Dream Team

Temporally Constrained Multi-Armed Bandits For Identifying Effective Team Structures



Sharon Zhou, Melissa Valentine, Michael Bernstein
Stanford University

What is the best way to organize teams?

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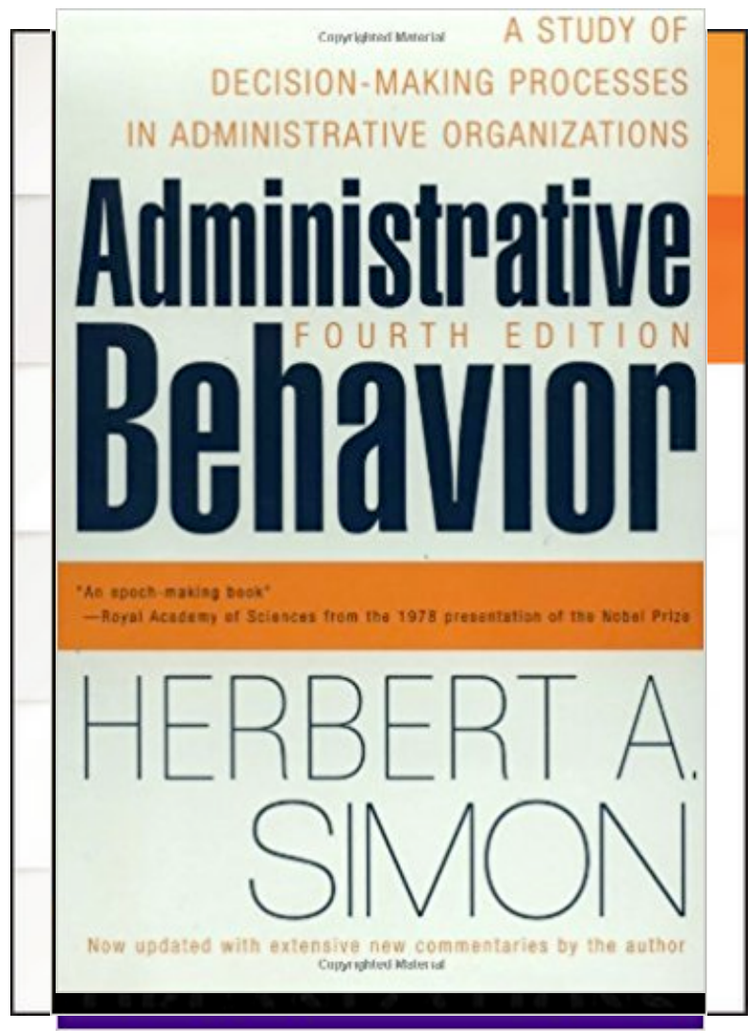
Rapidly try different strategies and converge on one



Rapidly try different strategies and converge on one

DreamTeam

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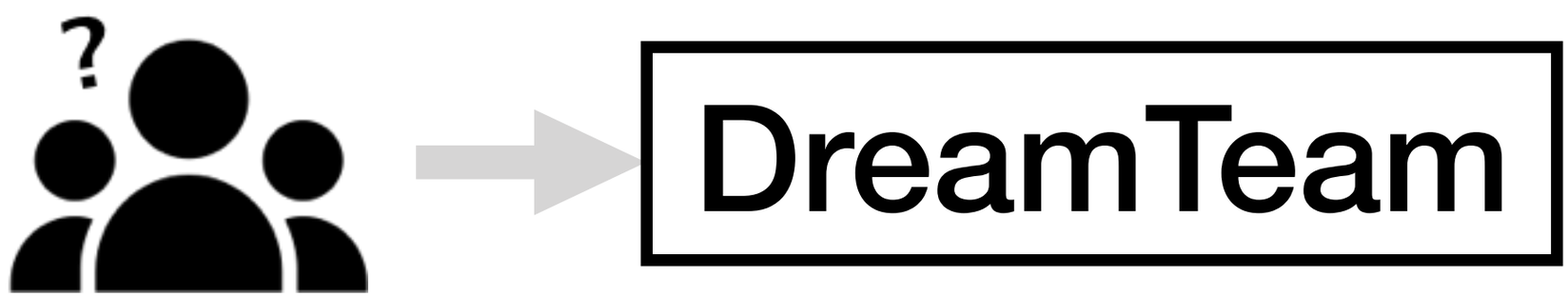

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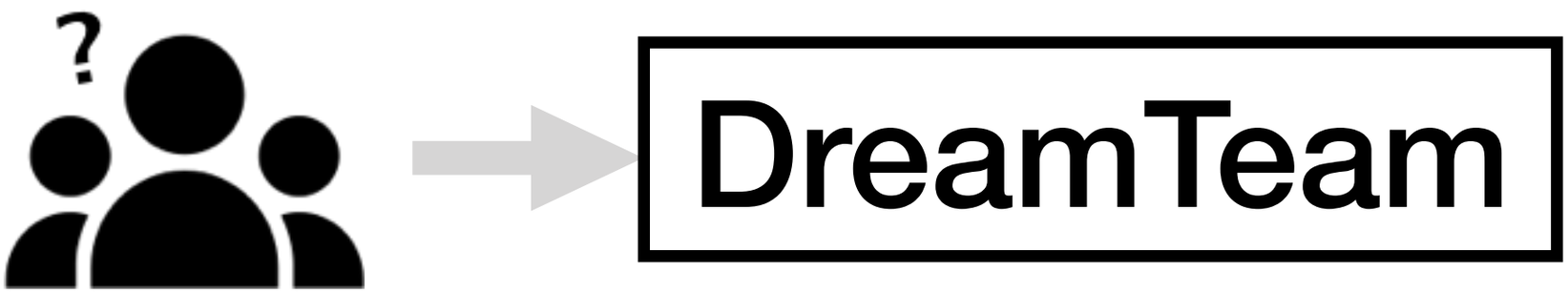

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DreamTeam

Rapidly try different strategies and converge on one

Rapidly try different strategies and converge on one

- There is no universally ideal way to structure all teams

Lawrence and Lorsch 1967
Donaldson 1999

Rapidly try different strategies and converge on one

- There is no universally ideal way to structure all teams

- It depends on the team members and their task

Lawrence and Lorsch 1967

Donaldson 1999

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- Novel algorithm to avoid overwhelming teams with deluge of different strategies

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- Our system, DreamTeam, outperformed manager-led and self-managed teams by over 40% on performance

Design

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Roles, norms, and interaction patterns that define how we collaborate are called *team structures*

Ilgen 2005

There are no universally ideal team structures

Lawrence and Lorsch 1967
Donaldson 1999

There are no universally ideal team structures

- Structural contingency theory

Lawrence and Lorsch 1967
Donaldson 1999

There are no universally ideal team structures

- Structural contingency theory
- Effective team structures depend on the members and their task

Lawrence and Lorsch 1967

Donaldson 1999

There are no universally ideal team structures

- Structural contingency theory
- Effective team structures depend on the members and their task
- Wrong structures lead to dysfunctional teams

Ilgen et al. 2005
Schippers et al. 2014
Ancona et al. 2001
Arrow 1997

Hierarchy

None, Centralized, Decentralized

Interaction Patterns

Emergent, Round-robin, Equally distributed

Norms of Engagement

None, Professional, Informal

Decision-Making Norms

None, Divergent, Convergent, Informed, Rapid

Feedback Norms

None, Encouraging, Critical

One configuration of team structures

Hierarchy

Centralized

Interaction Patterns

Equally distributed

Norms of Engagement

Professional

Decision-Making Norms

Convergent

Feedback Norms

Encouraging

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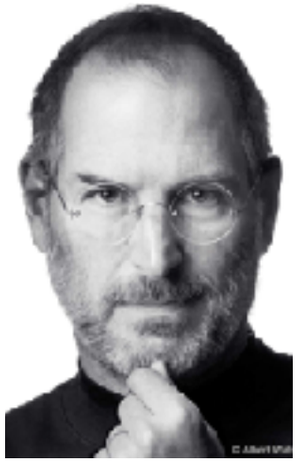

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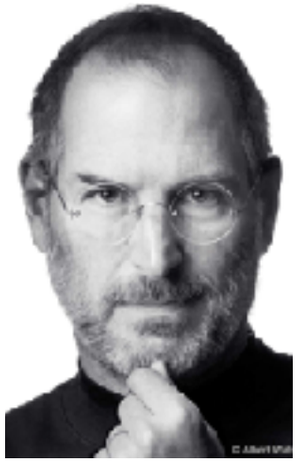
Hierarchy

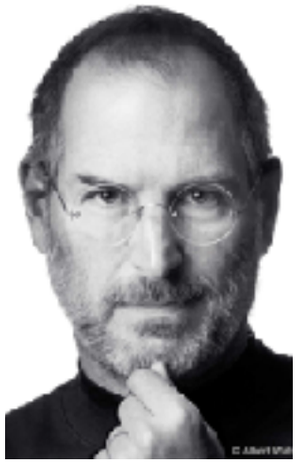


Centralized

Decentralized

Zappos.com

Hierarchy



Centralized

Decentralized

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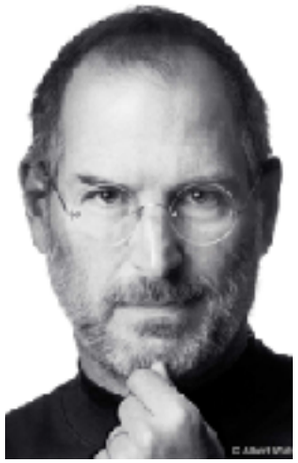
Norms of Engagement

GE

Professional

Hierarchy



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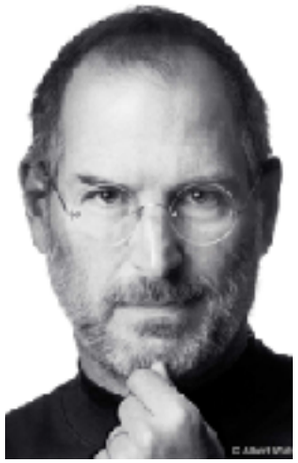

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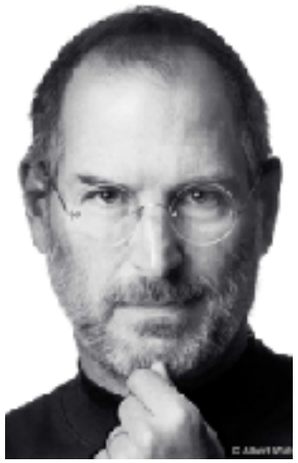
TRADER JOE'S

Encouraging

Hierarchy



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Goldman Sachs

DreamTeam

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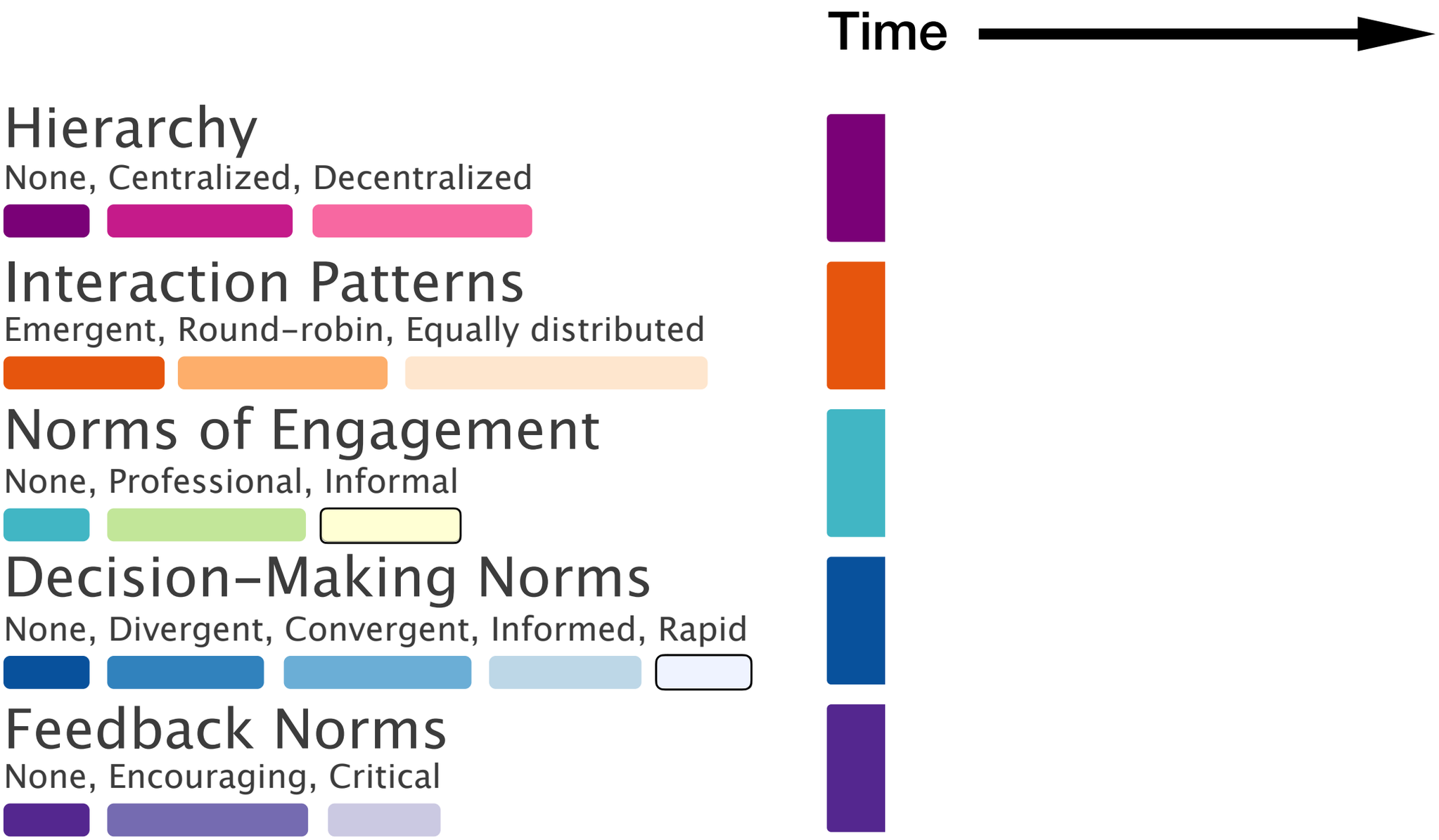
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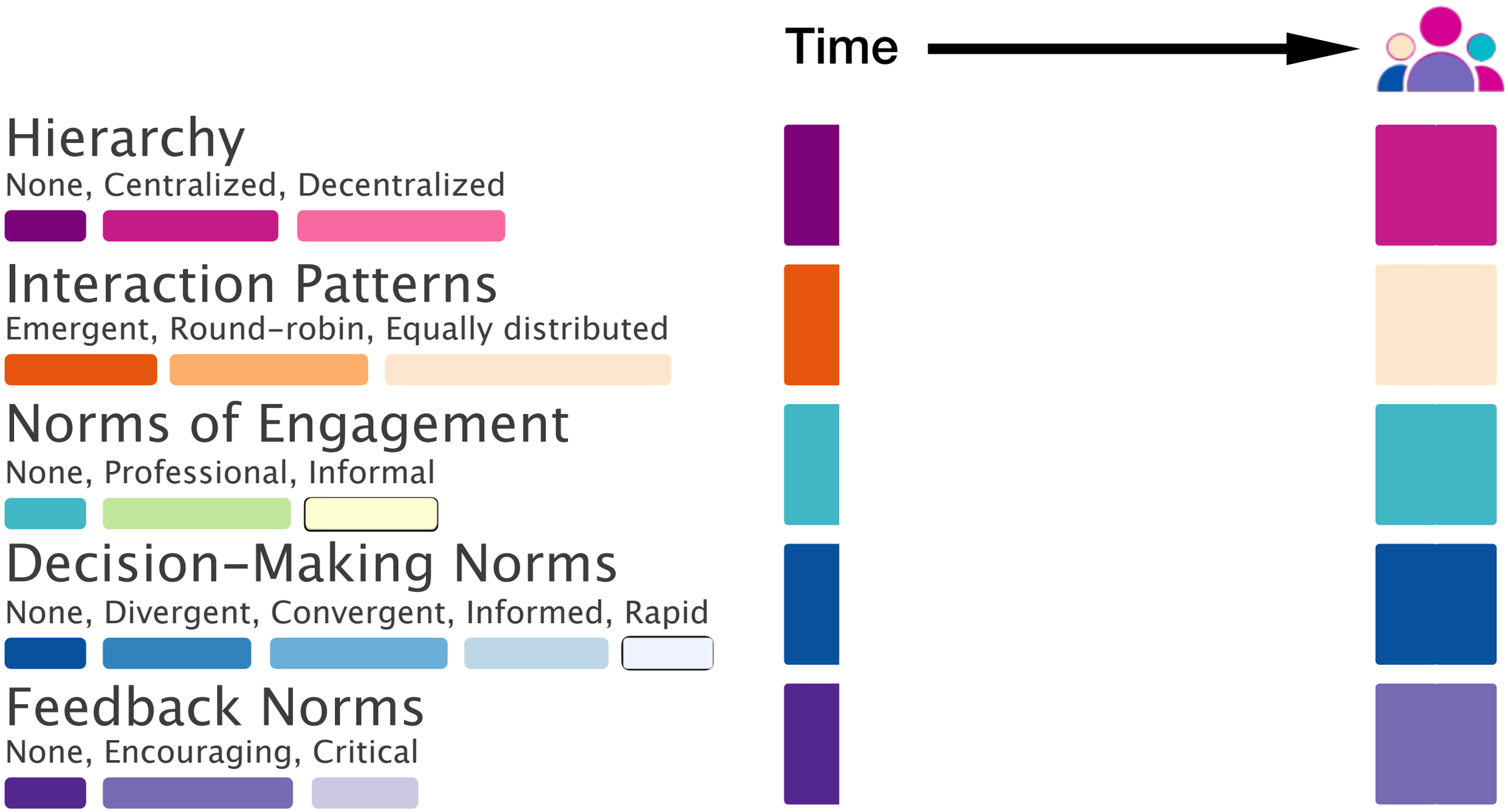
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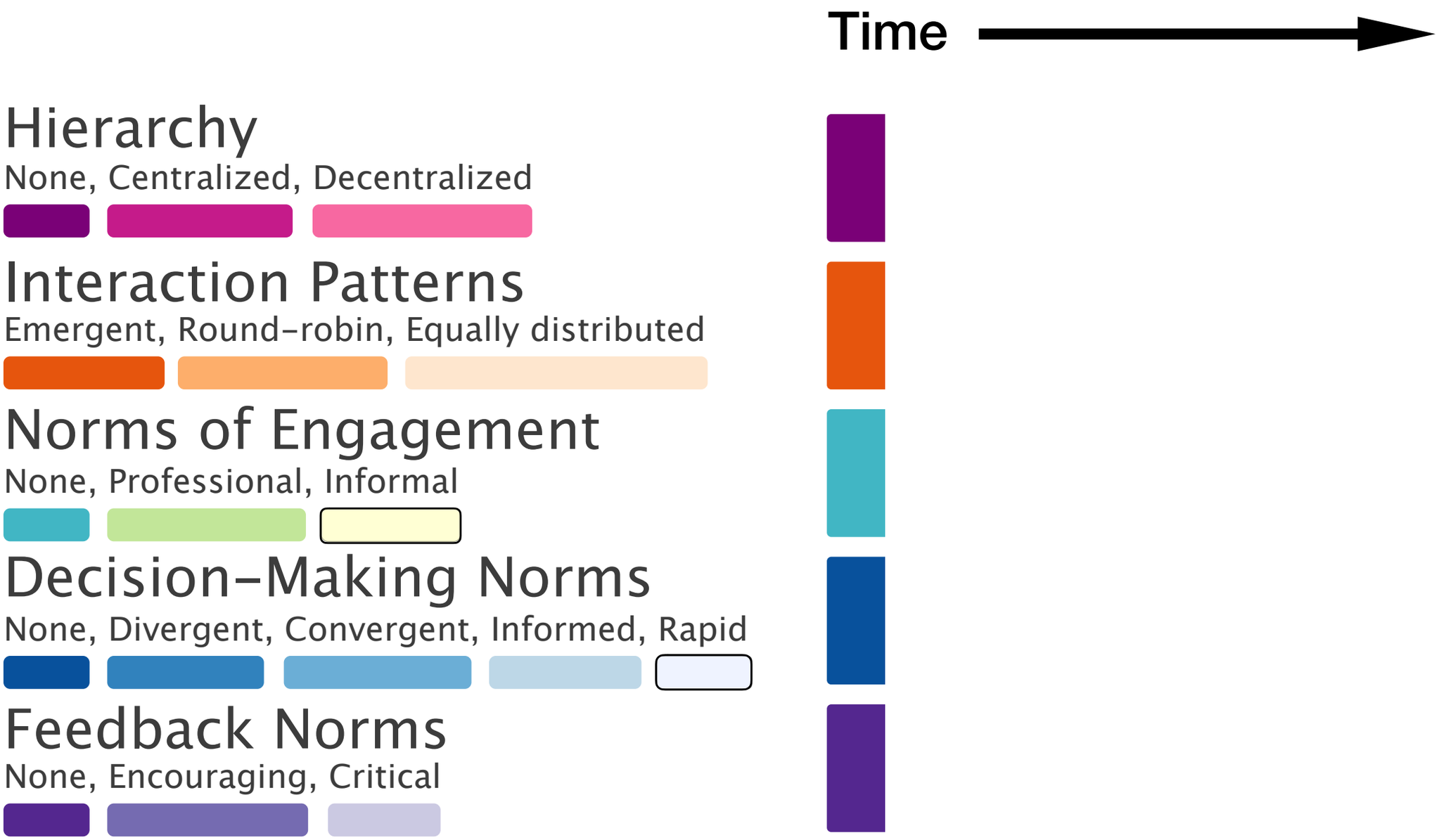
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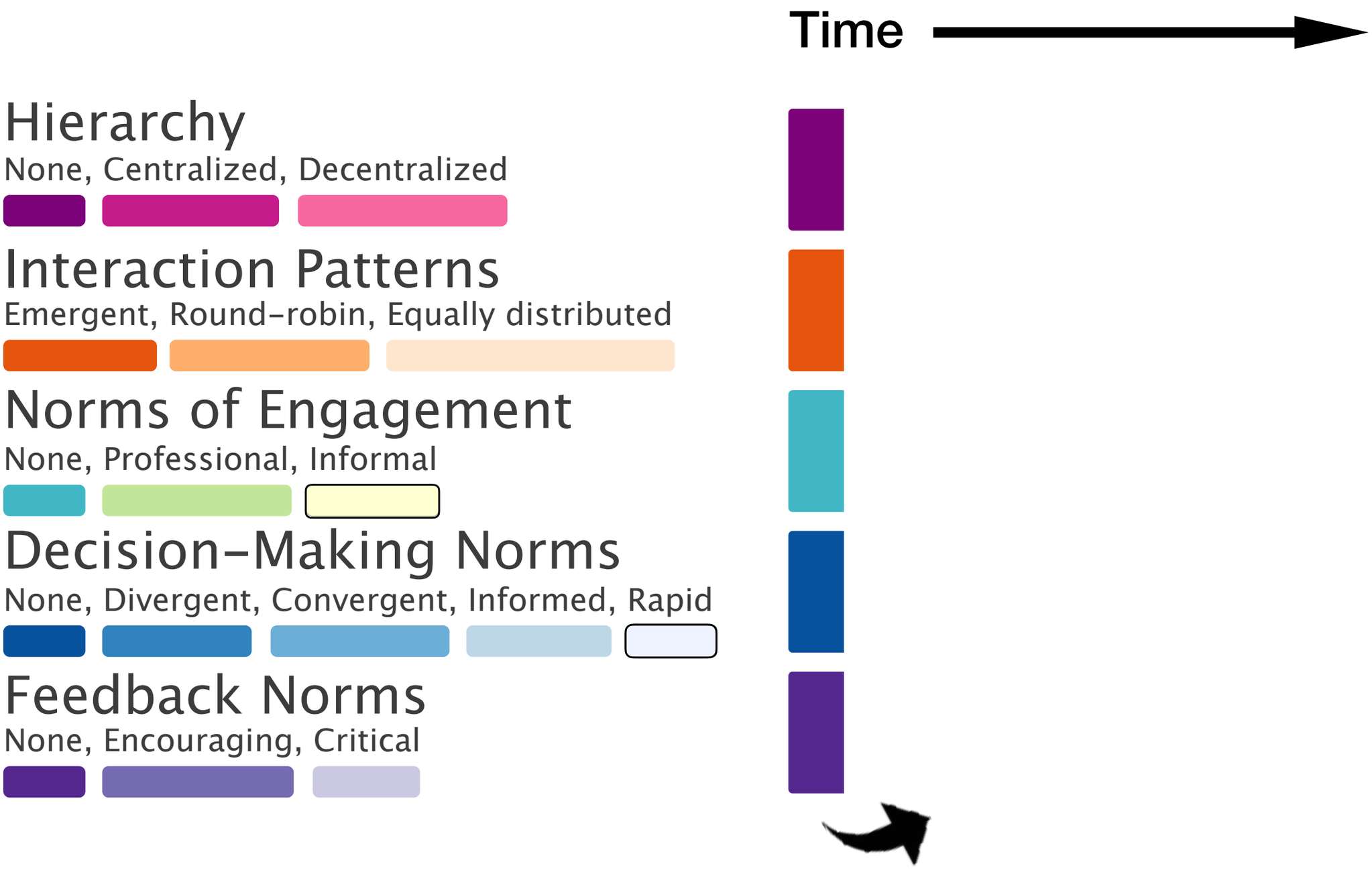
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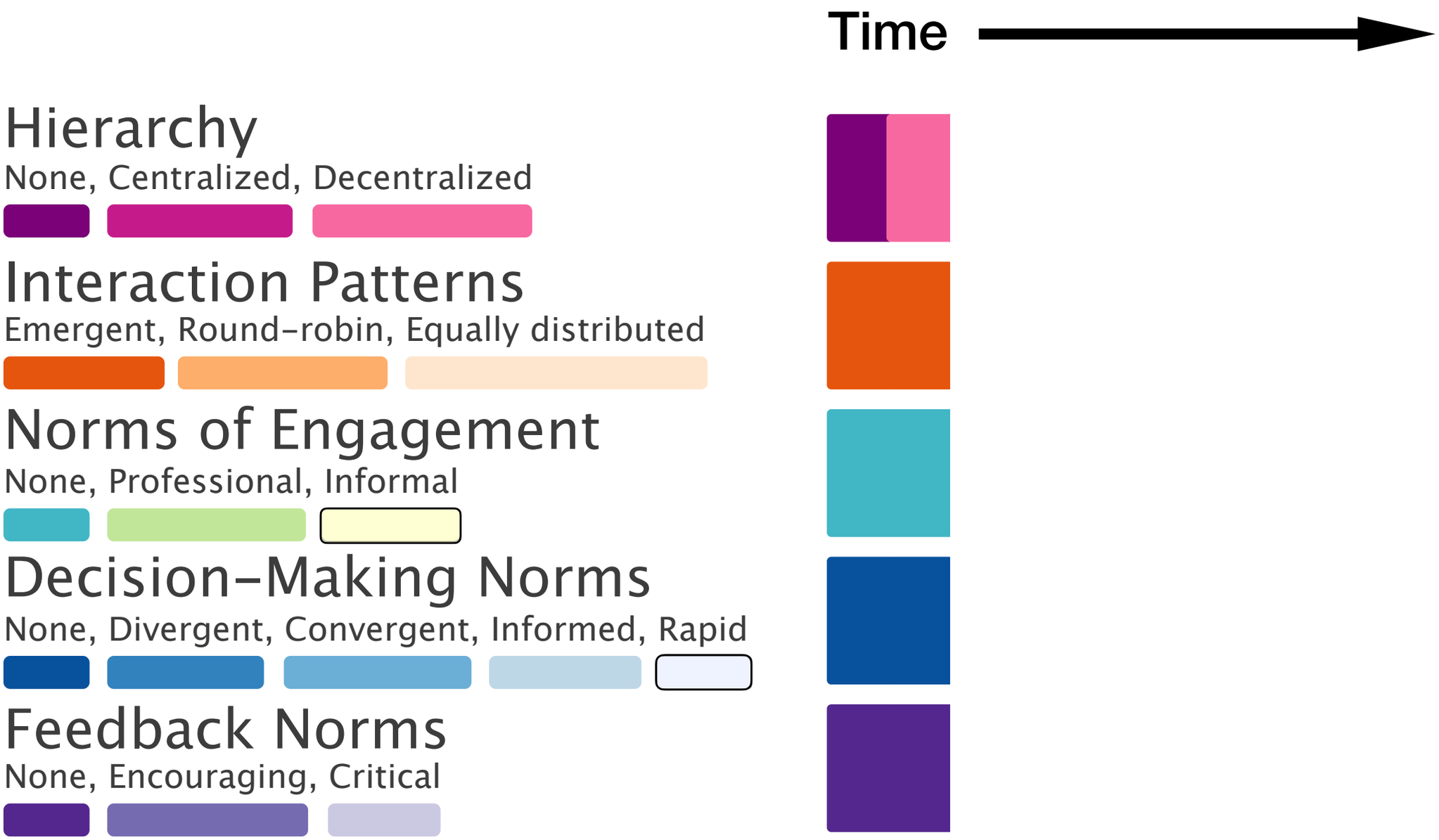
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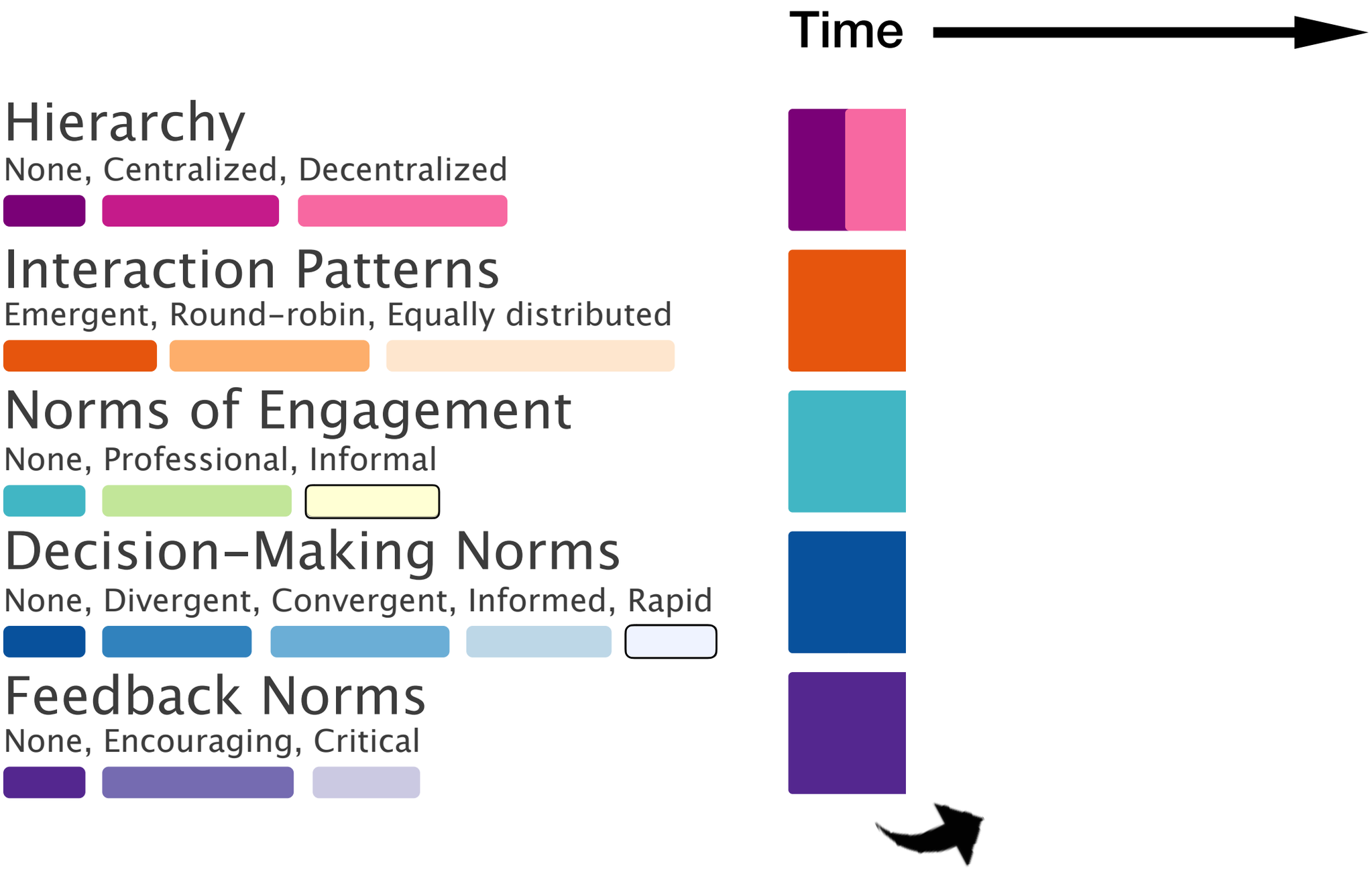
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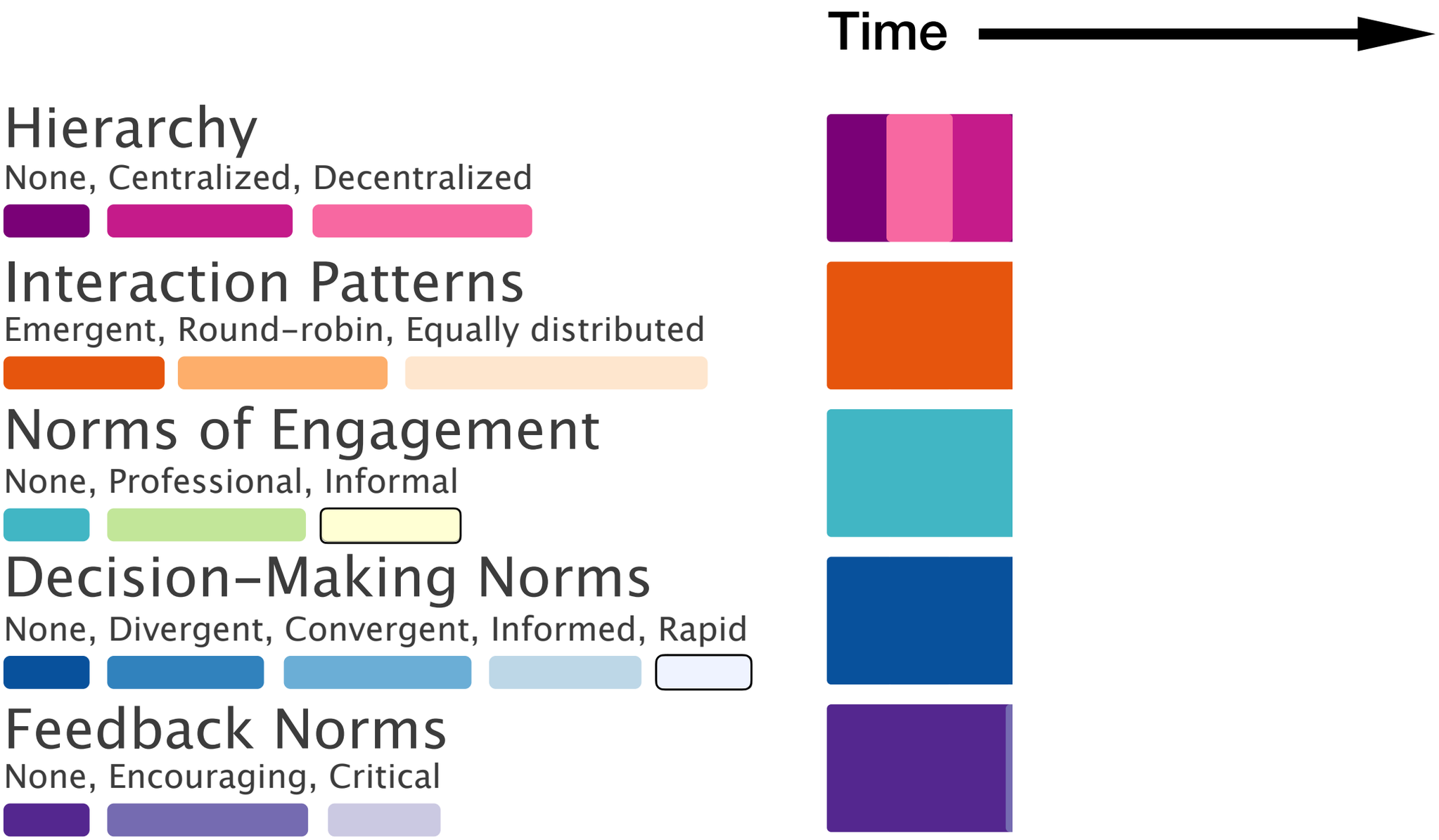
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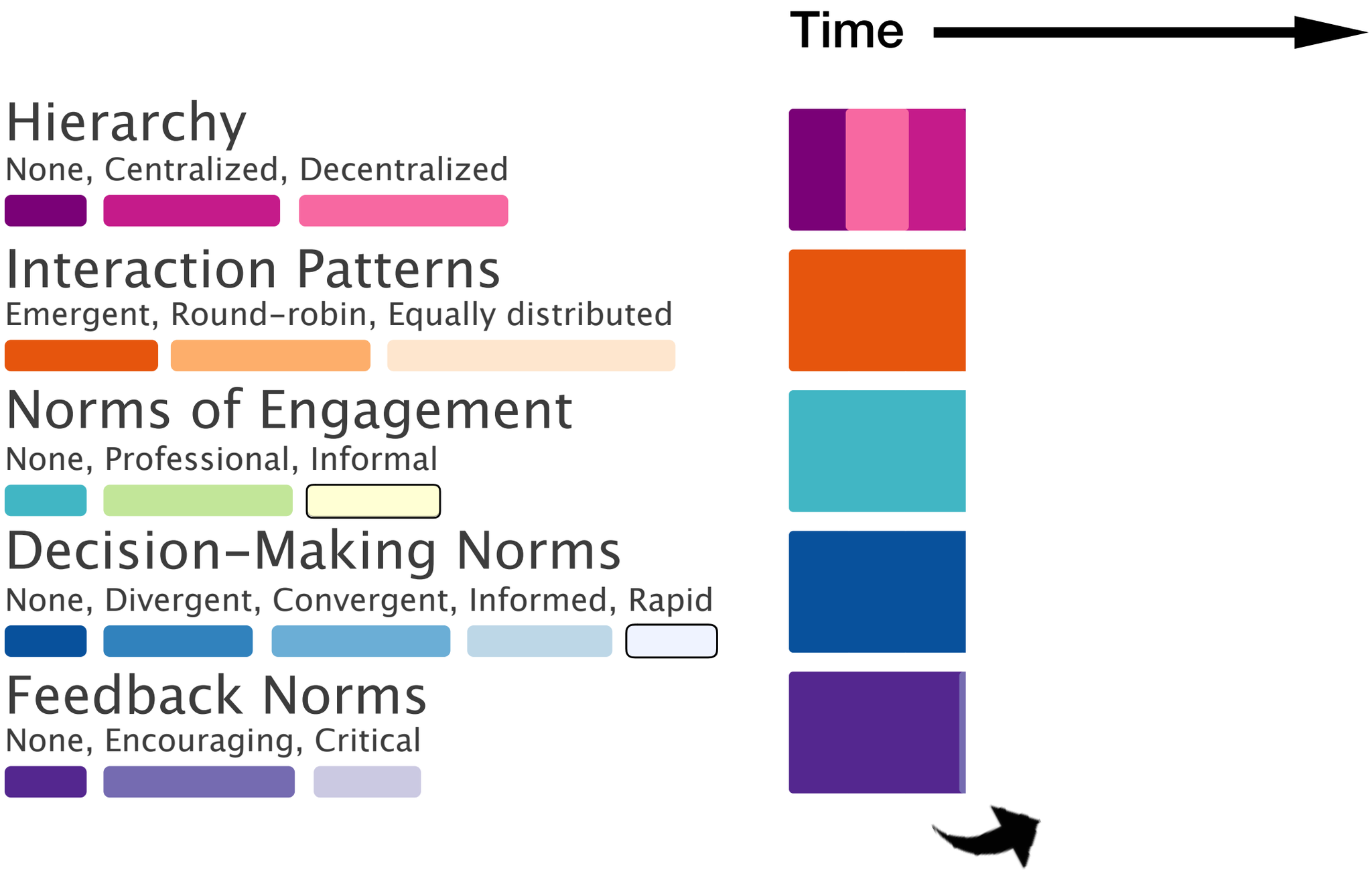
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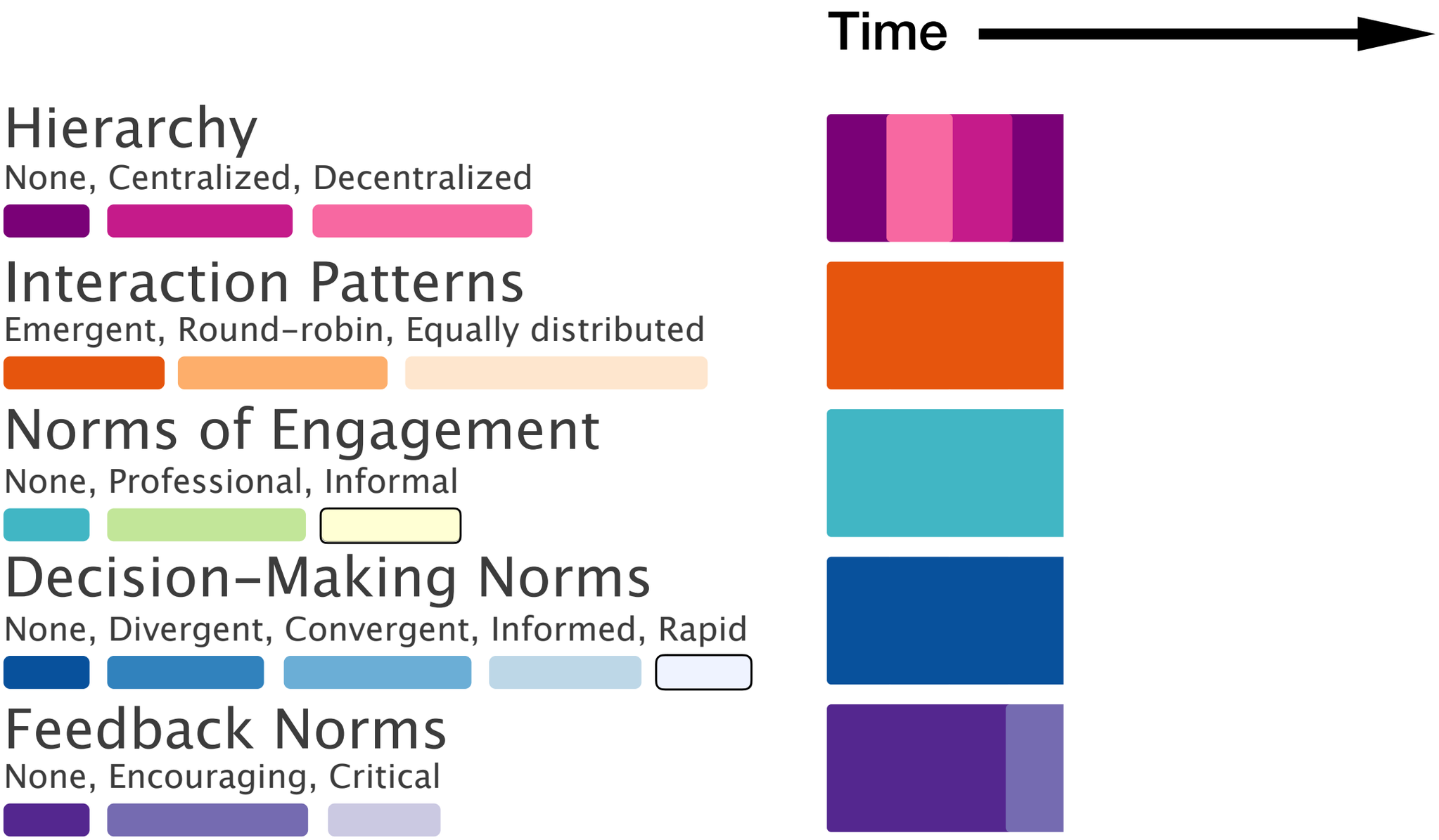
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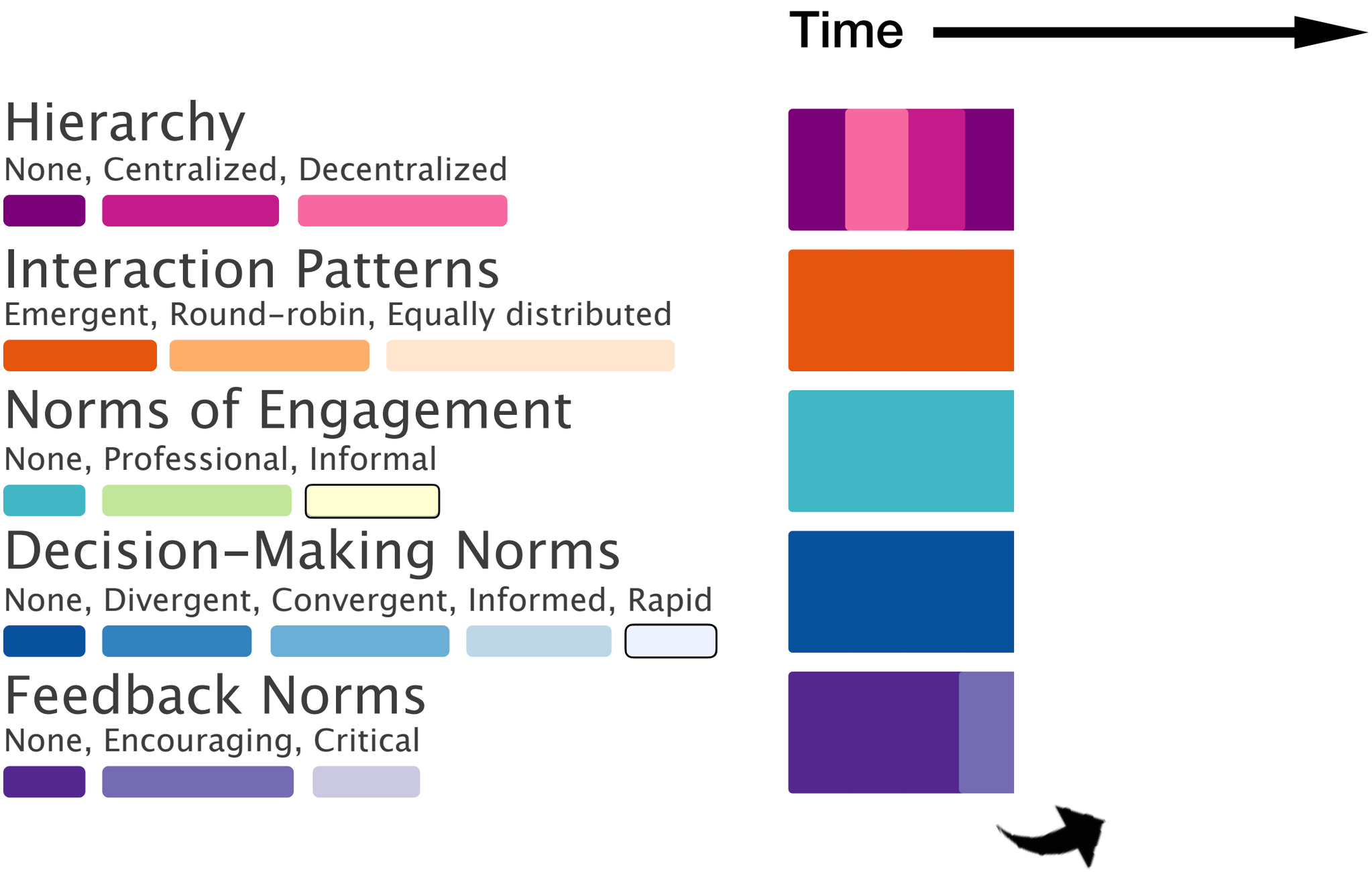
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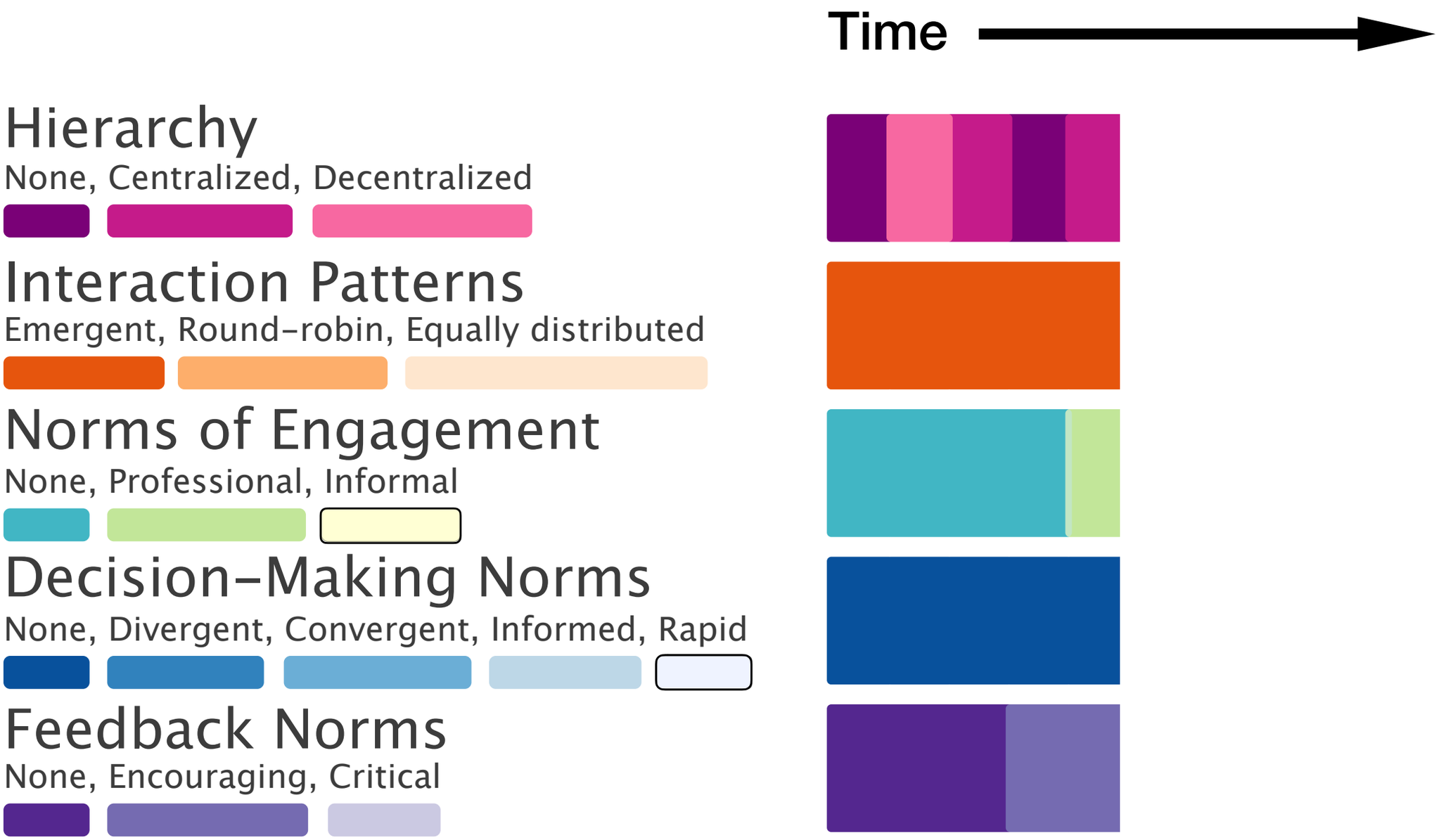
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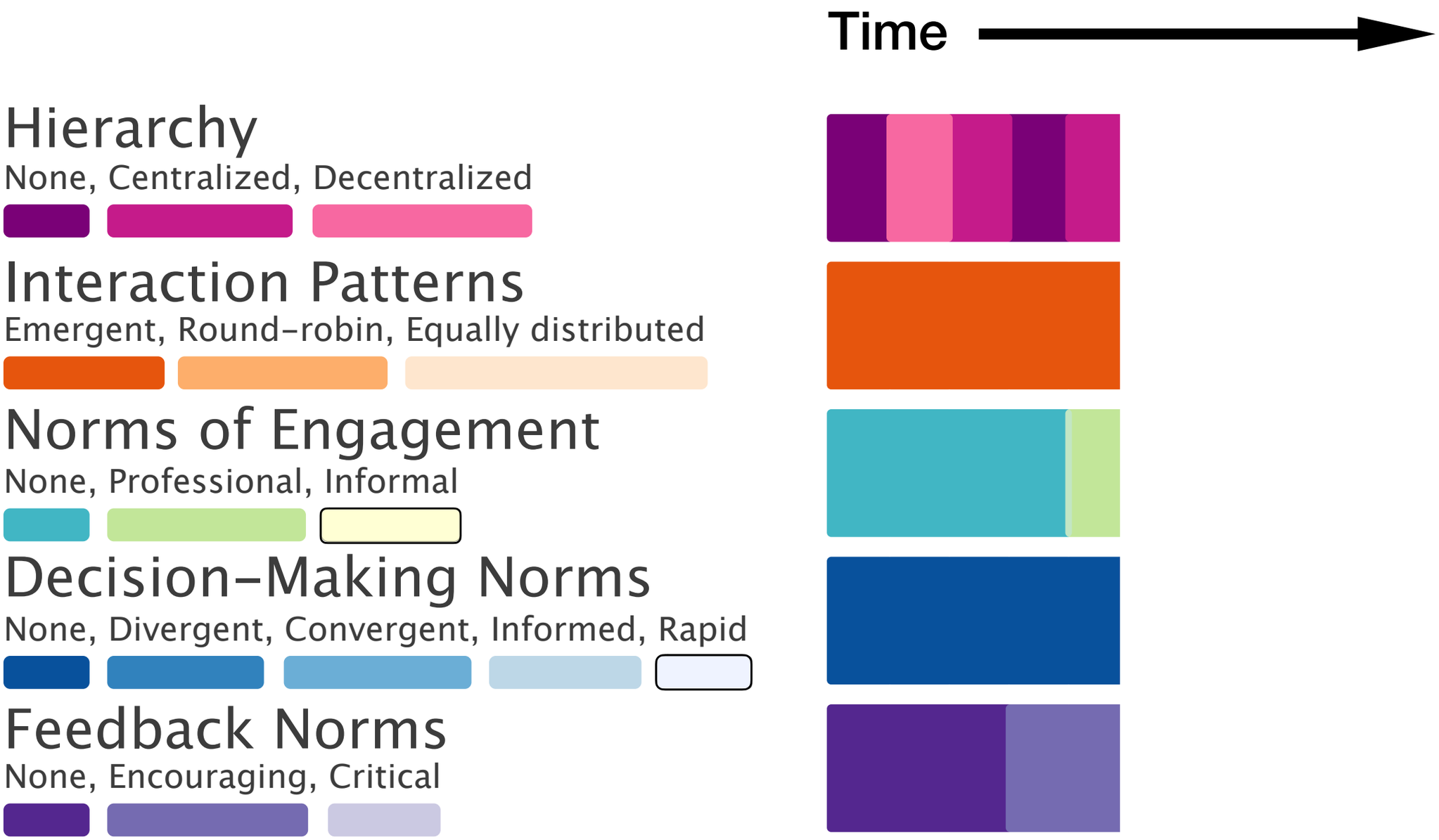
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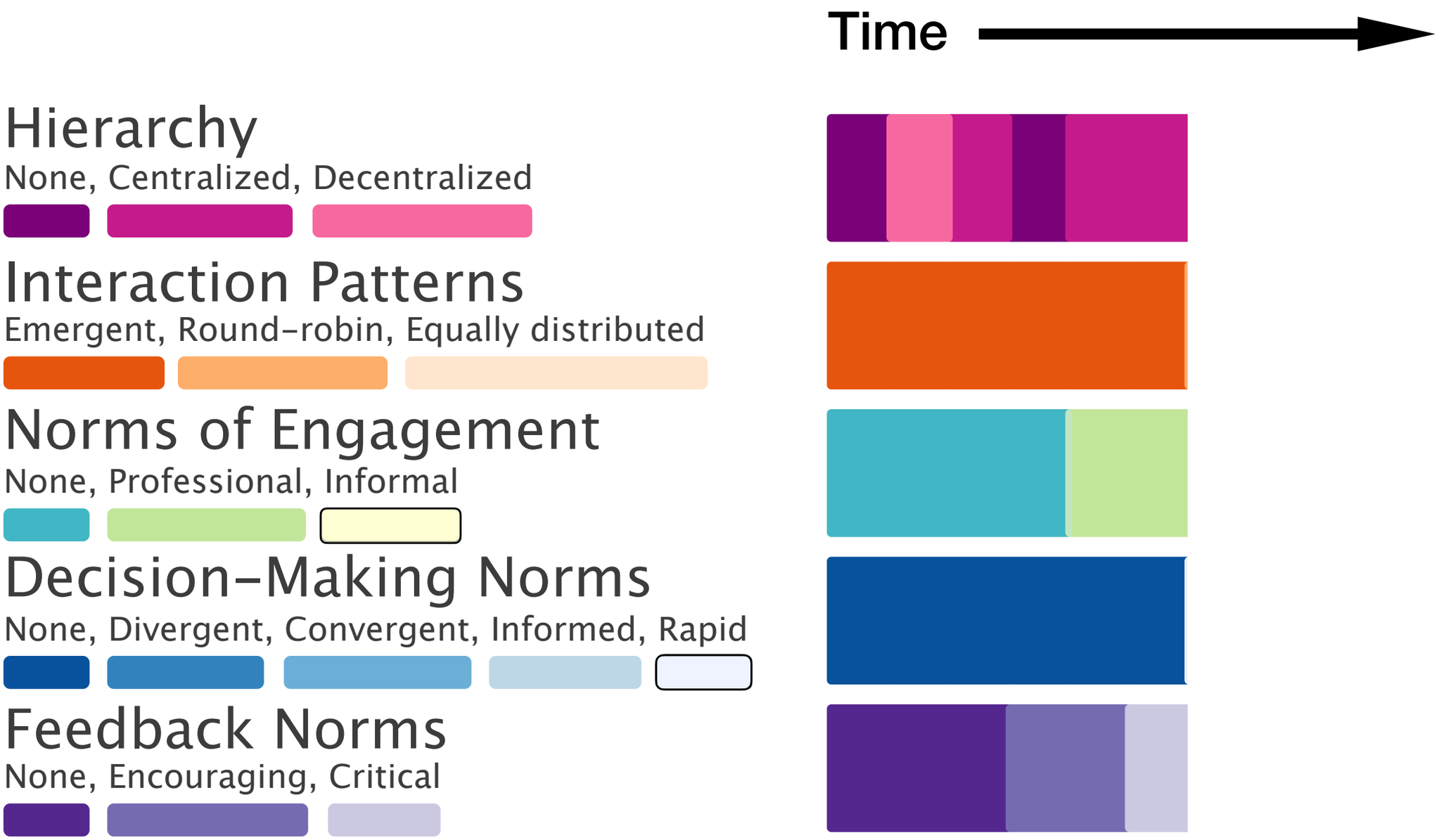
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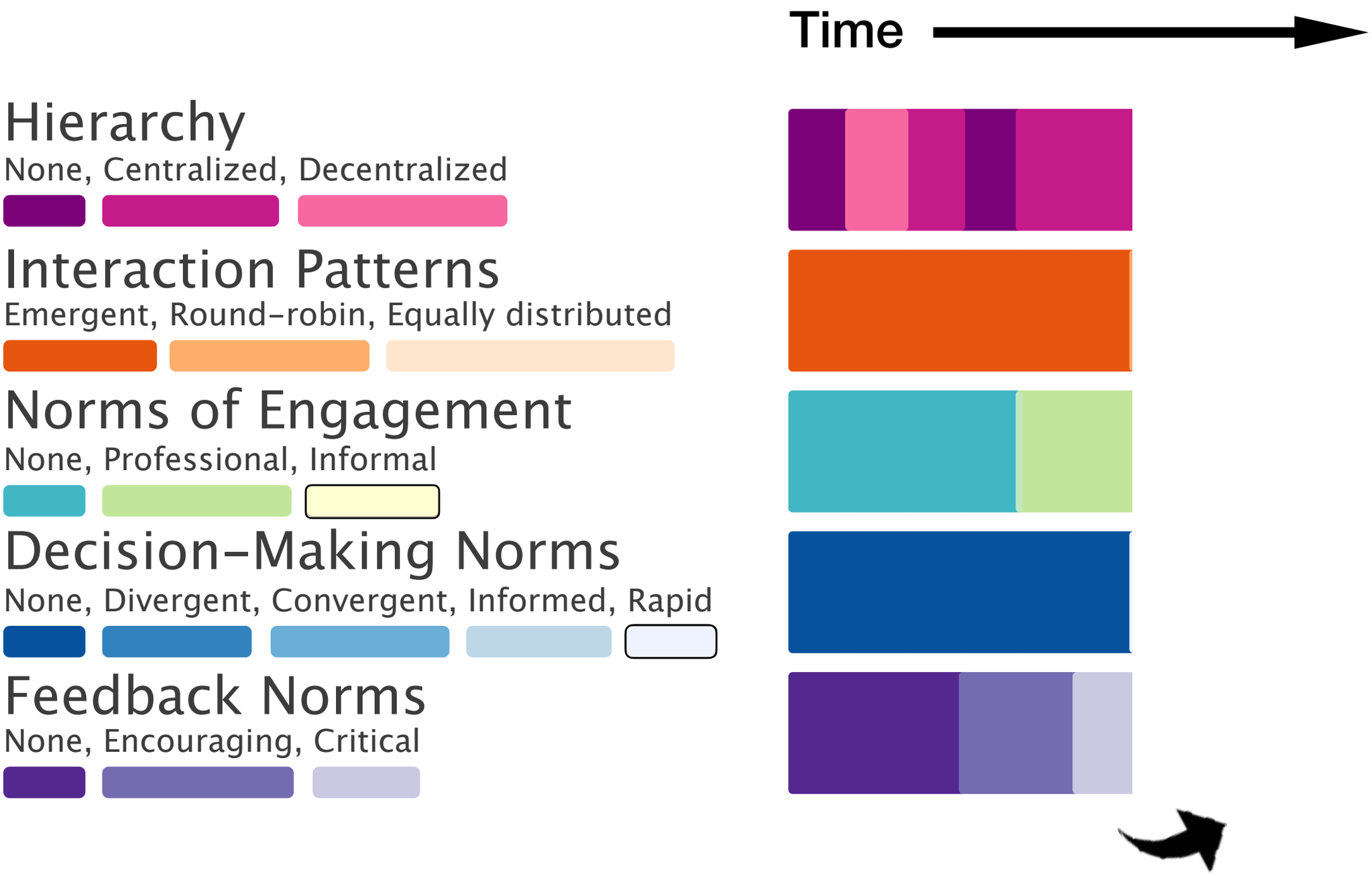
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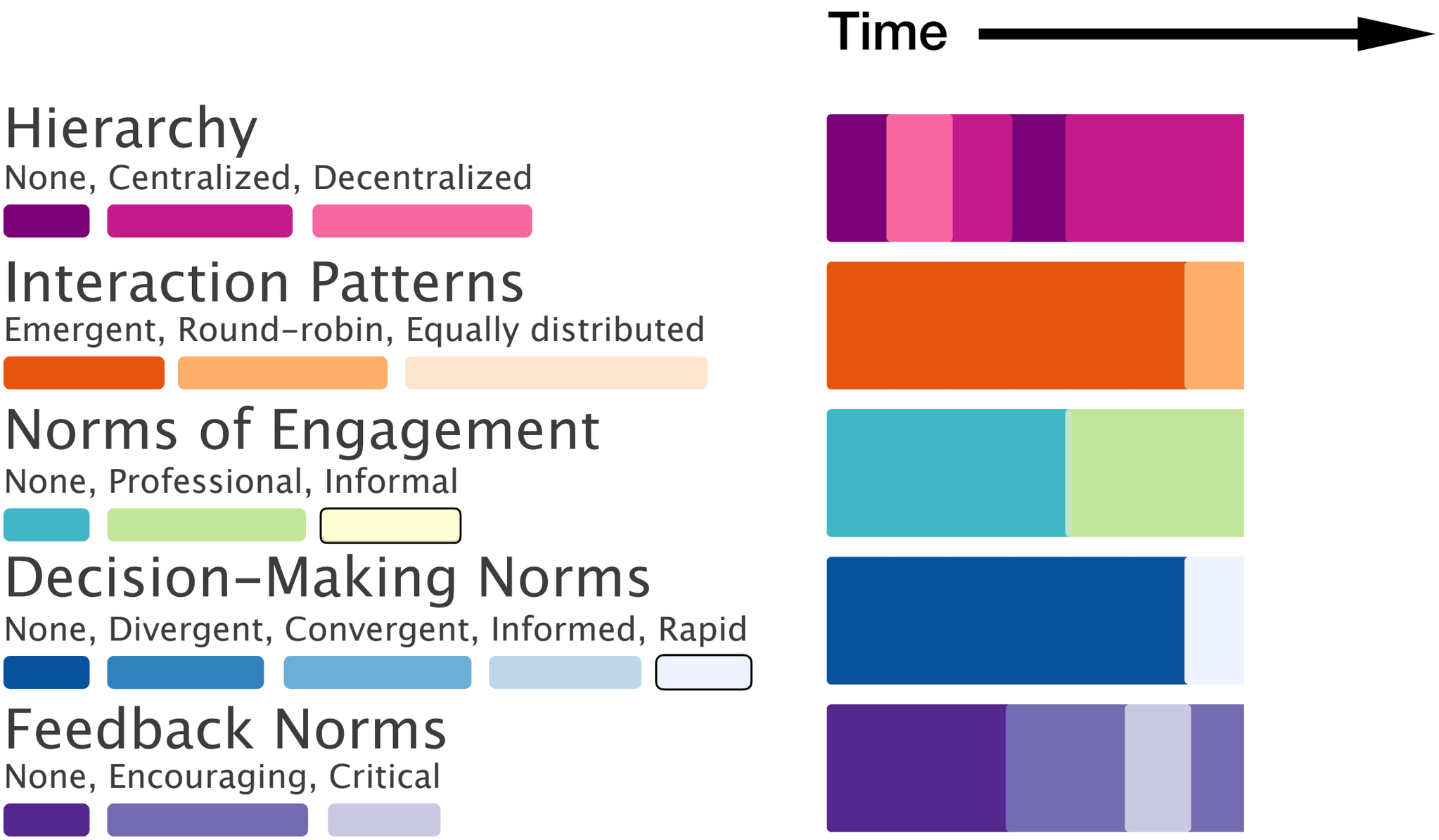
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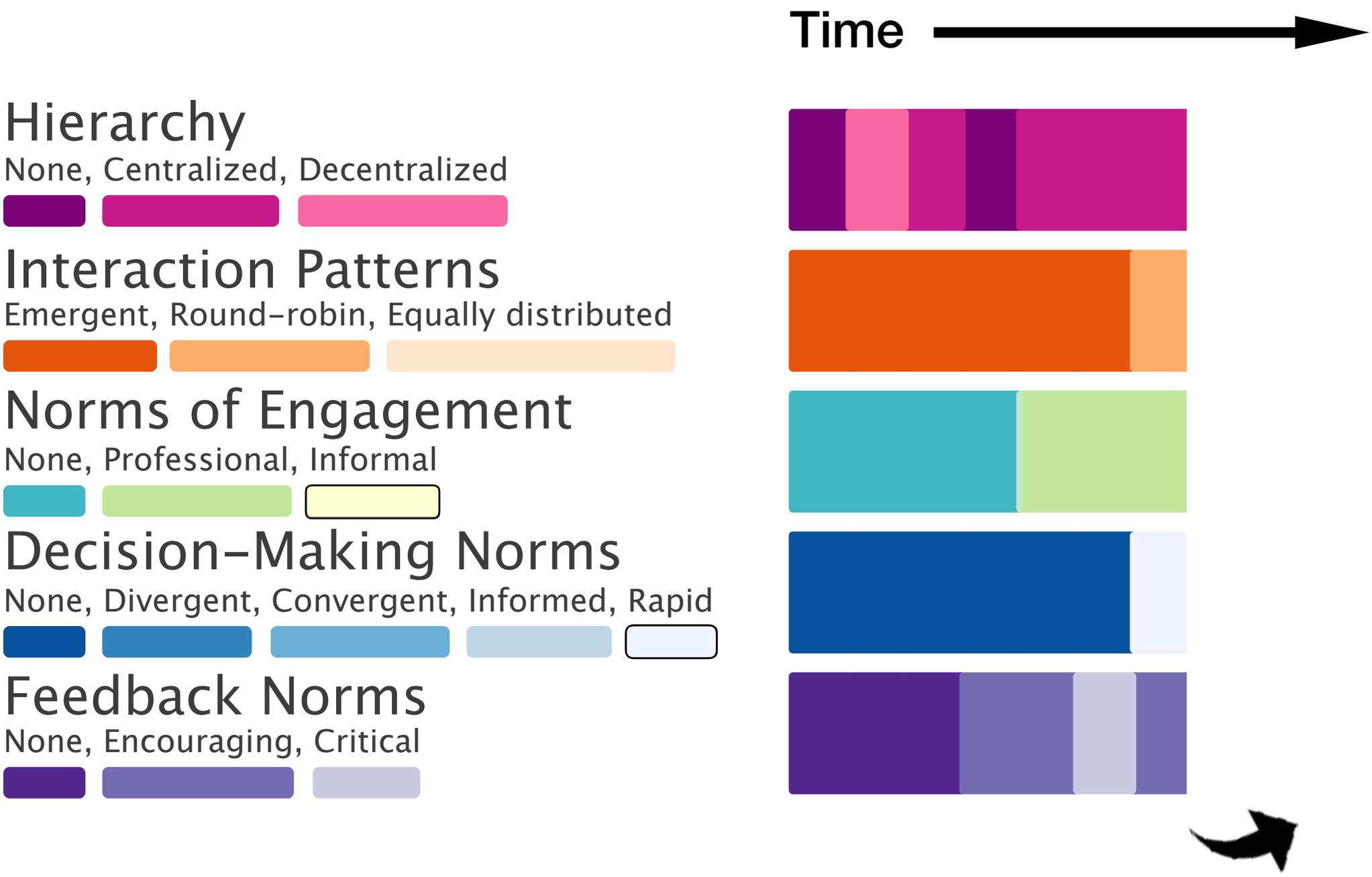
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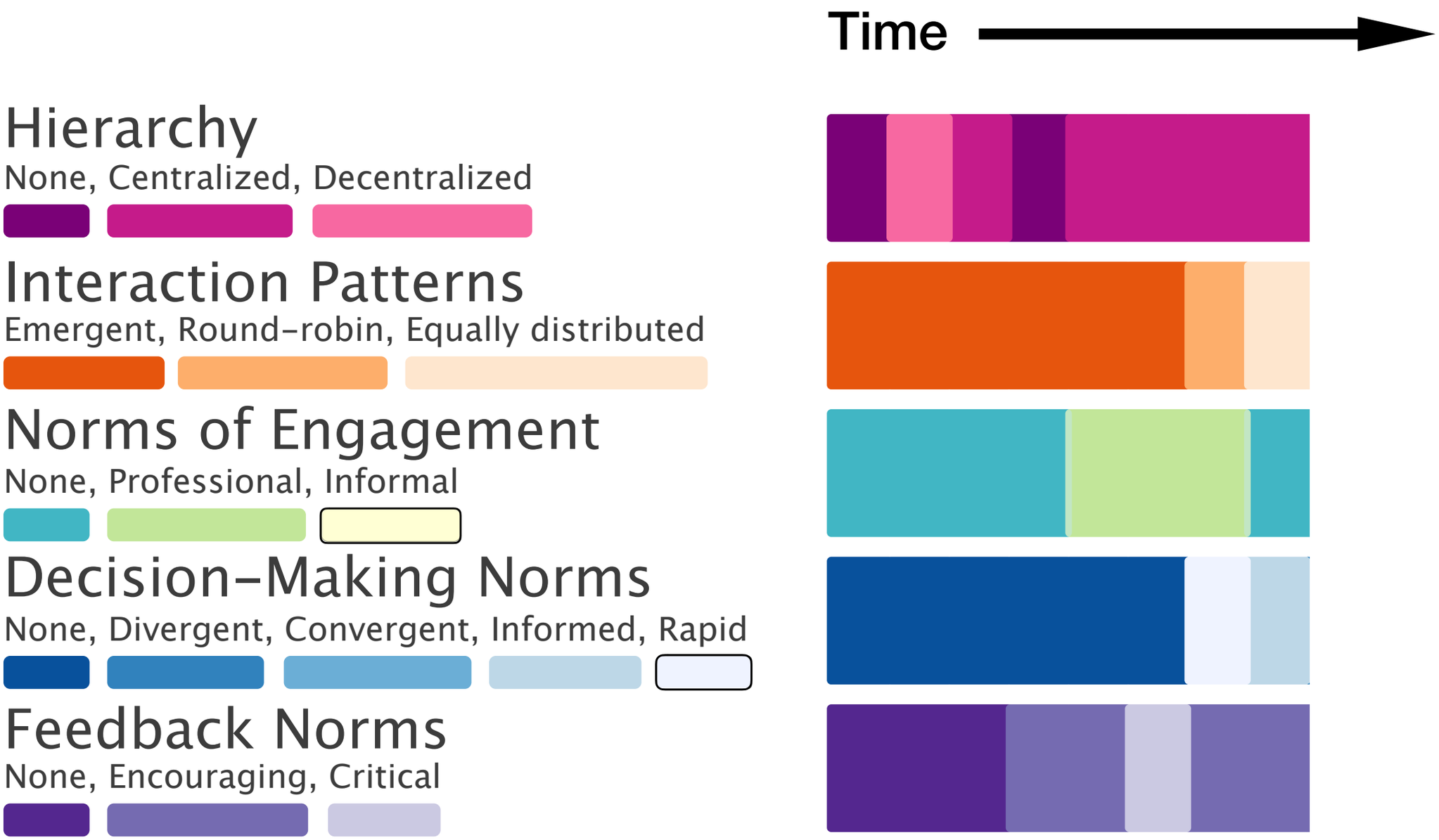
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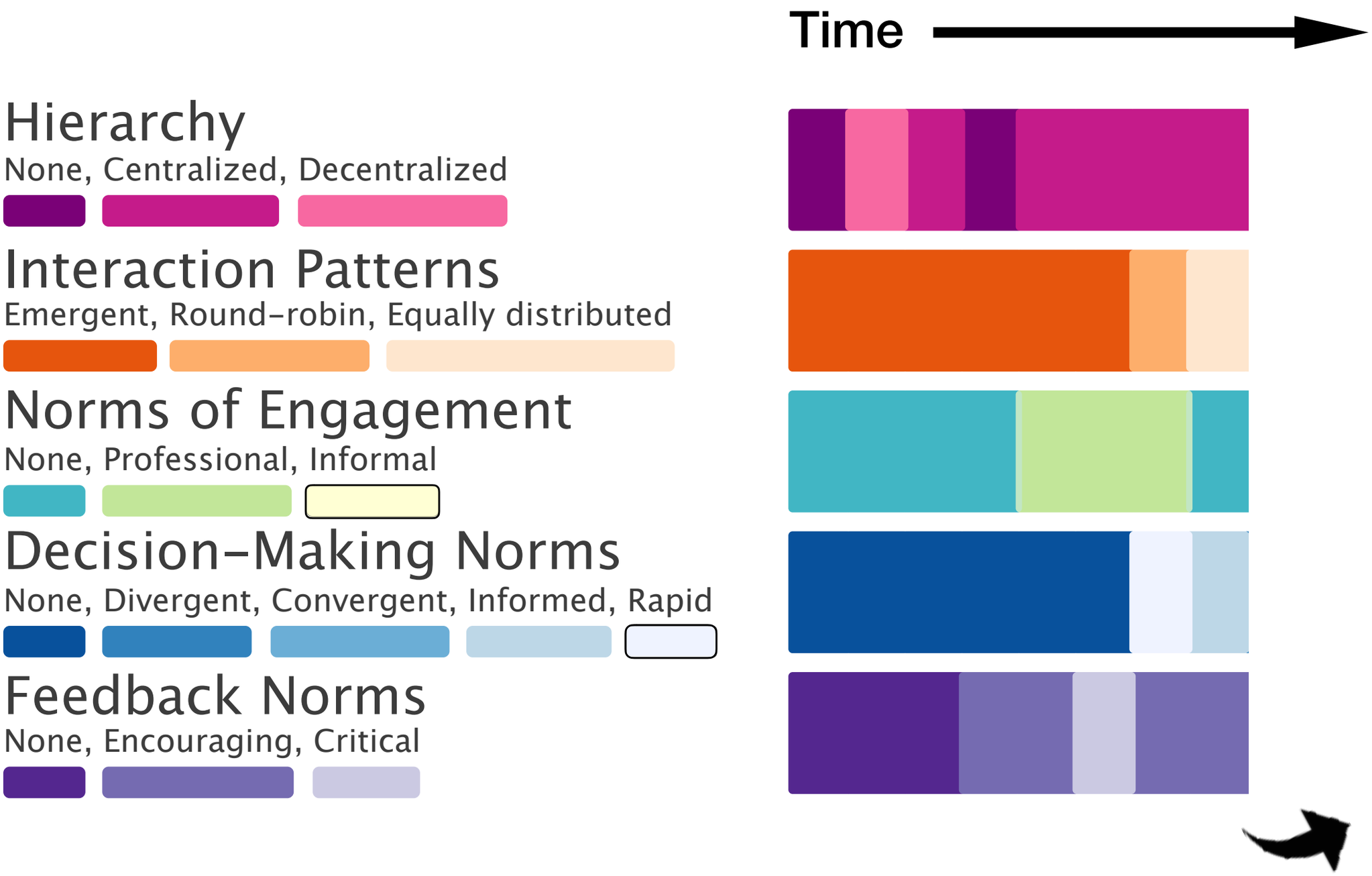
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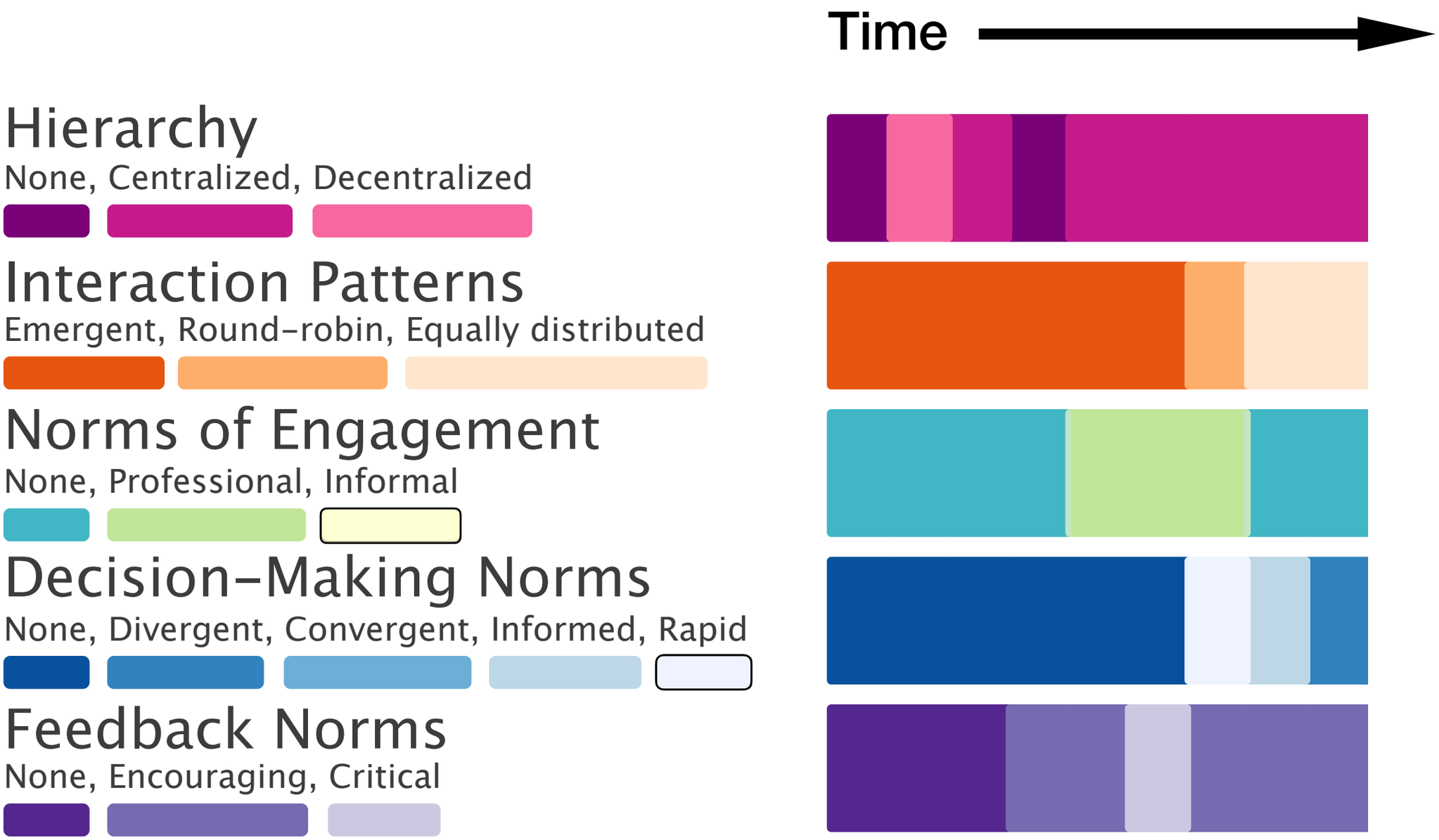
None, Divergent, Convergent, Informed, Rapid
Feedback Norms
None, Encouraging, Critical

DreamTeam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Interaction Patterns
Emergent, Round-robin, Equally distributed
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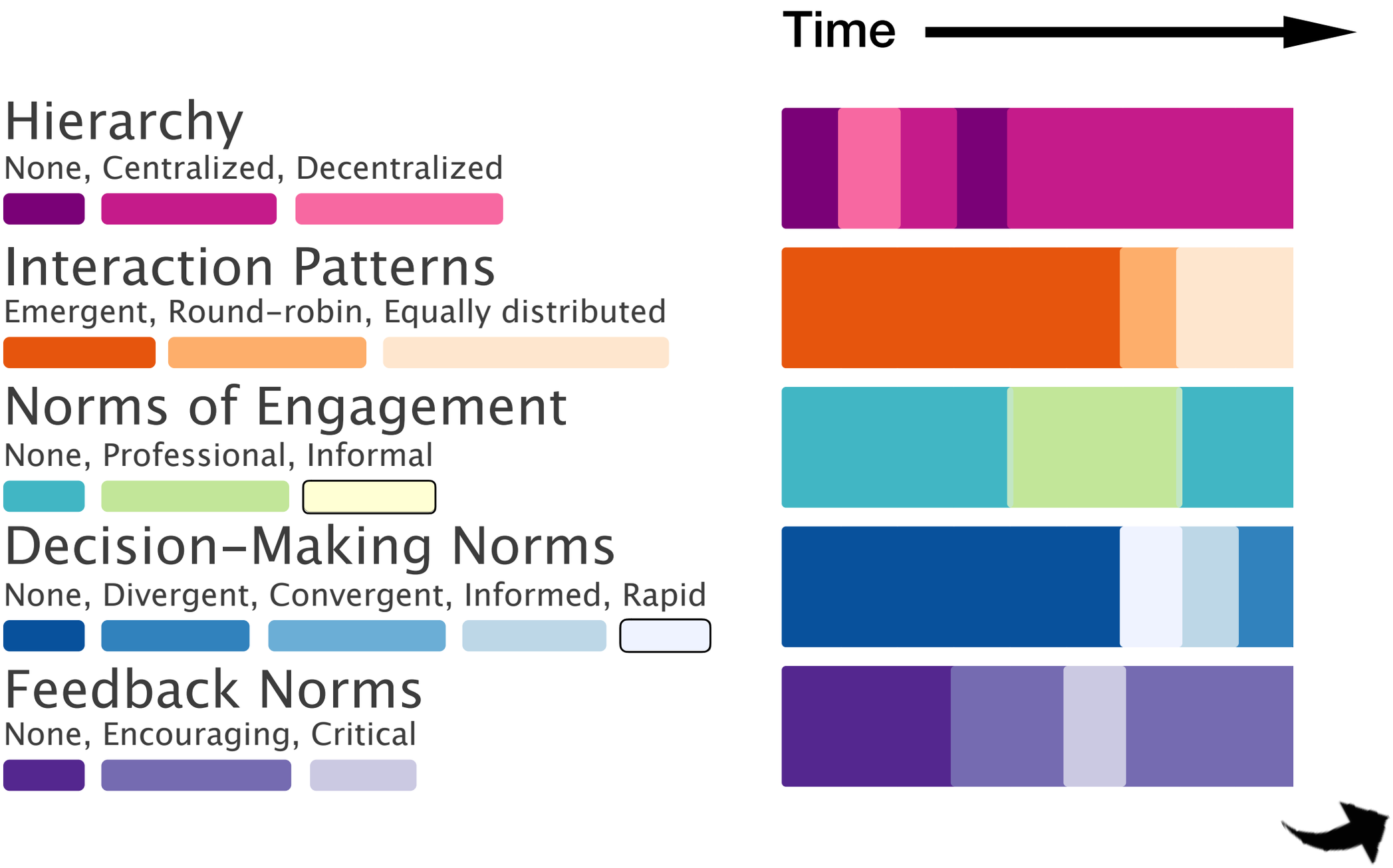
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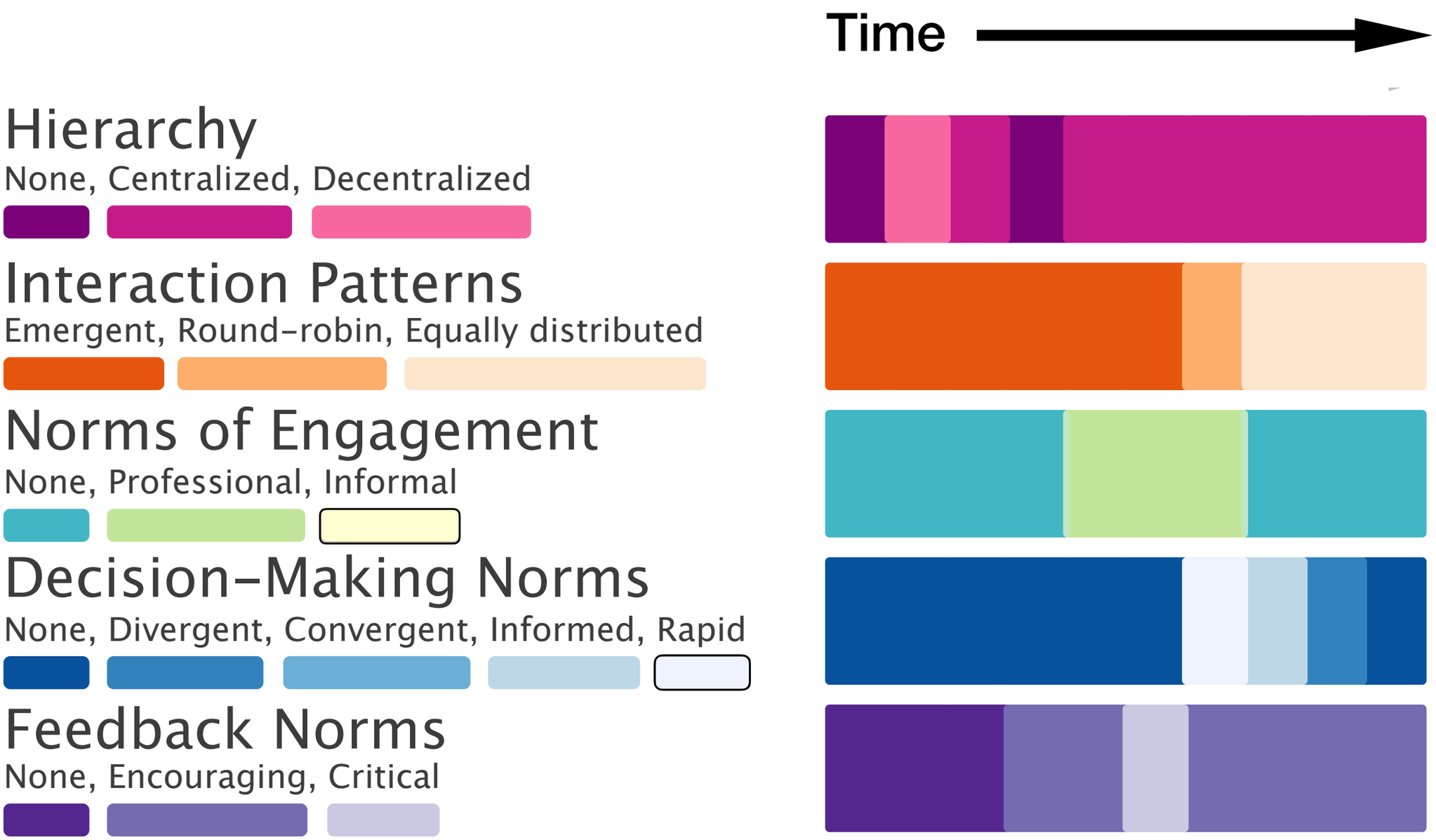
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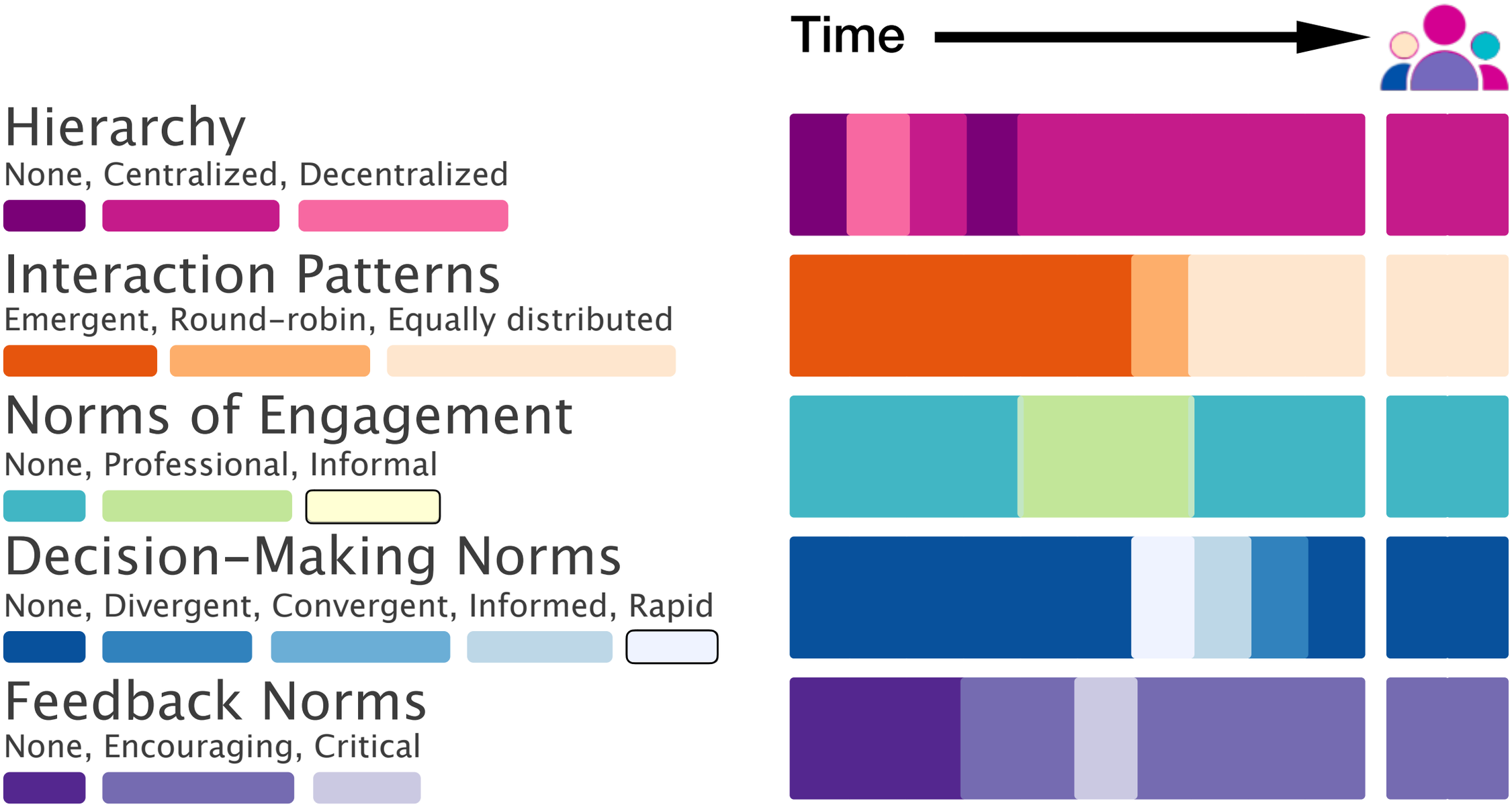
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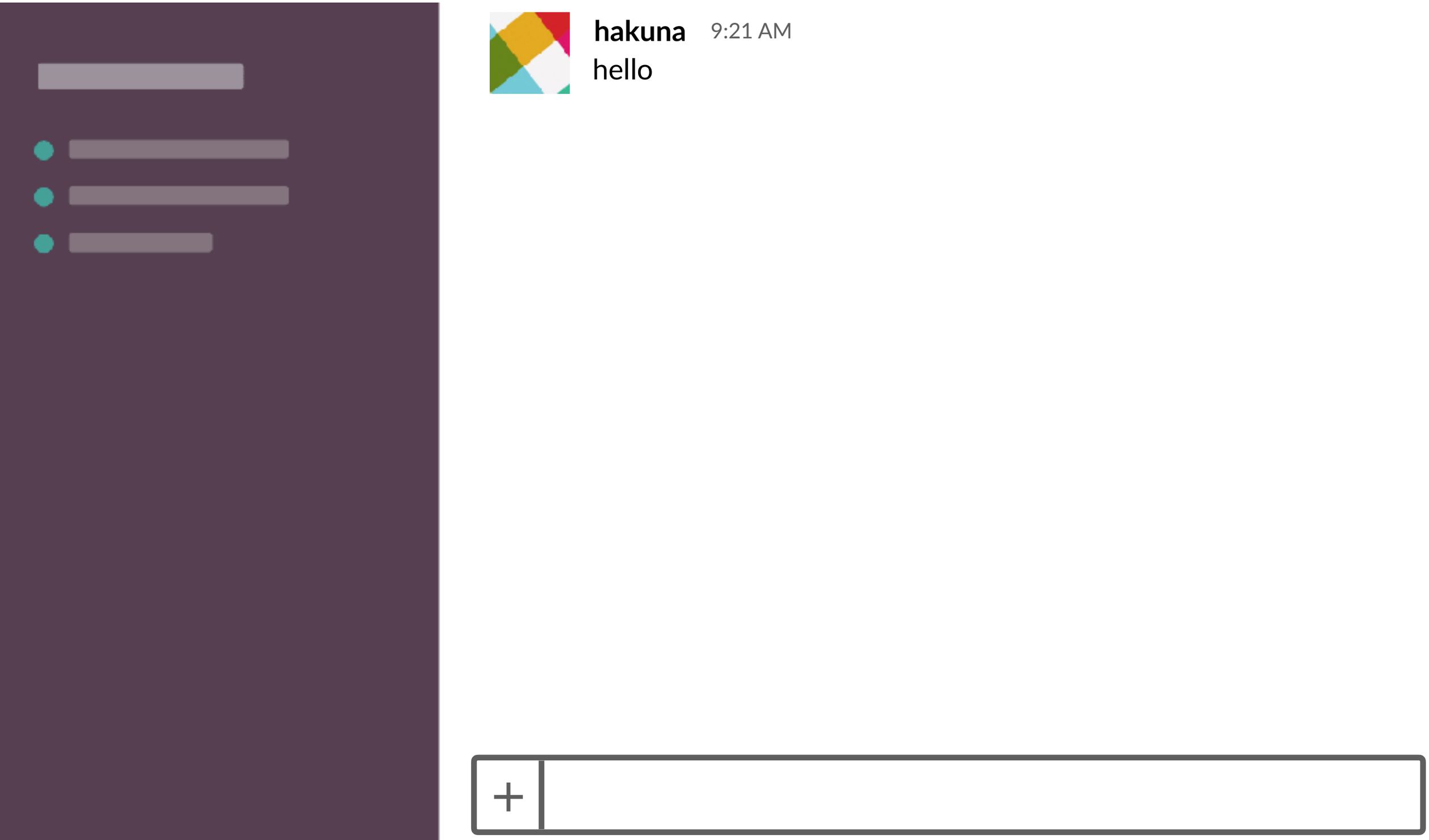
Teams form on Slack



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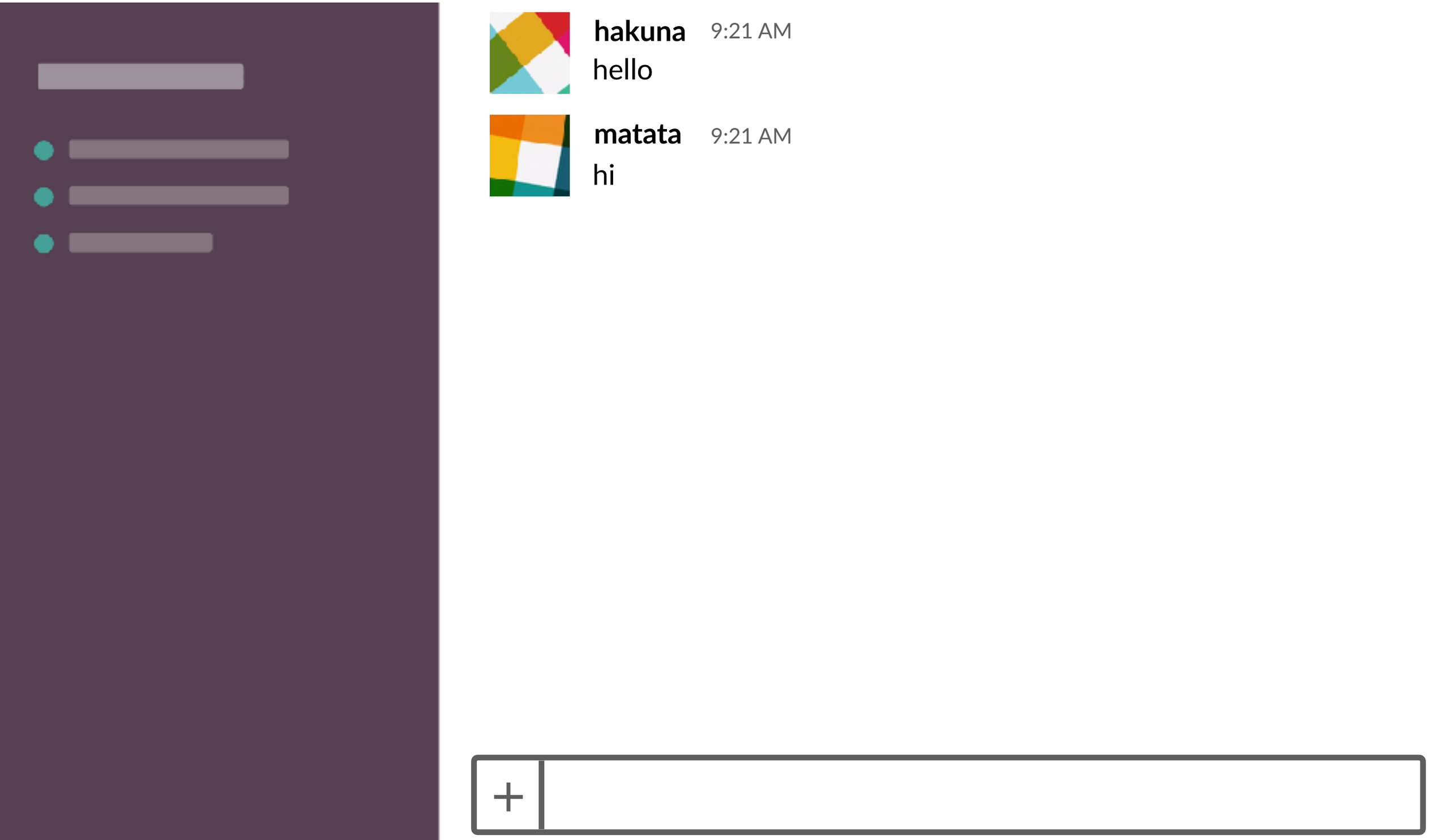

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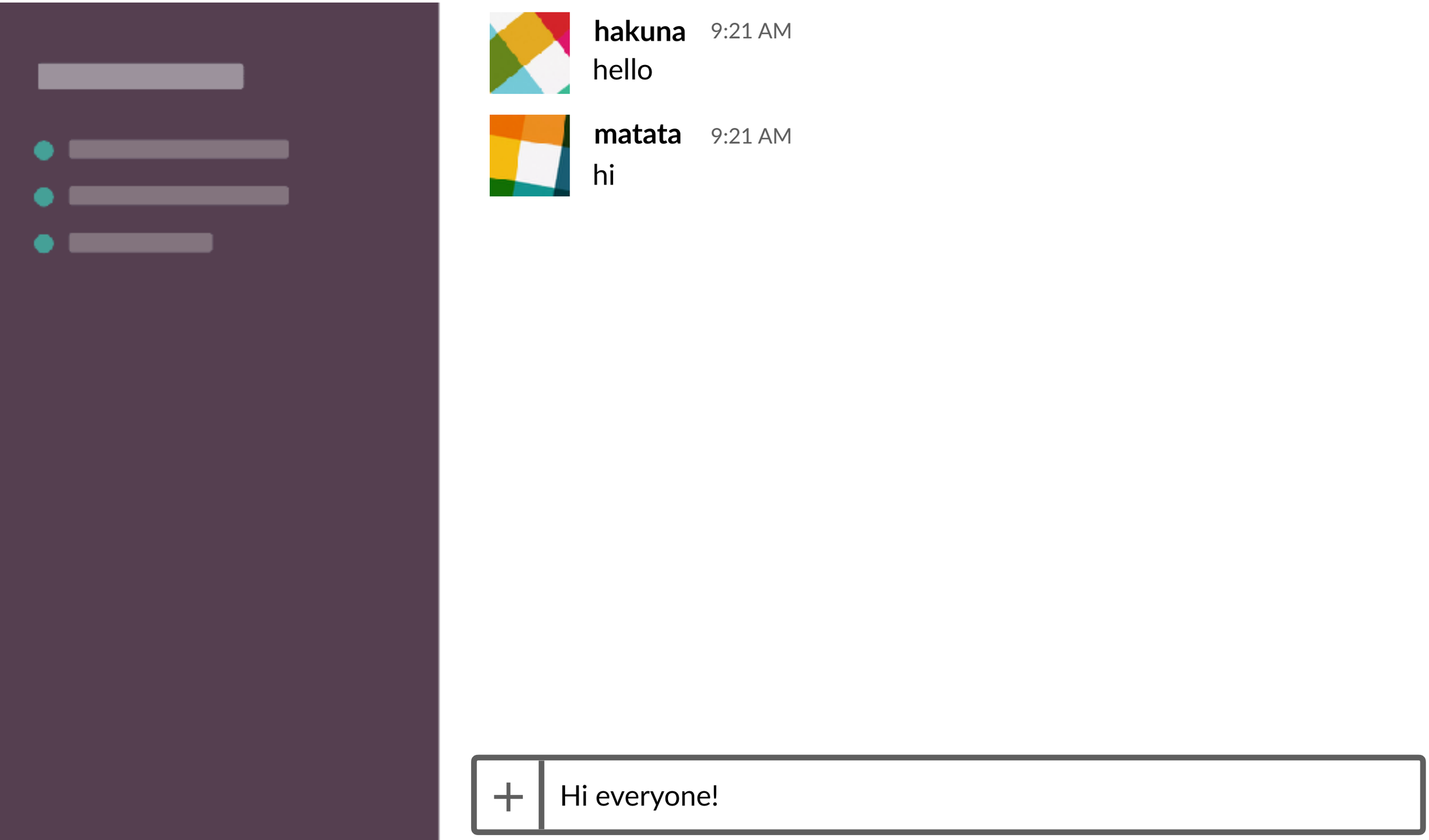

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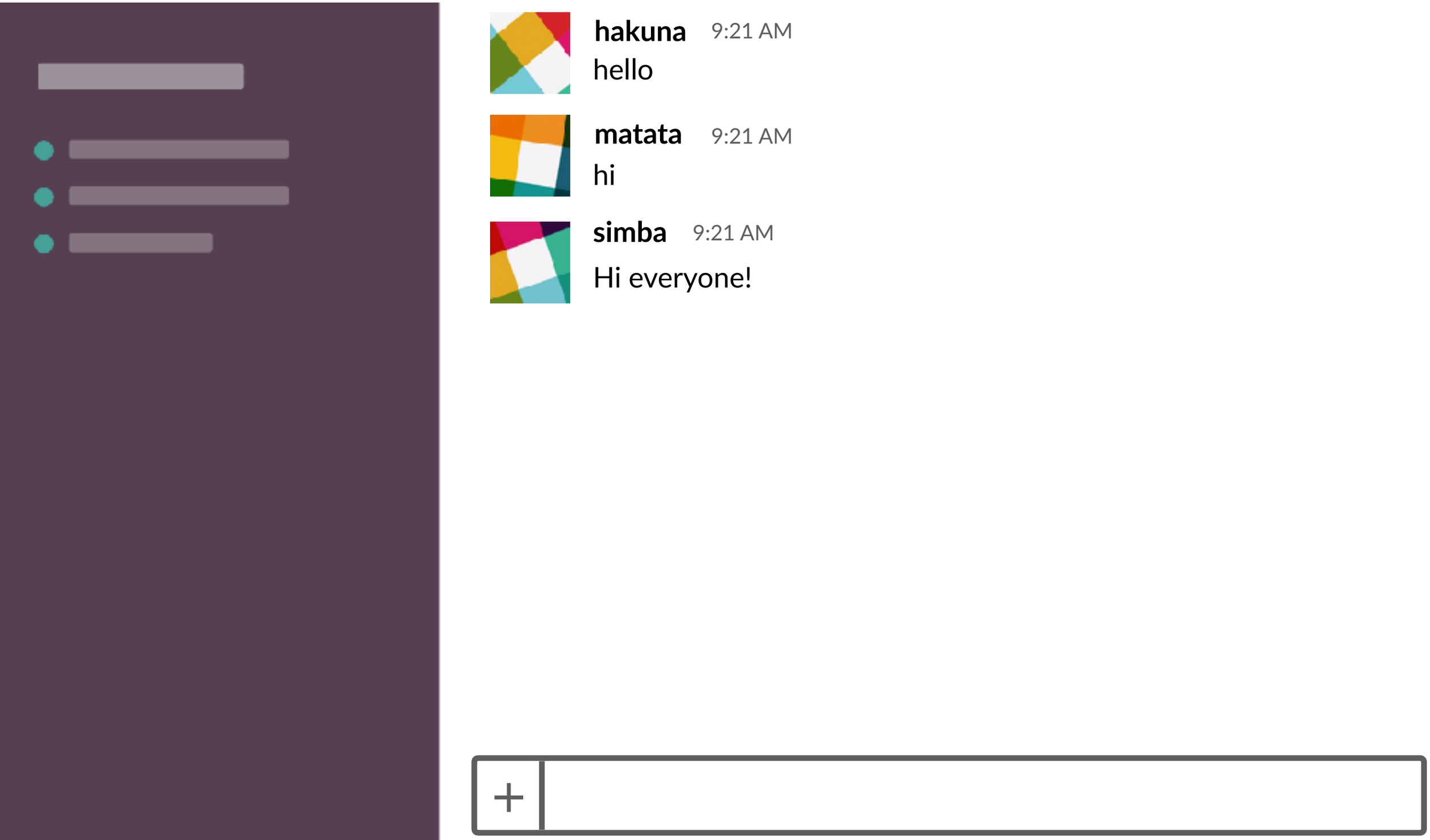

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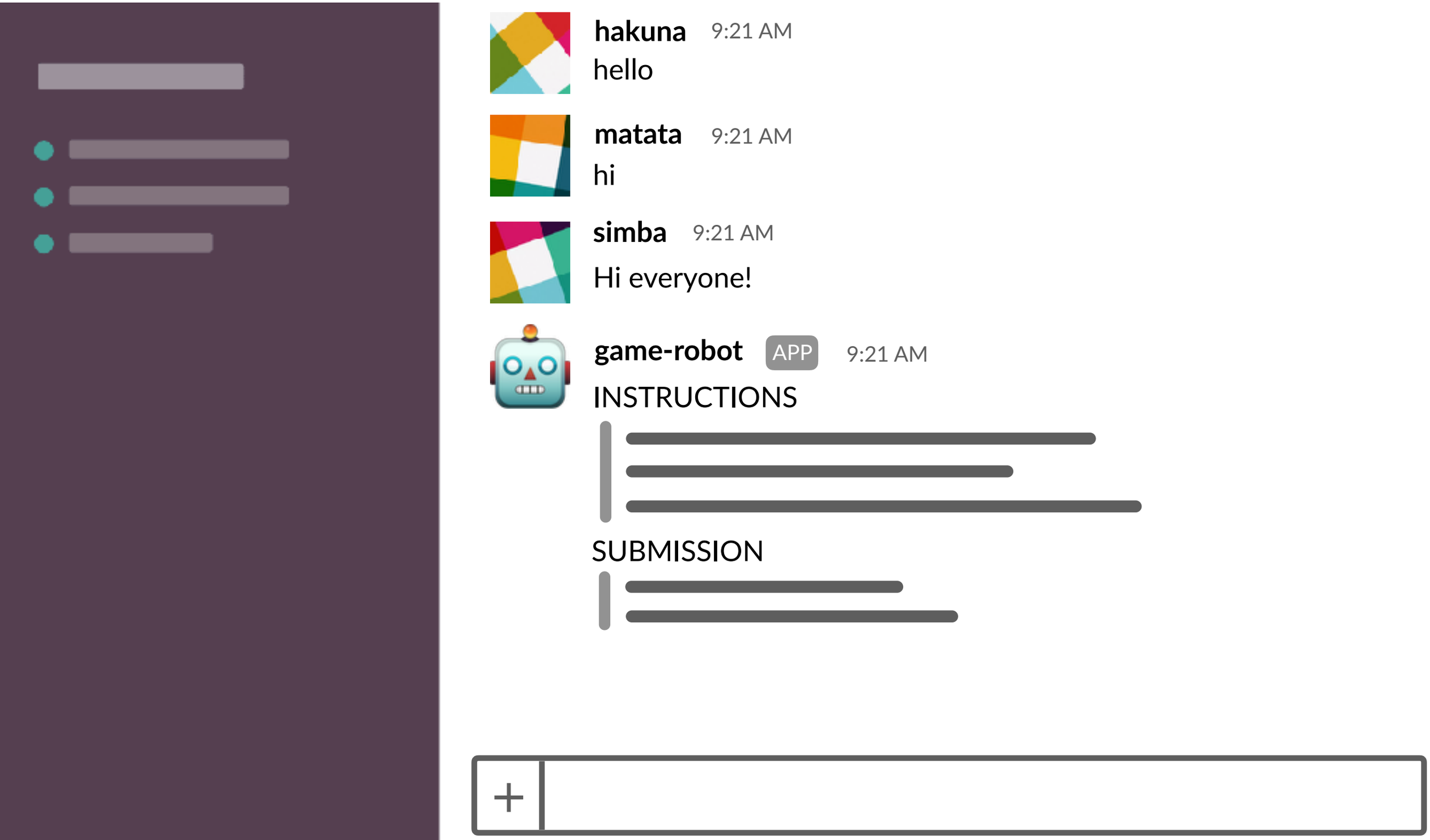

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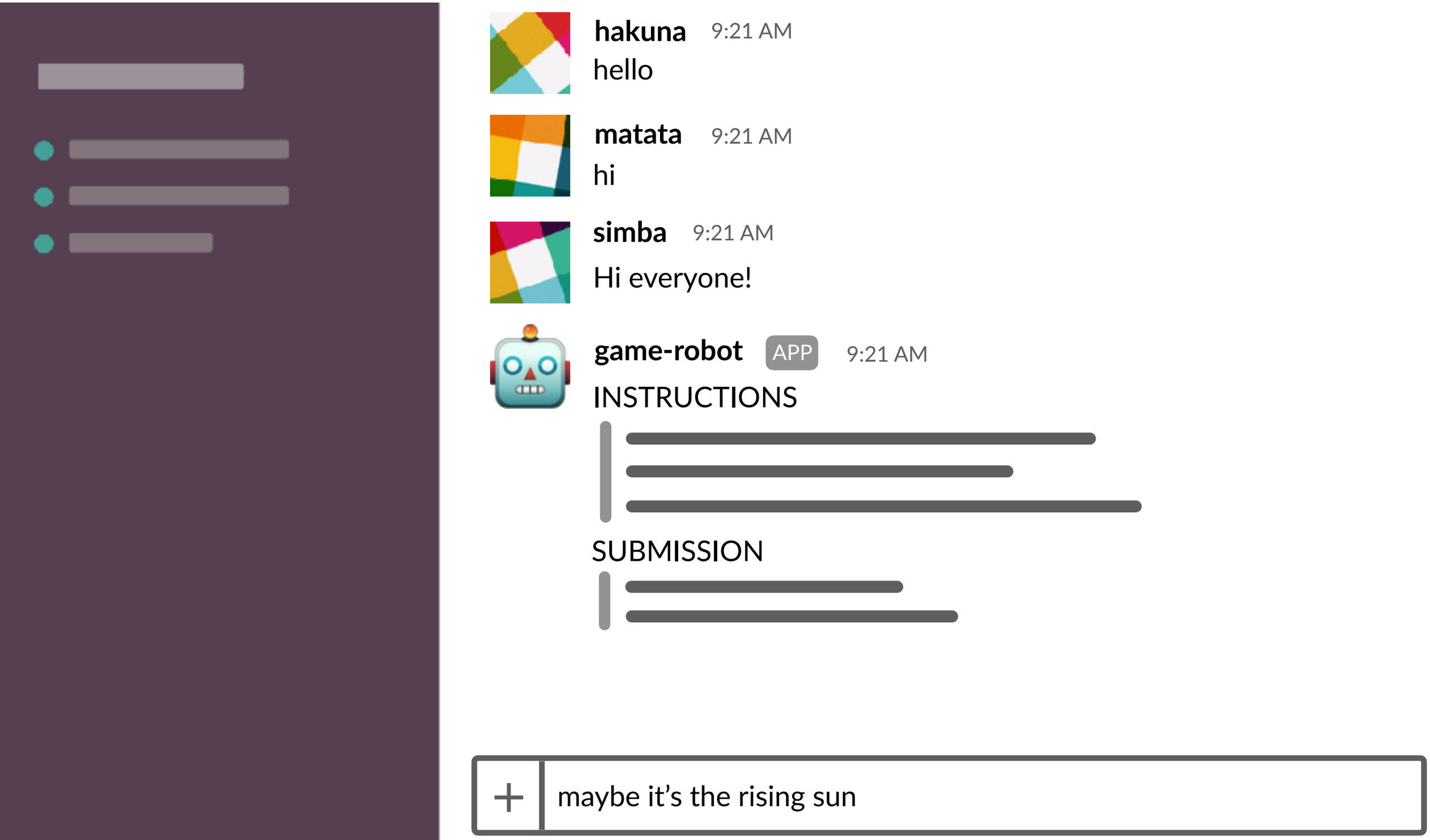

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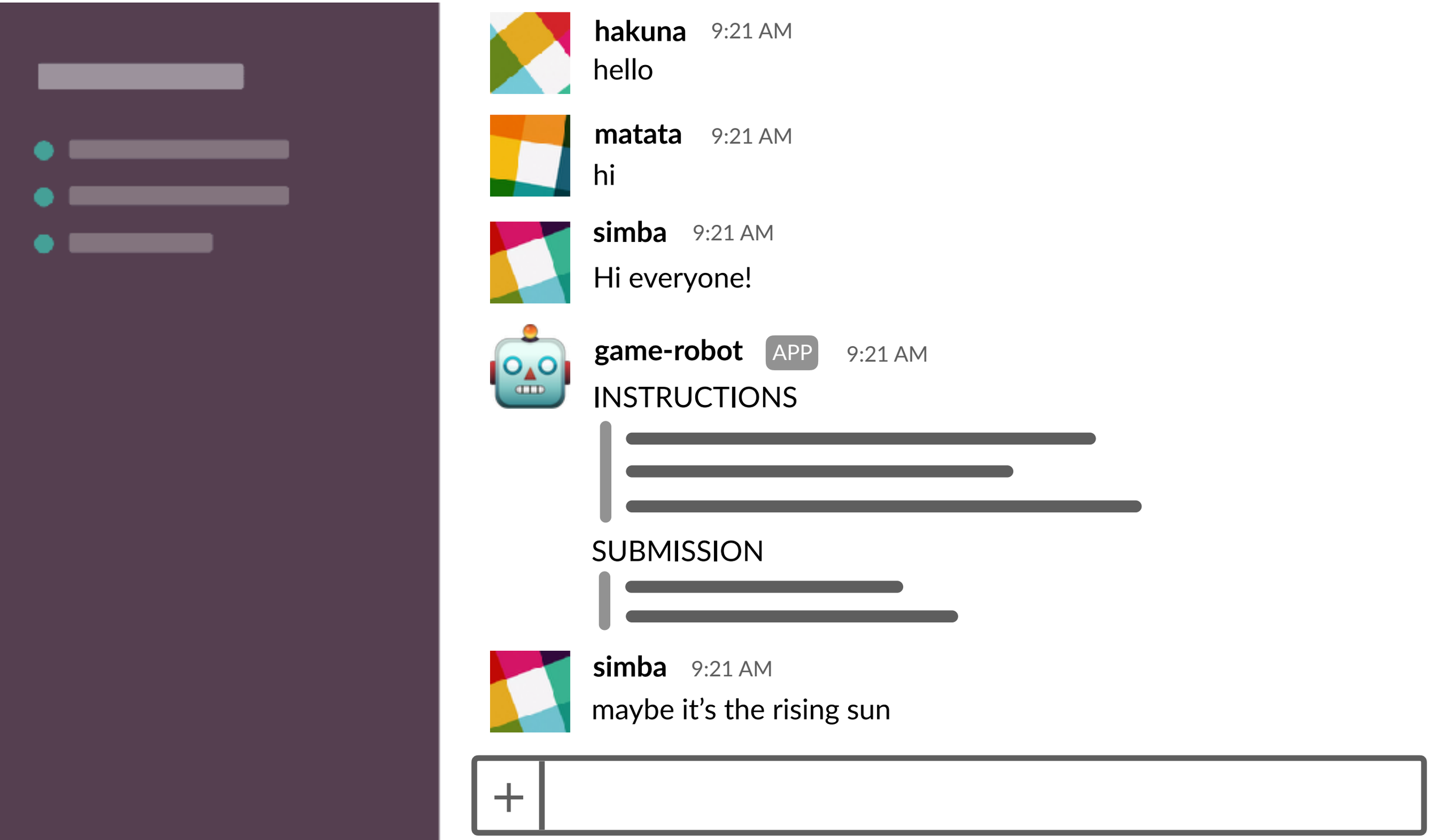
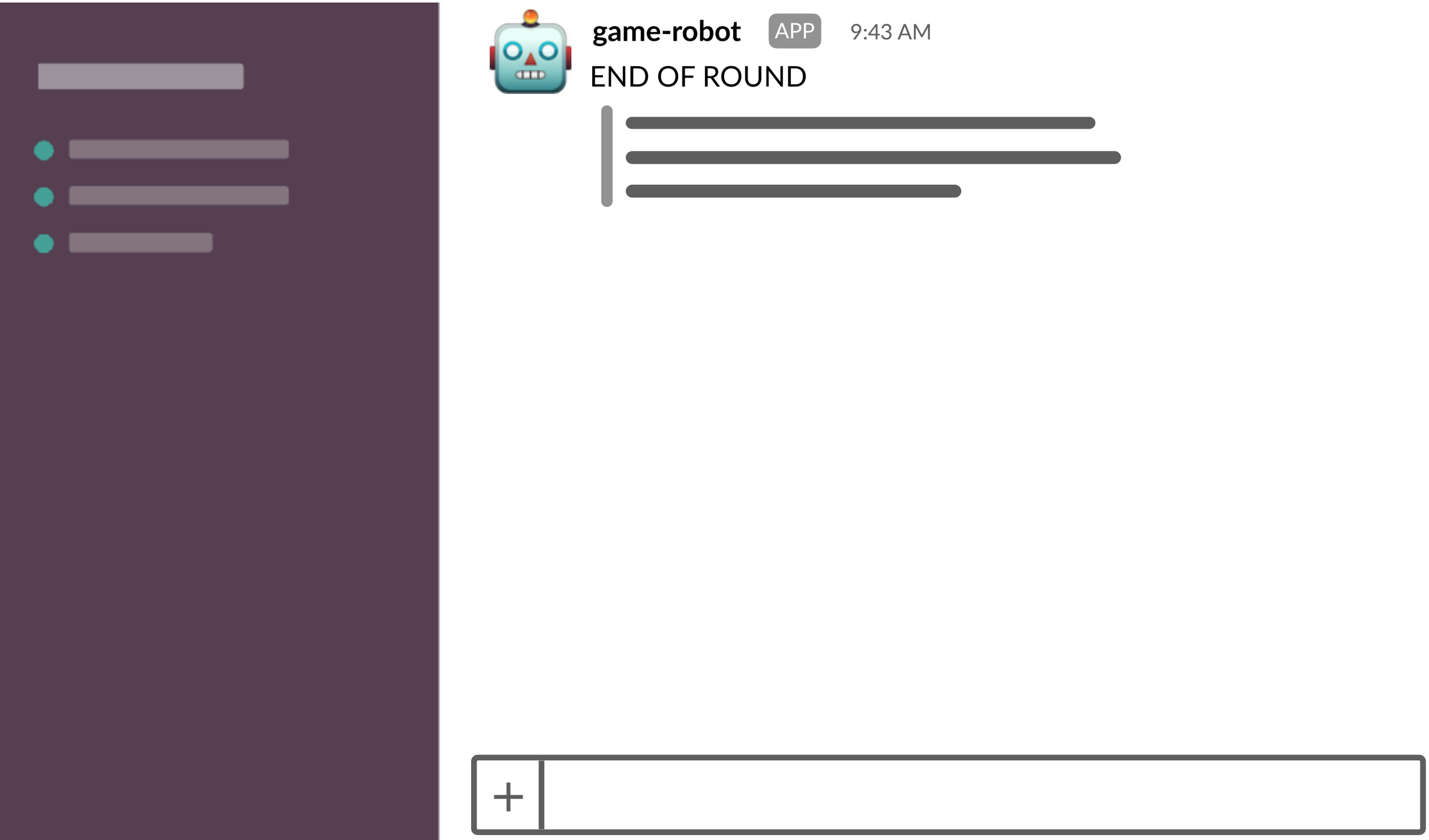


Coordination-robot gives teams structural interventions



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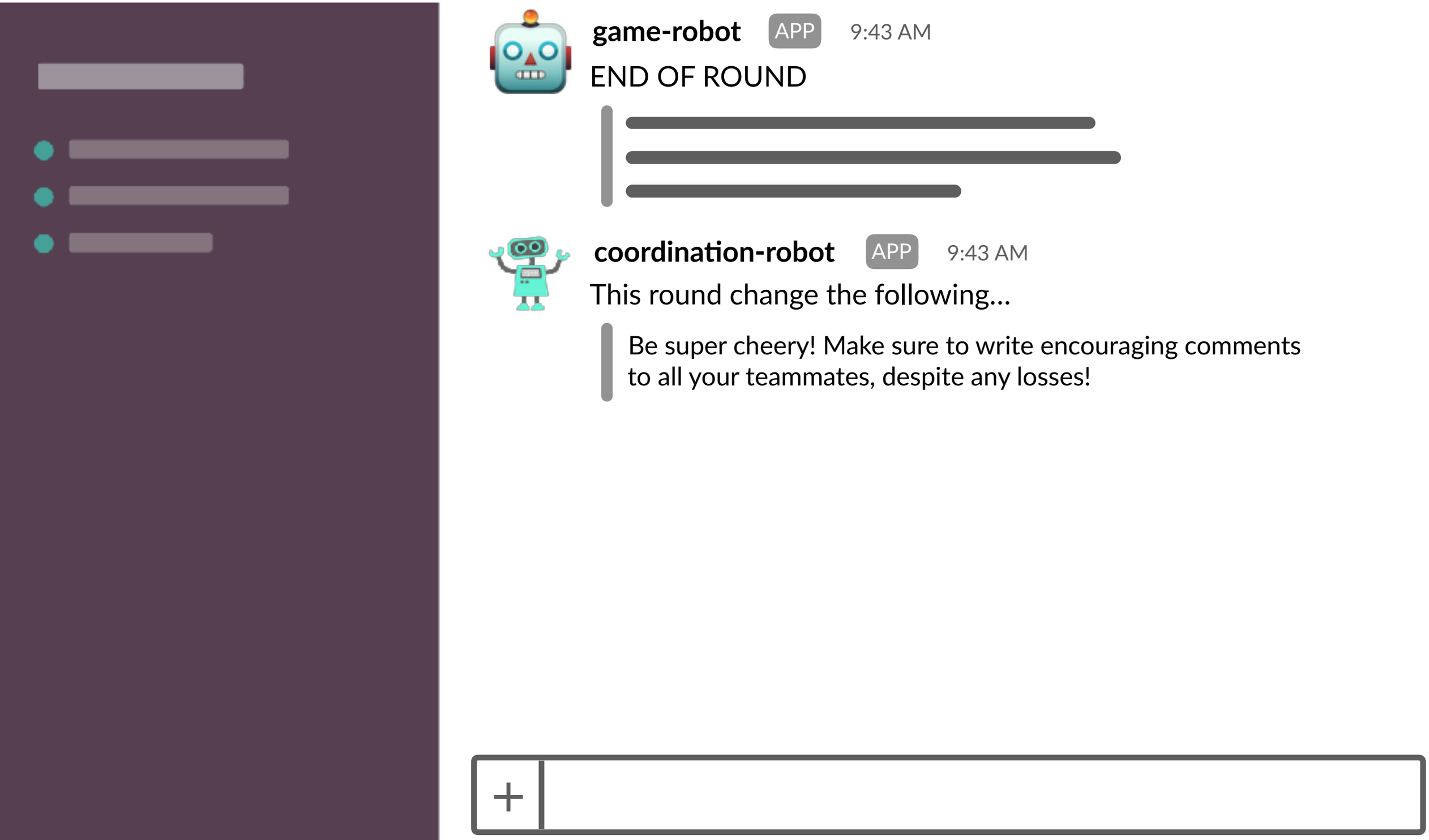

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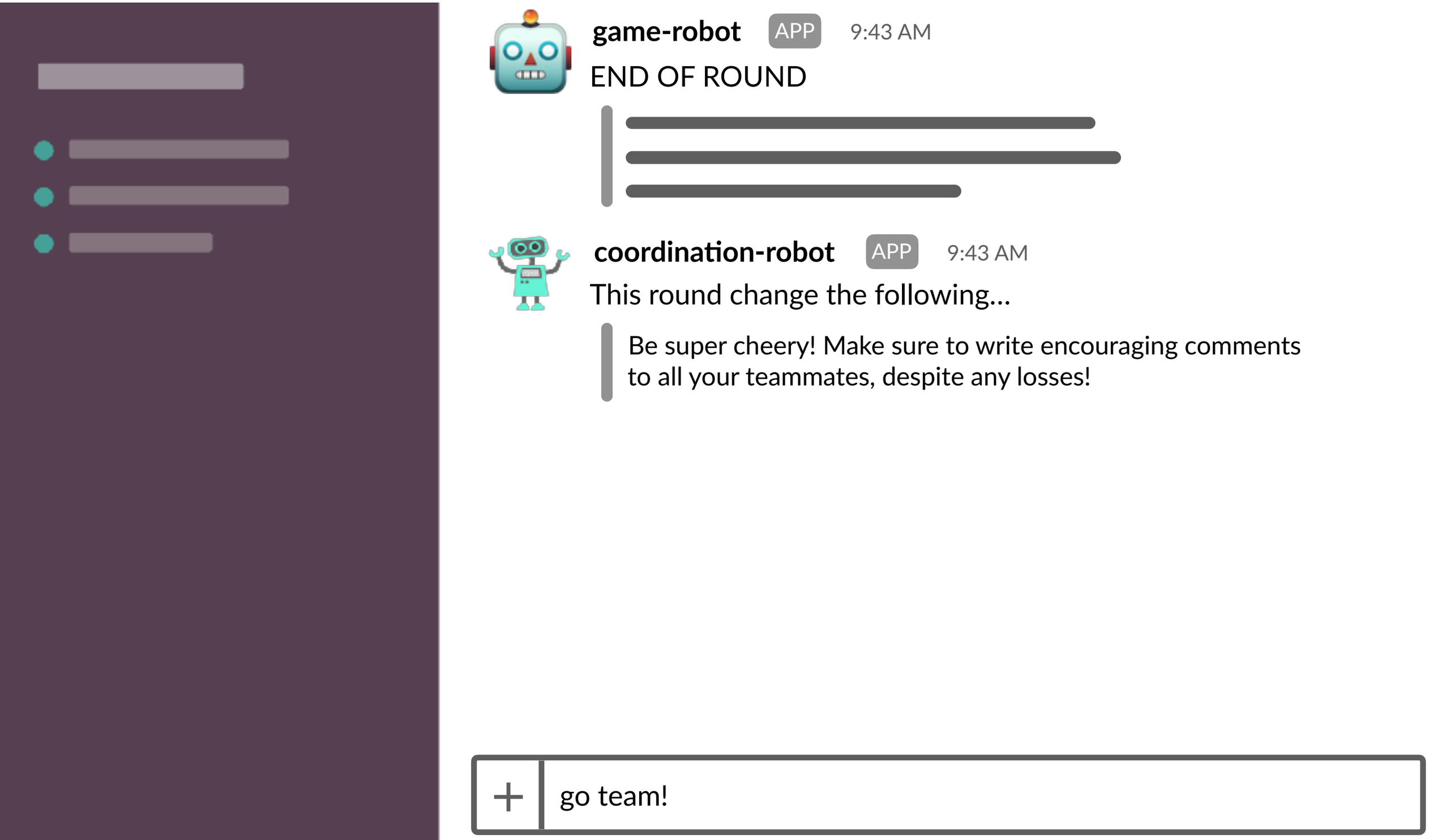

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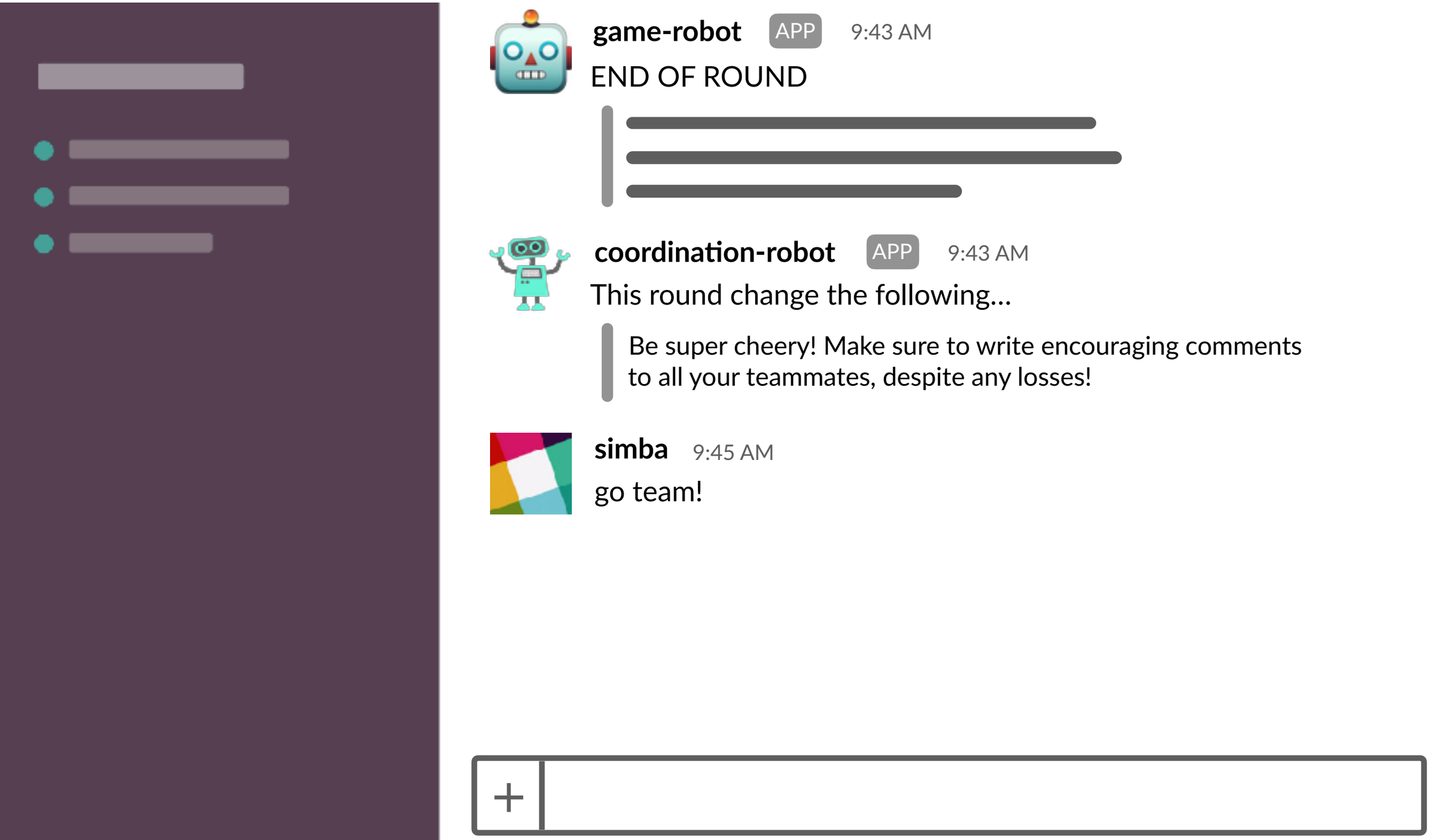

Across rounds, teams adapt to changing structures

System

DreamTeam is powered by a network of multi-armed bandits

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Multi-armed bandits efficiently

- explore different options (arms)
- exploit the best arms over time

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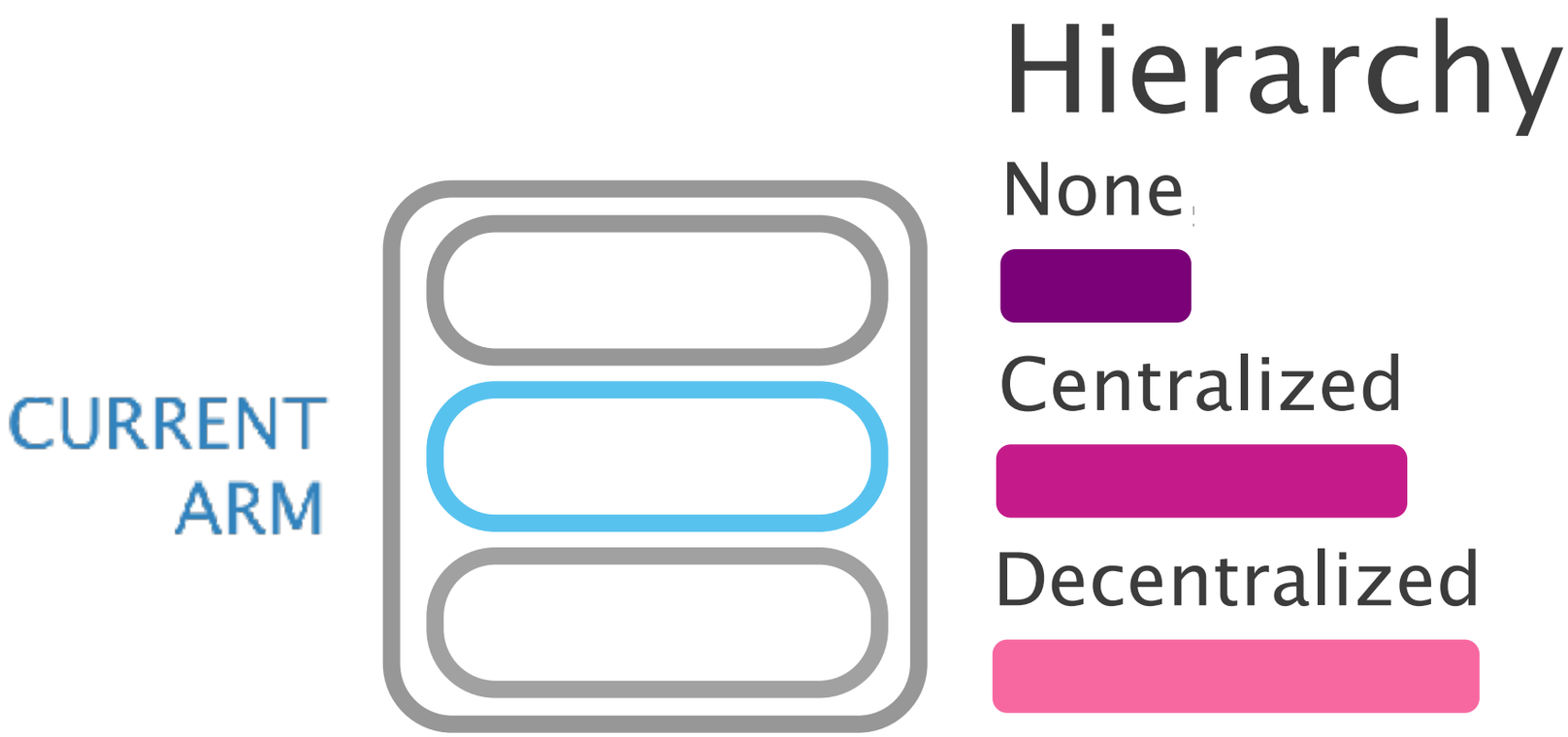

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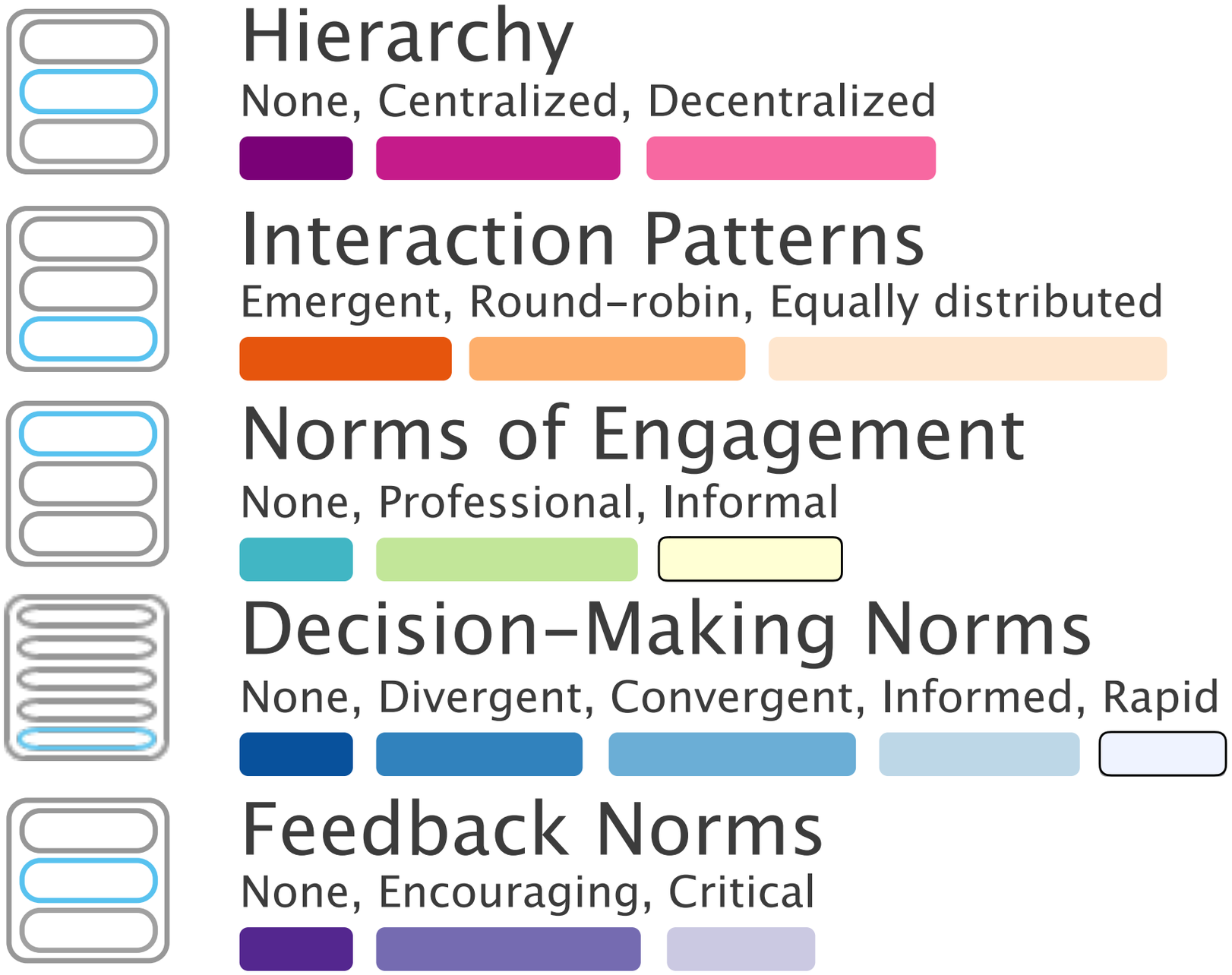

Gabillon et al. 2011
Caron and Bhagat 2013
Cesa-Bianchi et al. 2013

Bandits suggest an overwhelming number of changes

Hierarchy

Centralized

Interaction Patterns

Equally distributed

Norms of Engagement

Professional

Decision-Making Norms

Convergent

Feedback Norms

Encouraging

Bandits suggest an overwhelming number of changes

Hierarchy

Decentralized

Interaction Patterns

Round-robin

Norms of Engagement

Informal

Decision-Making Norms

Divergent

Feedback Norms

Critical

Bandits suggest an overwhelming number of changes

Hierarchy

None

Interaction Patterns

Equally distributed

Norms of Engagement

None

Decision-Making Norms

Rapid

Feedback Norms

Encouraging

Bandits suggest an overwhelming number of changes

Hierarchy

Centralized

Interaction Patterns

Equally distributed

Norms of Engagement

None

Decision-Making Norms

Rapid

Feedback Norms

Encouraging

How many changes can be made at once?

How many changes can be made at once?

How many changes can be made at once?

- Teams' receptiveness to structural change varied temporally
- Most receptive near the midpoint of their progress

Okhuysen and Waller 2002

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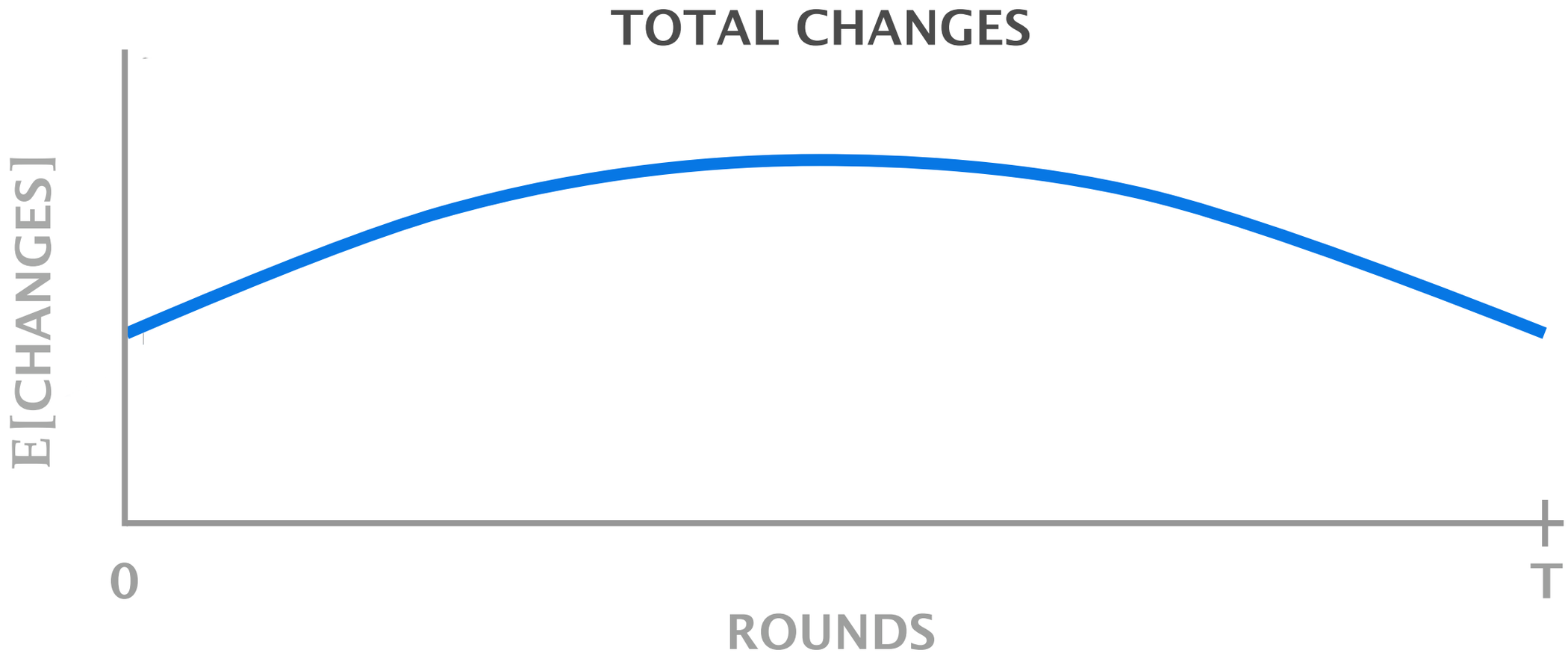
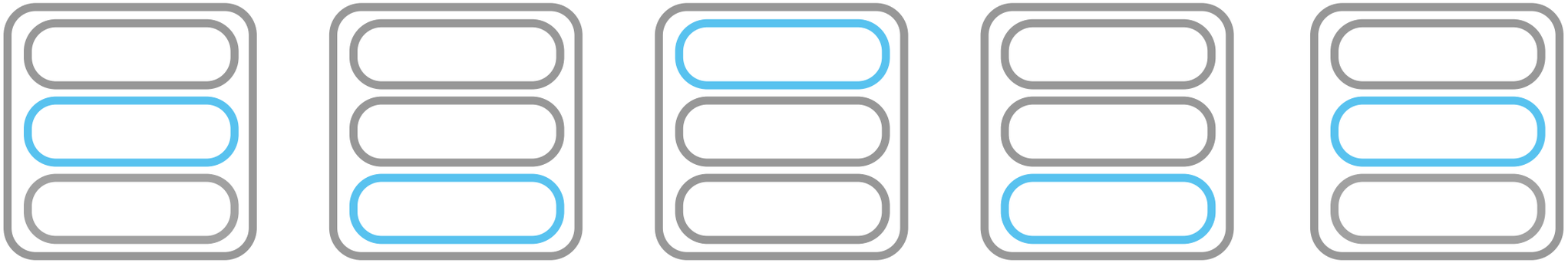
- Most receptive near the midpoint of their progress



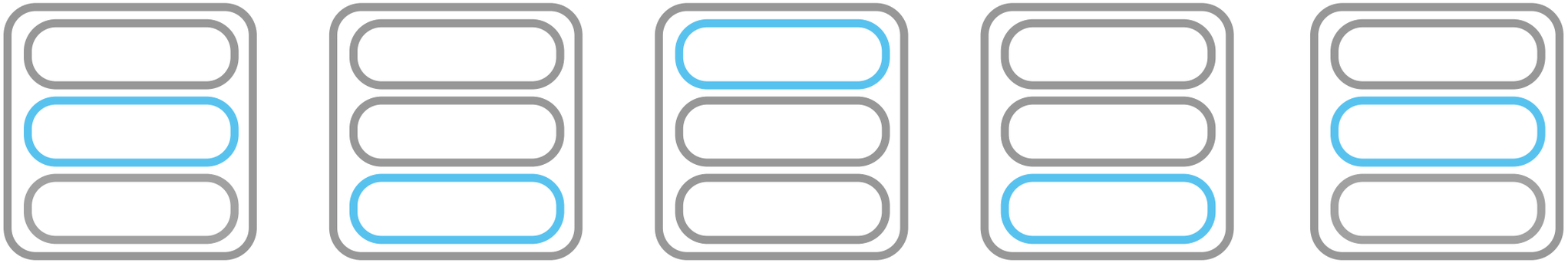
Use constraints to limit total changes across the network

Use constraints to limit total changes across the network



E[changes] = 5

Use constraints to limit total changes across the network



E[changes] = 5

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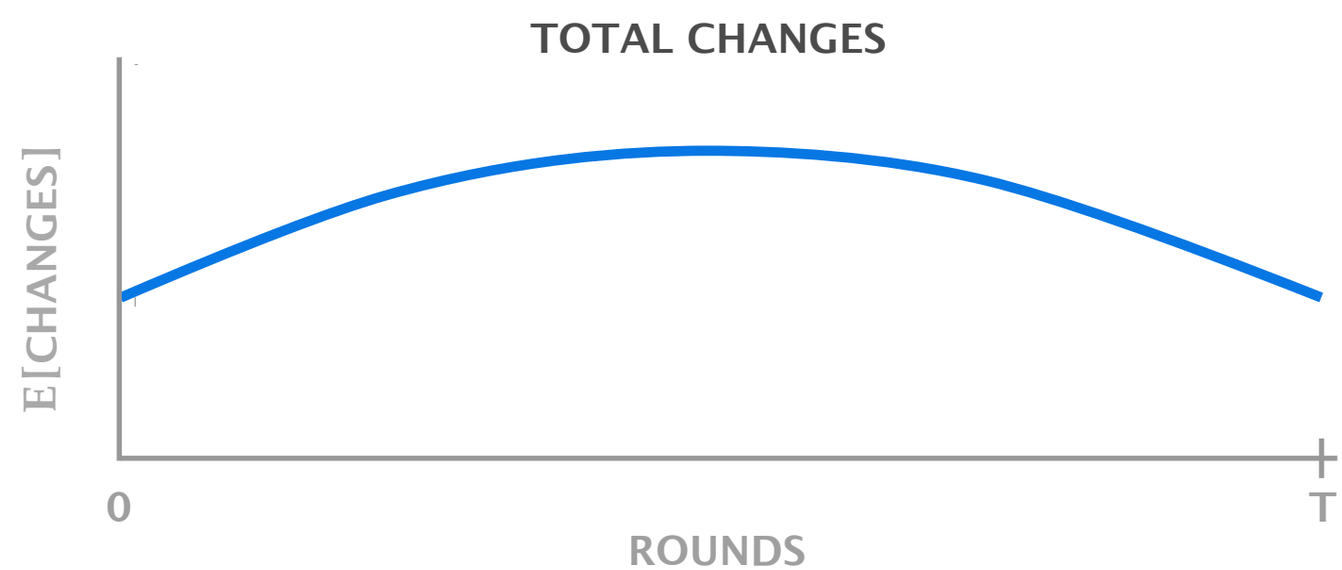
Constraint = 2



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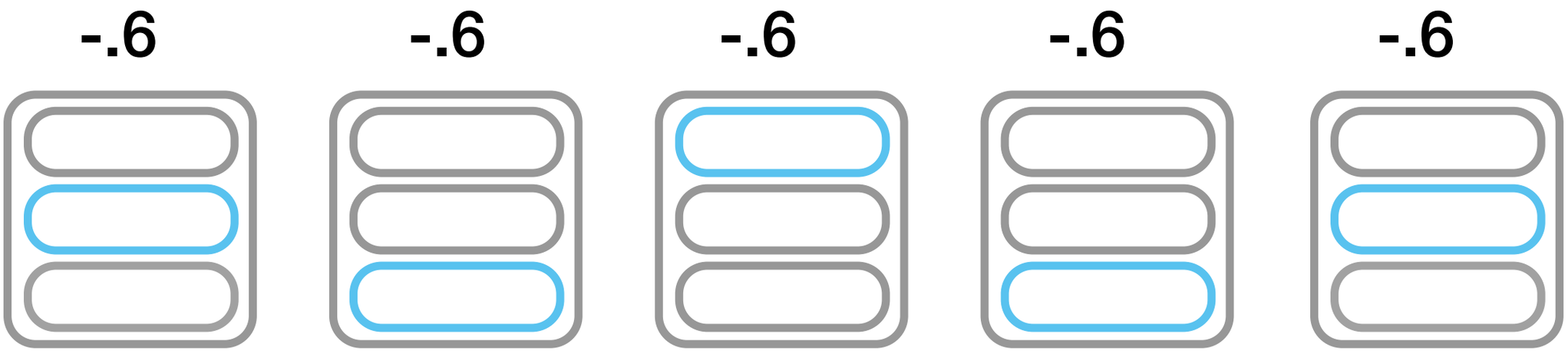

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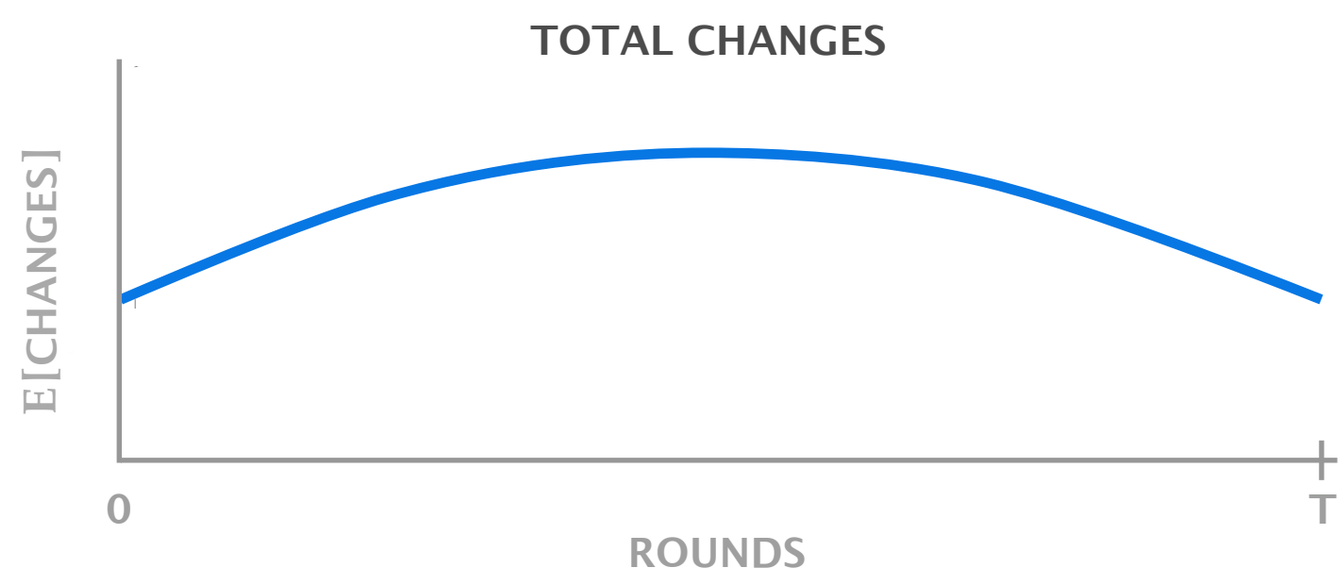

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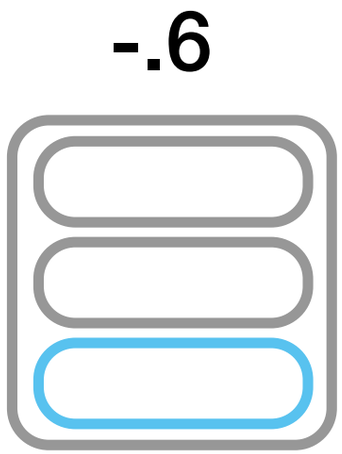

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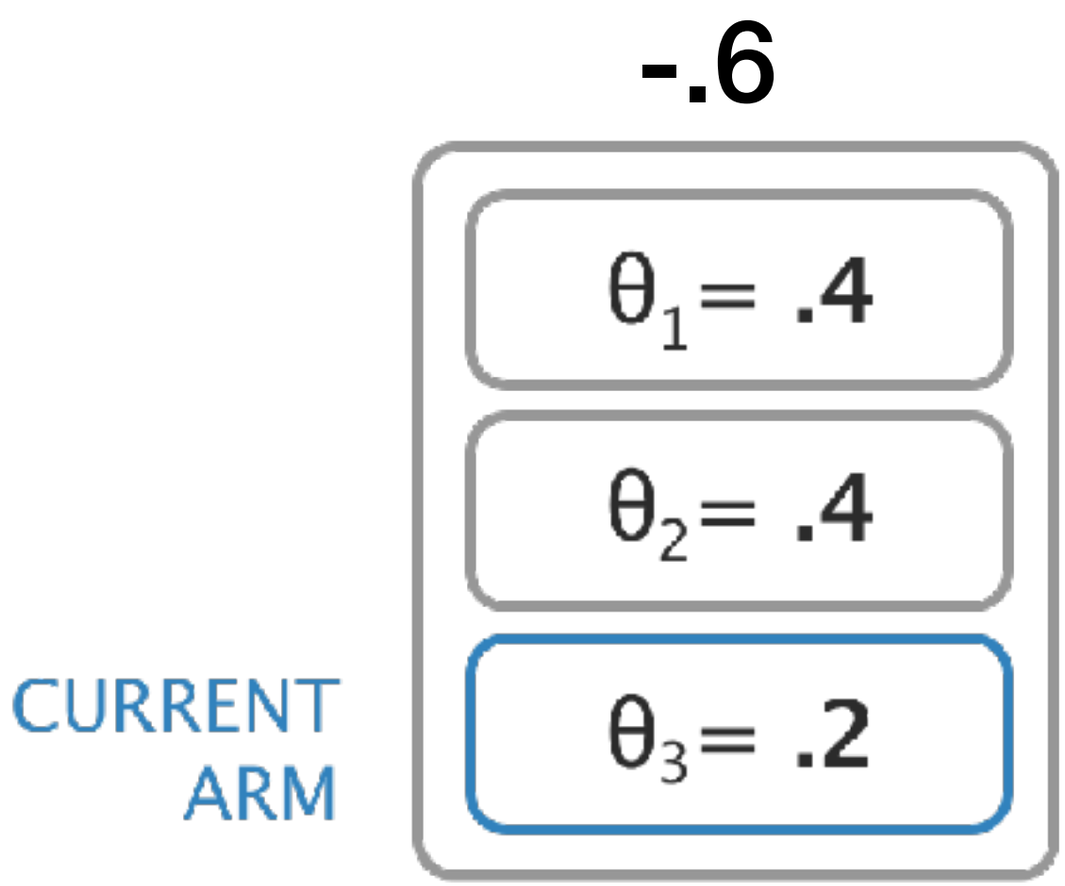

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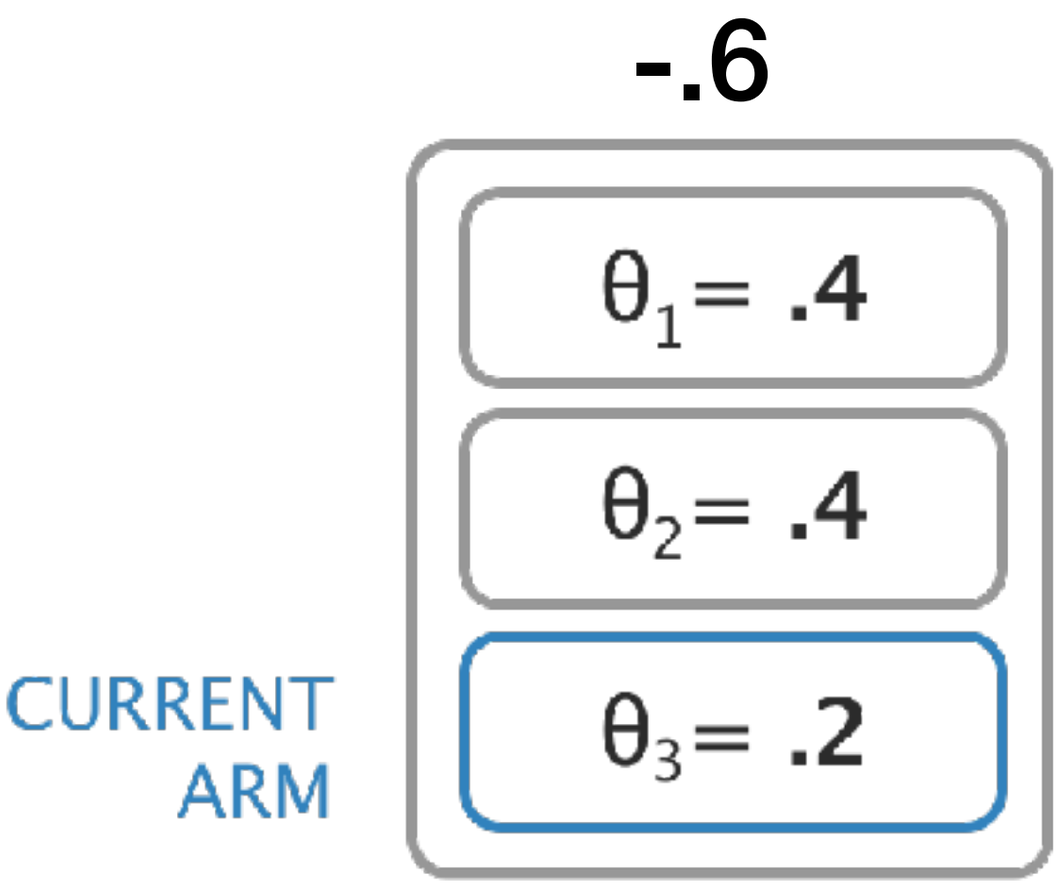
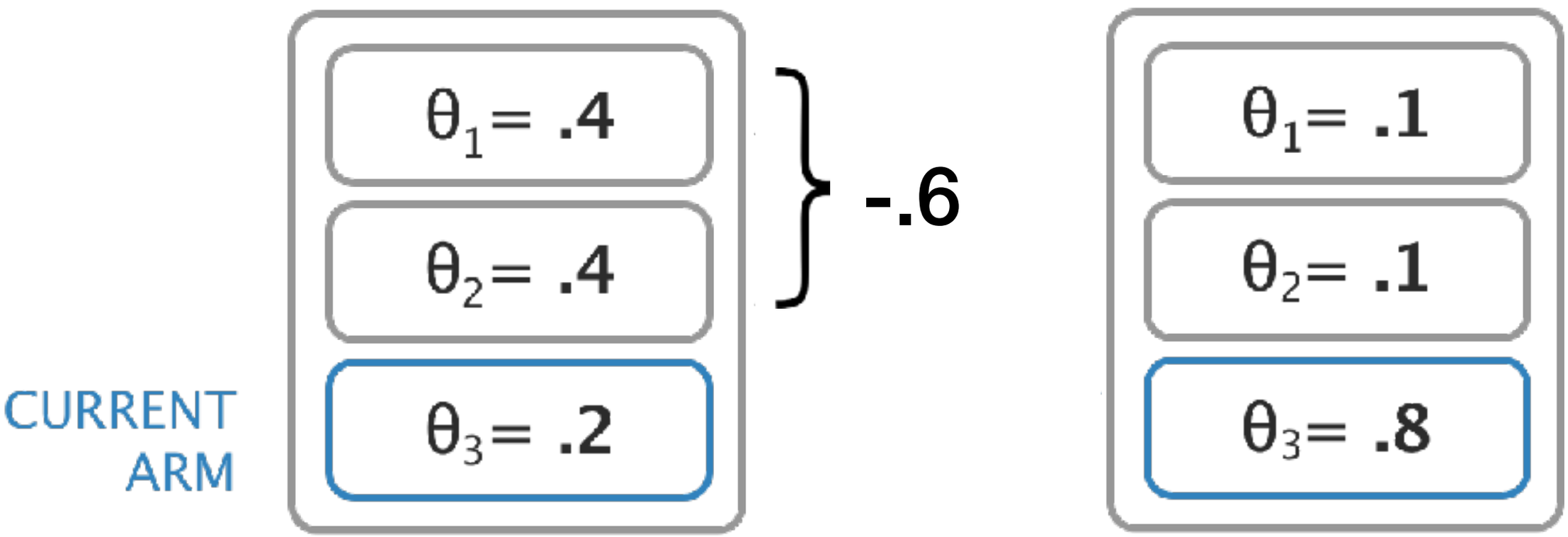


Thompson sampling probabilities θ_i represent likelihood of choosing arm i

Agrawal and Goyal 2012

Use constraints to limit total changes across the network



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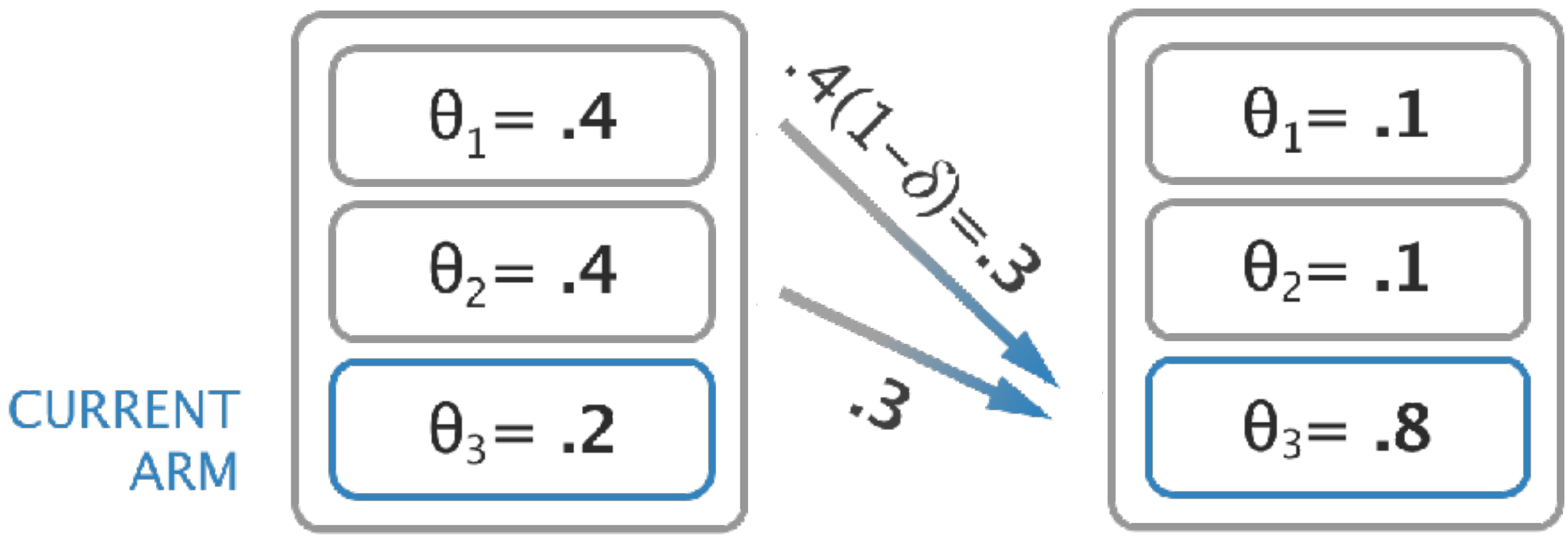

Thompson sampling probabilities represent likelihood of choosing arm

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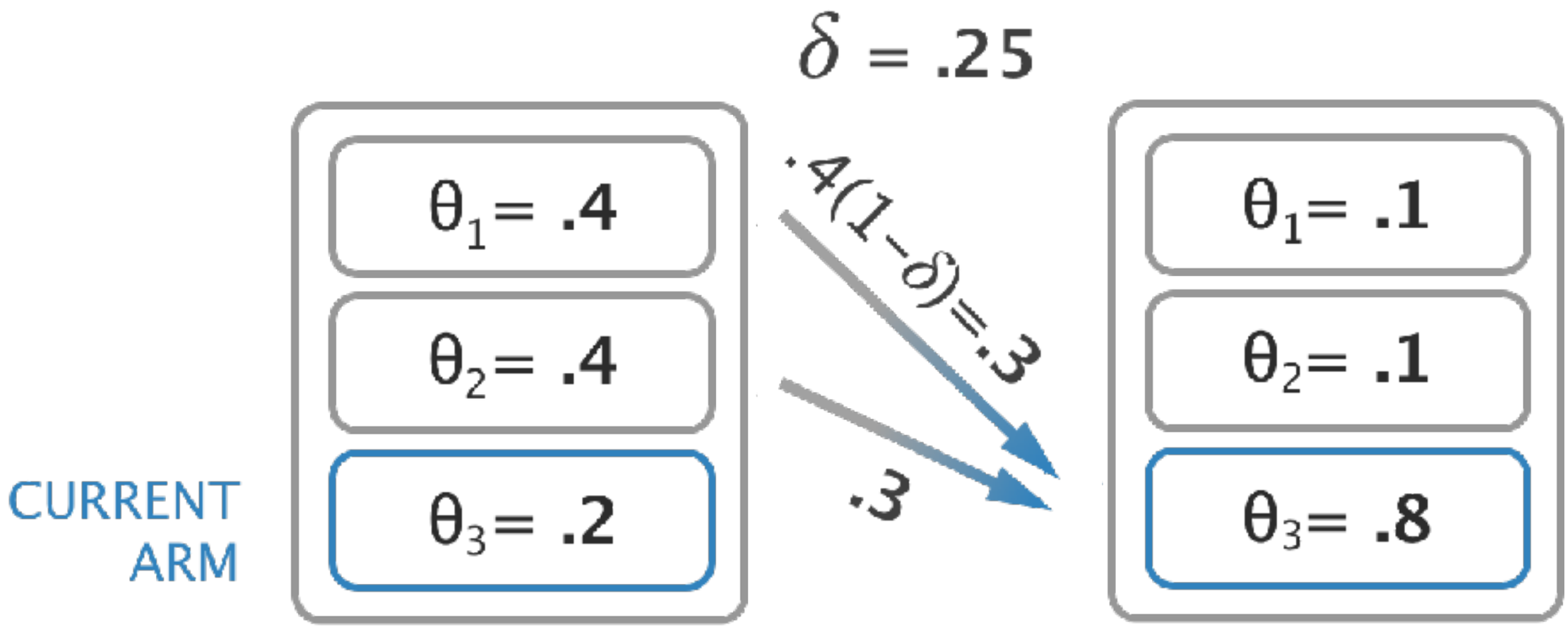


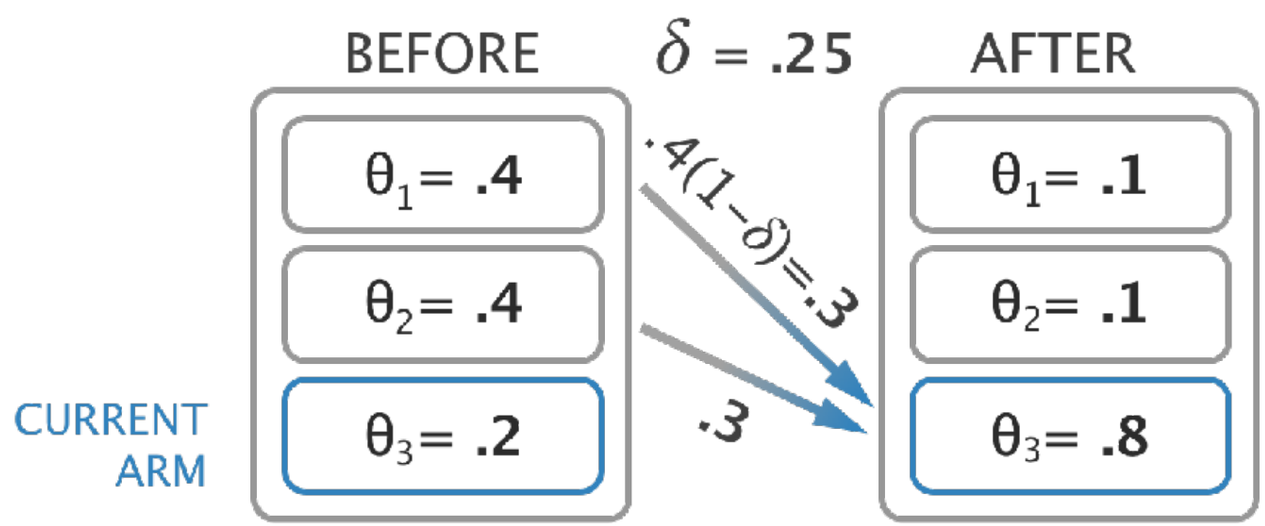
$$\theta'_i = \begin{cases} \theta_i \delta, \text{ if } i \neq c \\ \theta_i + \sum_{j \neq c} \theta_j (1-\delta), \text{ if } i = c \end{cases}$$

Use constraints to limit total changes across the network

E[changes] = 5

>

Constraint = 2



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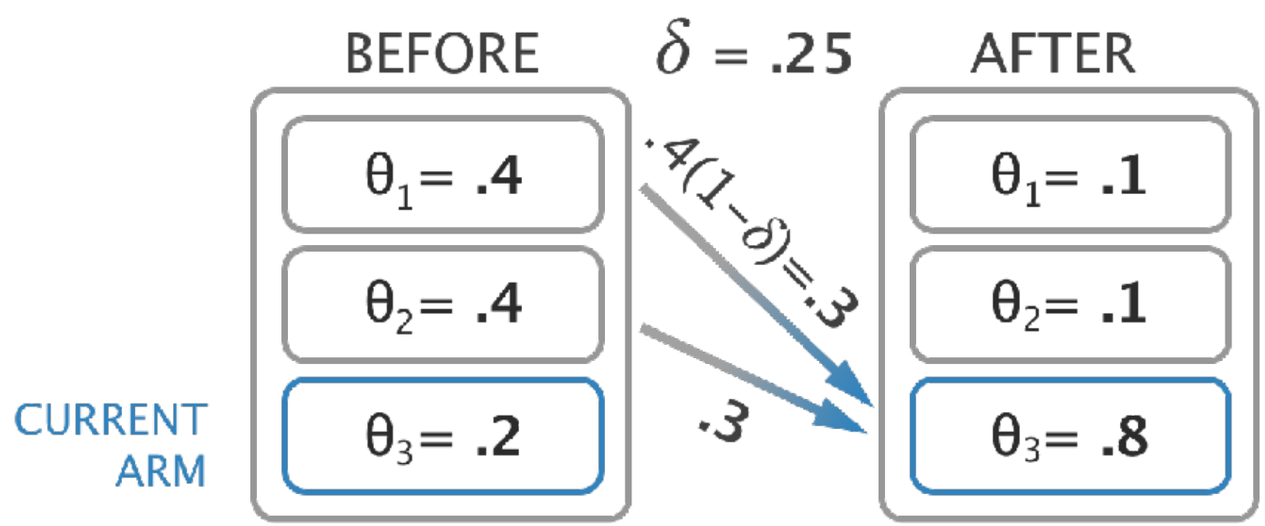
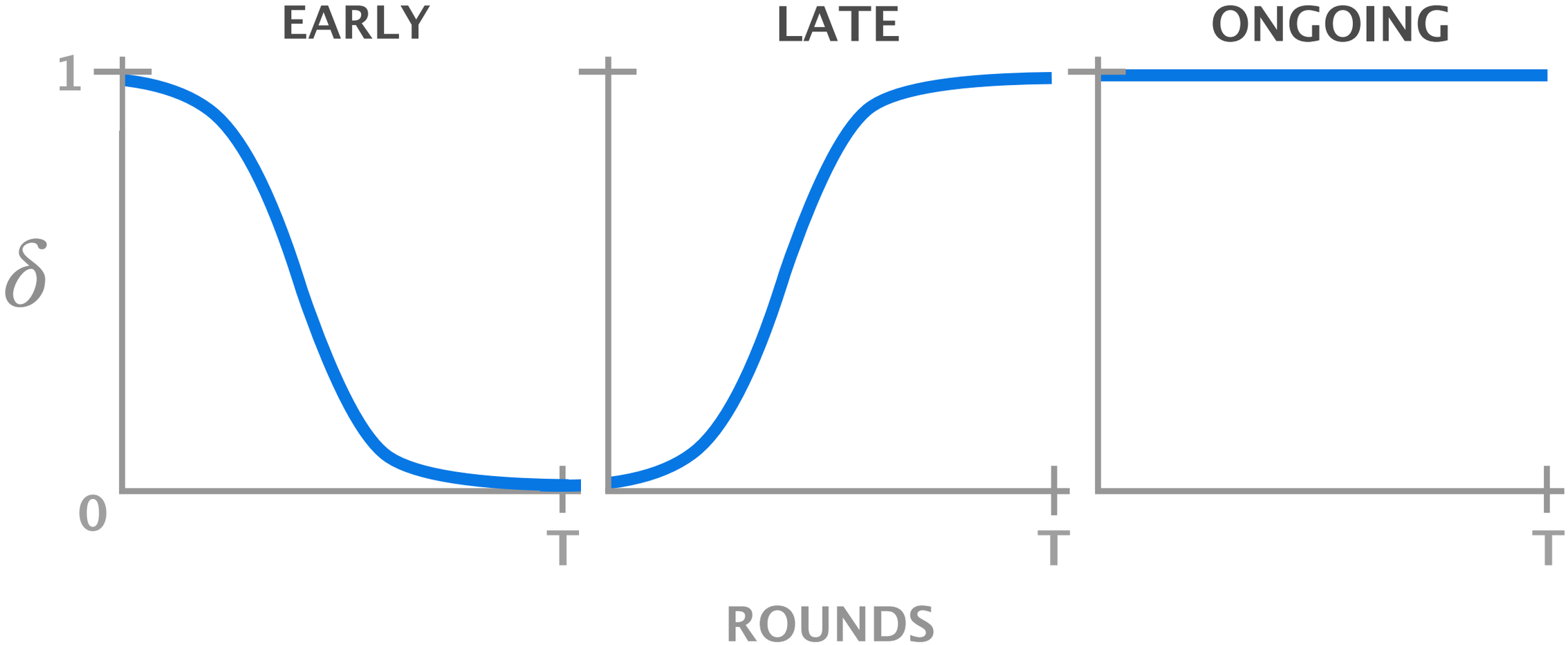


How do we prioritize what should change?

How do we prioritize what should change?

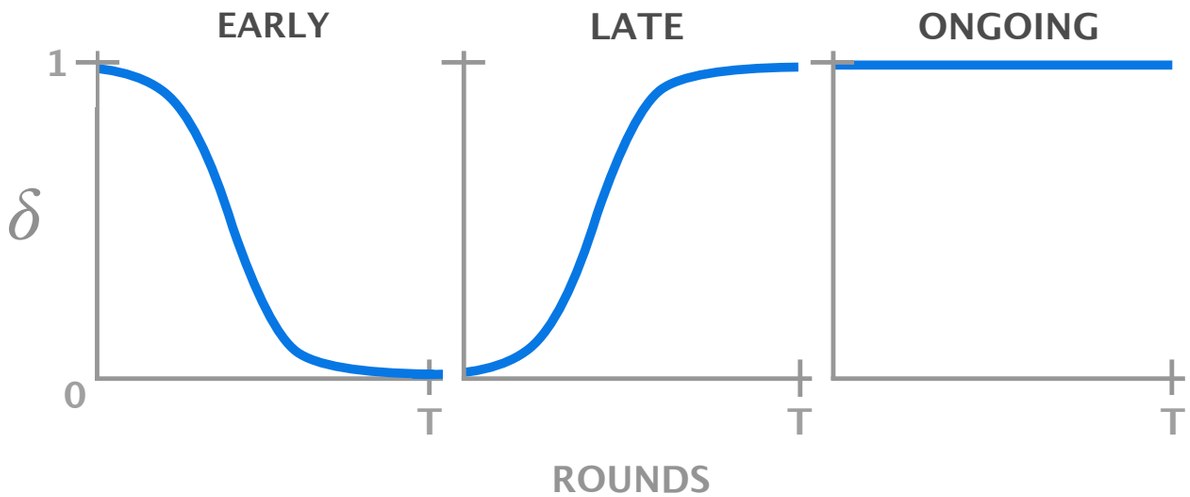
- Team are receptive to changes in some dimensions **earlier**, others **later**

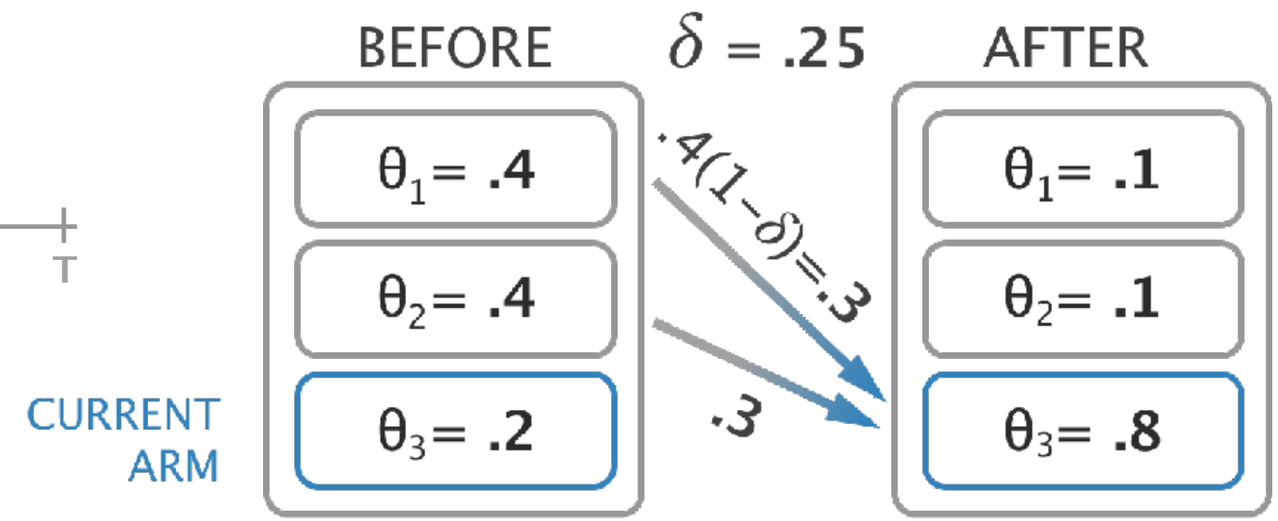


Marks et al 2001

How do we prioritize what should change?

- Team are receptive to changes in some dimensions **earlier**, others **later**





Evaluation

135 people from
Amazon Mechanical Turk

135 people from
Amazon Mechanical Turk

45 teams on Slack

135 people from
Amazon Mechanical Turk

45 teams on Slack

Task adapted from Codenames

1. **Manager-chosen**

   List of team structures given to an elected manager

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2. **Collectively-chosen**
   List of team structures given for teams to choose

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   Team structures chosen by unconstrained bandits, communicated with coordination-robot

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   No intervention

1. **Manager-chosen**
   List of team structures given to an elected manager

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   List of team structures given for teams to choose

3. **Unconstrained bandit-chosen**
   Team structures chosen by unconstrained bandits, communicated with coordination-robot

4. **Control**
   No intervention

5. **DreamTeam**
   Team structures chosen by temporally constrained bandits, communicated with coordination-robot

DreamTeam teams significantly outperform other conditions

Measured performance using scores on 10 rounds of the task.

DreamTeam outperformed:

Manager-chosen	by	46%
Collectively-chosen		45%
Unconstrained bandit-chosen		41%
Control		38%

Repeated measures ANCOVA $p<0.05$, all post-hoc Tukey pairwise comparisons to Dreamteam $p<0.05$. $N=45$.
We used a non-intervention training round as a covariate, to control for teams' initial performance.

Managers were risk-averse and hesitant to explore

- 2 structures explored on average
- At most 3 combinations explored, as opposed to 8-9 in the bandit conditions
- Managers also varied in involving team for feedback or imposing recommendations

lions1975 3:30 PM

Do you like the first way better?

Tversky and Kahneman 1992

Managers were risk-averse and hesitant to explore

- 2 structures explored on average
- At most 3 combinations explored, as opposed to 8-9 in the bandit conditions
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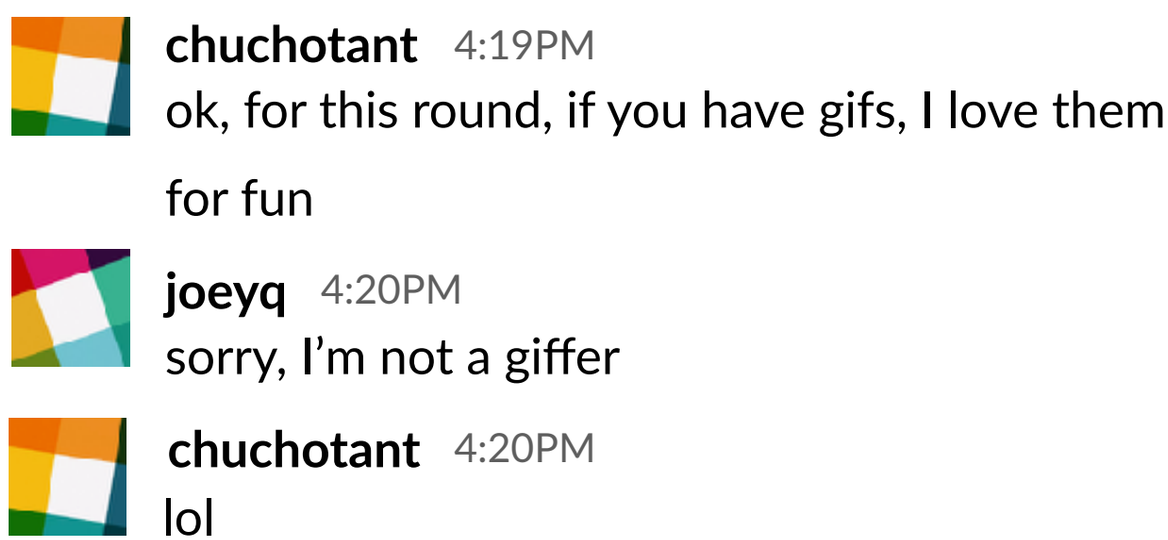

Overwhelmed, teams under unconstrained bandits ignored changes

- 33% of teams ignored the chosen structures
- Difficult to galvanize collective effort, e.g. leadership election, round-robin participation

coordination-robot APP

This round, do the following differently from last round, please!

> Take turns suggesting answers. Make an order of who goes 1st, 2nd, 3rd.
>
> You're a democracy. Vote on what to submit and respect the majority vote. Do not submit until there's a majority on one of them.
>
> Take time explaining the answers you suggest and reflect on why a previous submission was right or wrong.
>
> Add some fun with images, emojis, and GIFs to your discussion. Spend time getting to know your teammates.

DreamTeam teams engaged with the exploration of novel structures

DreamTeam teams engaged with the exploration of novel structures

anne_turker 1:40 PM

I'm scared to type anything

DreamTeam teams engaged with the exploration of novel structures

anne_turker 1:40 PM
I'm scared to type anything

coordination-robot APP 2:11 PM
This round, do the following differently from last round, please!

> Be super cheery! Make sure to write encouraging comments to all your teammates, d
> other.

Note: We're trying to help your team work better with these guidelines. Please fulfill them as
affect compensation.)

nickbstack 2:11 PM
go team!!!!

loulou 2:11 PM
we are killin it

anne_turker 2:12 PM
you guys are awesome!!!!

DreamTeam teams engaged with the exploration of novel structures

anne_turker 1:40 PM
I'm scared to type anything

anne_turker 2:55 PM
You guys were the best team ever!

coordination-robot APP 2:11 PM
This round, do the following differently from last round, please!

> Be super cheery! Make sure to write encouraging comments to all your teammates, d
> other.

Note: We're trying to help your team work better with these guidelines. Please fulfill them as
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nickbstack 2:11 PM
go team!!!!

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we are killin it

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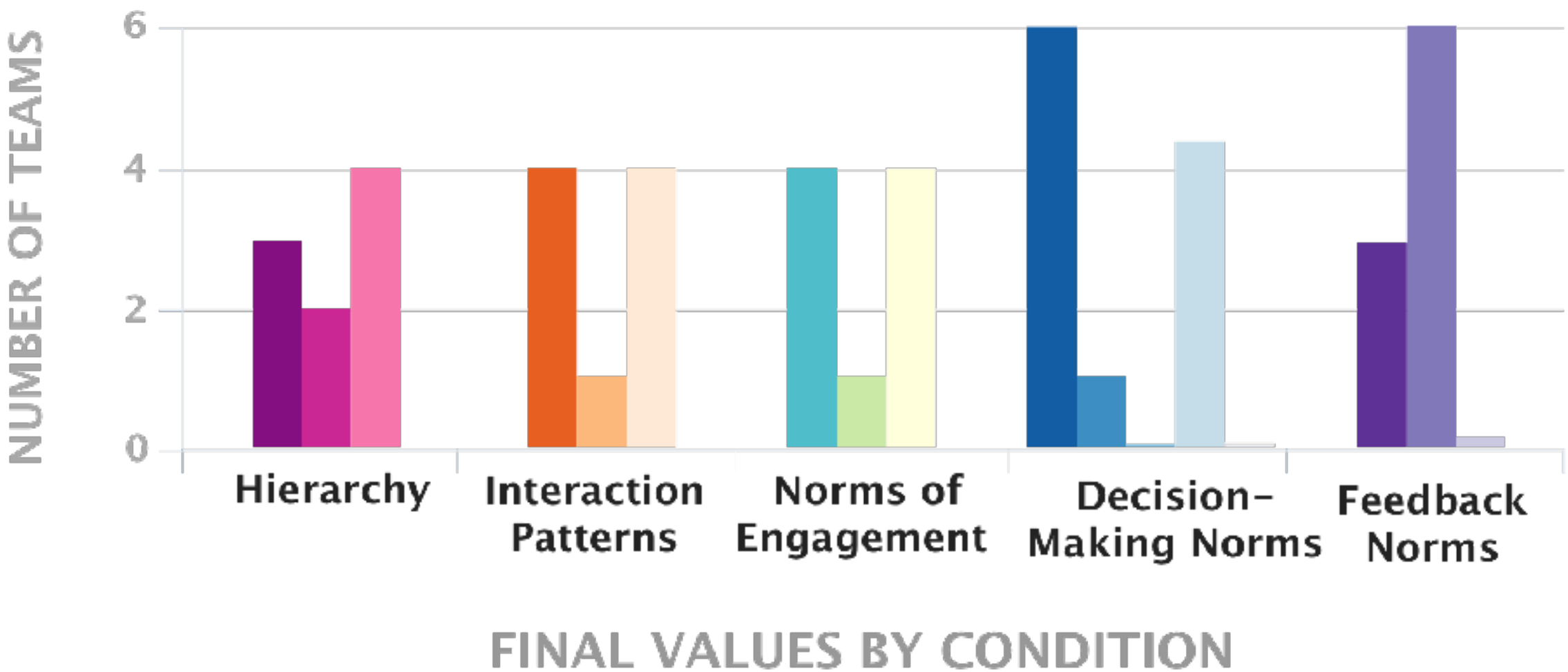
Effective structures varied substantially

Supports structural contingency theory:
There are no universally ideal structures



Limitations & Opportunities

- Feedback focused on performance, not yet on self-reported metrics
- The same task iteratively, not yet the changing demands or tasks of a team

Discussion

The future of work opens opportunities for computationally augmented teams

- Help overcome manager biases of team’s needs through exploration

The future of work opens opportunities for computationally augmented teams

- Help overcome manager biases of team’s needs through exploration

- Represent a step toward a partnership between computation and collaboration

The future of work opens opportunities for computationally augmented teams

- Help overcome manager biases of team’s needs through exploration

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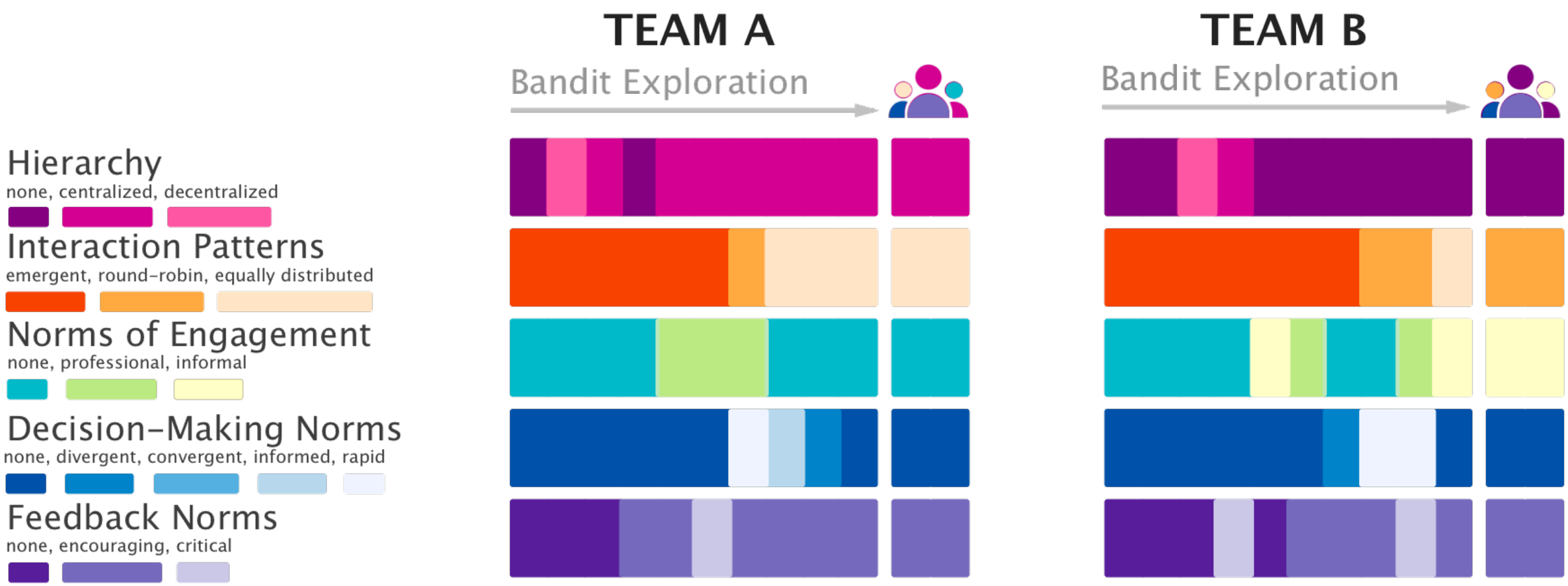
DreamTeam


TEAM A
Bandit Exploration
TEAM B
Bandit Exploration
Hierarchy
none, centralized, decentralized
Interaction Patterns
emergent, round-robin, equally distributed
Norms of Engagement
none, professional, informal
Decision-Making Norms
none, divergent, convergent, informed, rapid
Feedback Norms
none, encouraging, critical

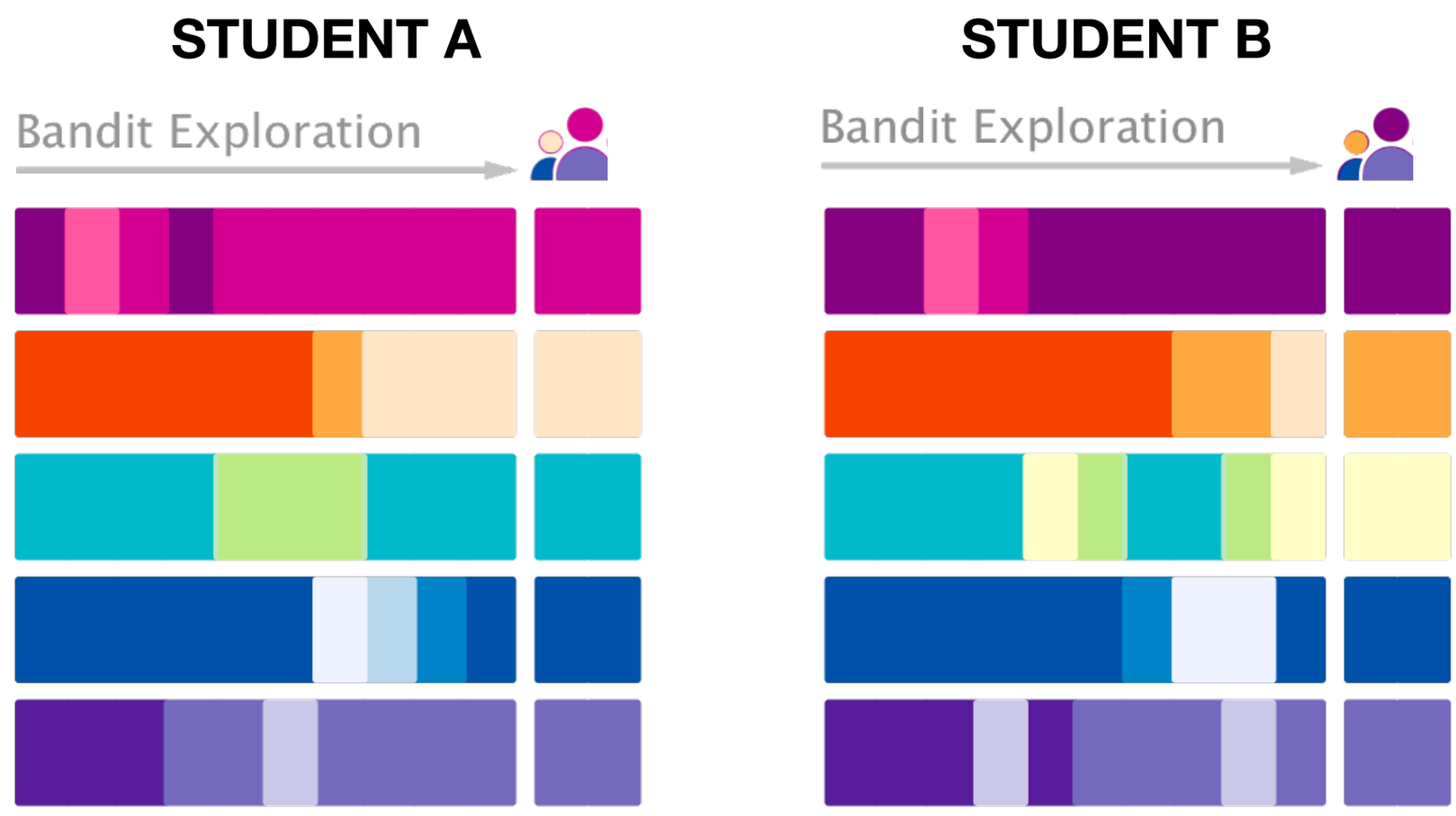
DreamAdvisor

Involvement
hands-on / hands-off

Meetings
every day / every week / ad hoc

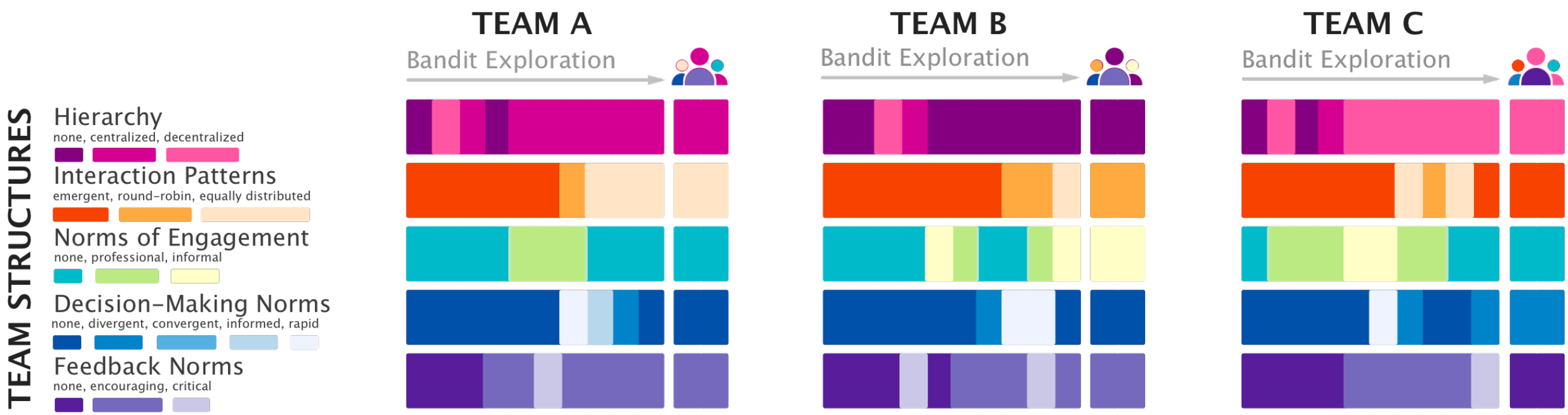
Level of feedback
high-level / low-level / everything

???



In Search of the Dream Team

Temporally Constrained Multi-Armed Bandits For Identifying Effective Team Structures



Sharon Zhou, Melissa Valentine, Michael Bernstein
Stanford University

Contributions

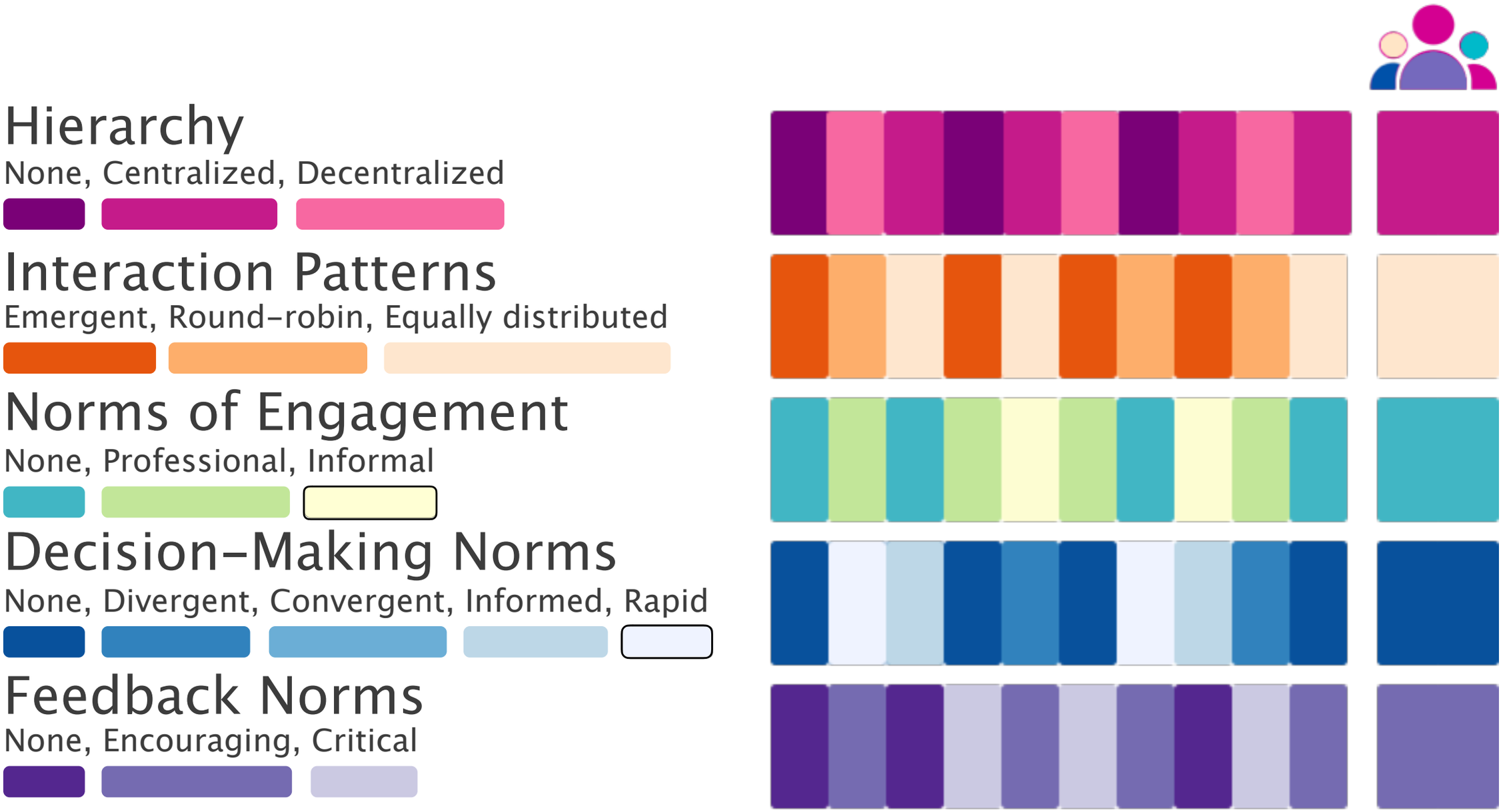
1. Concept of computationally empowered **identification of effective team structures**

2. A system — **DreamTeam** — manifesting this concept

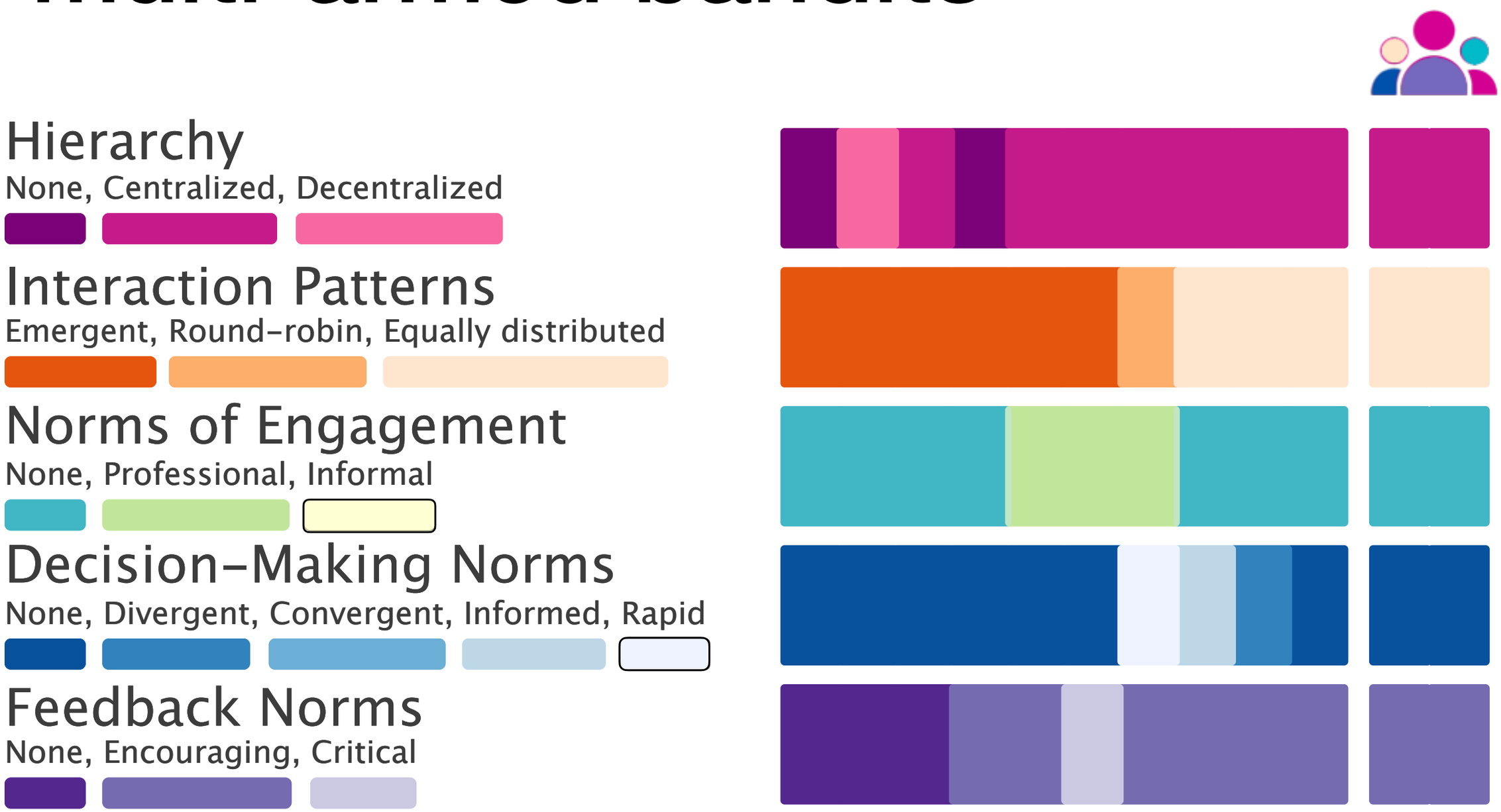
3. **Temporal constraints** which regulate exploration timing in a network of **multi-armed bandits**

4. An **evaluation** demonstrating that this approach outperforms traditional ones on a complex collaborative task

Multi-armed bandits overwhelm teams with simultaneous change



Temporally constrained multi-armed bandits



HCI systems have been designed for specific structures

Interaction Patterns

equally distributed

Meeting Mediator: Enhancing Group Collaboration with Sociometric Feedback

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Abstract
In this paper we present the Meeting Mediator (MM), a real-time, personal, and portable system providing feedback to enhance group collaboration. Social interactions are captured using Sociometric badges [6] and are visualized on mobile phones to promote change in behavior. In a study on brainstorming and problem-solving meetings, MM had a significant effect on overlapping speaking time and interactivity level without distracting the subjects. Our system encourages effective group dynamics that may lead to higher performance and satisfaction. We envision MM to be deployed in real-world organizations to improve interactions across various group collaboration contexts.

HCI systems have been designed for specific structures

Interaction Patterns

round-robin

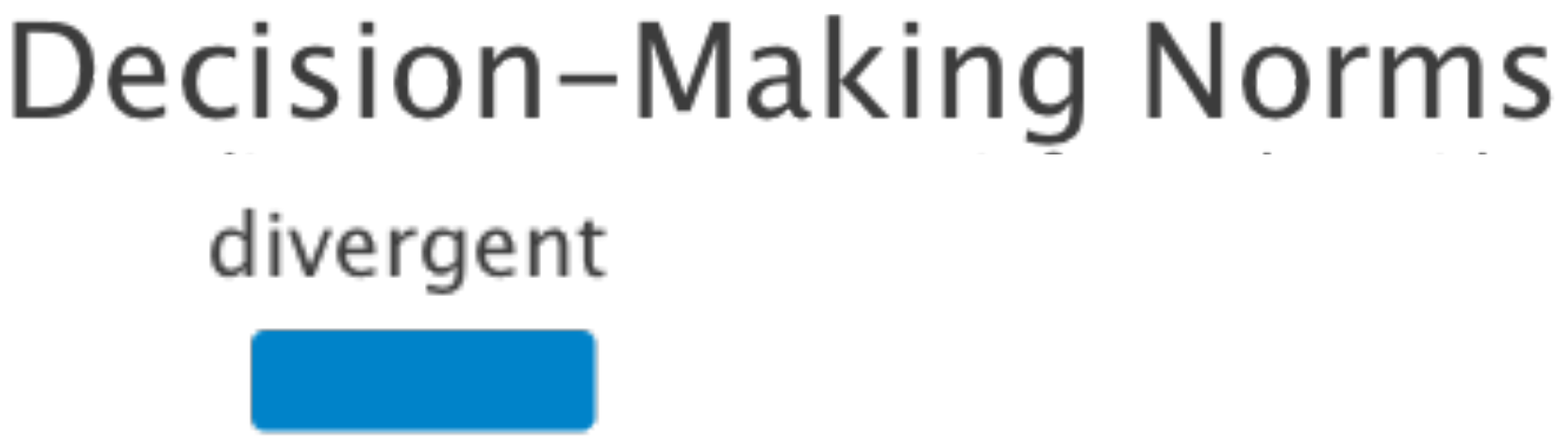
Turn-Taking Protocols for

Mouse-Driven Collaborative Environments

Kori Inkpen[1], Joanna McGrenere[2], Kellogg S. Booth[1], Maria Klawe[1]

[1]Department of Computer Science
The University of British Columbia
Vancouver, British Columbia, V6T 1Z4, Canada

HCI systems have been designed for specific structures



Mechanical Novel: Crowdsourcing Complex Work through Reflection and Revision

Joy Kim, Sarah Sterman, Allegra Argent Beal Cohen, Michael S. Bernstein
Stanford University
{jojo0808, ssterman, aacohen}@stanford.edu, msb@cs.stanford.edu

TRACT
dsourcing systems accomplish large tasks with scale
need by breaking work down into independent parts,
large tasks by decomposing work into independent m
tasks. These microtask systems present work in an asse
line-like structure called a workflow [6], using mechan

HCI systems have been designed for specific structures

Decision-Making Norms

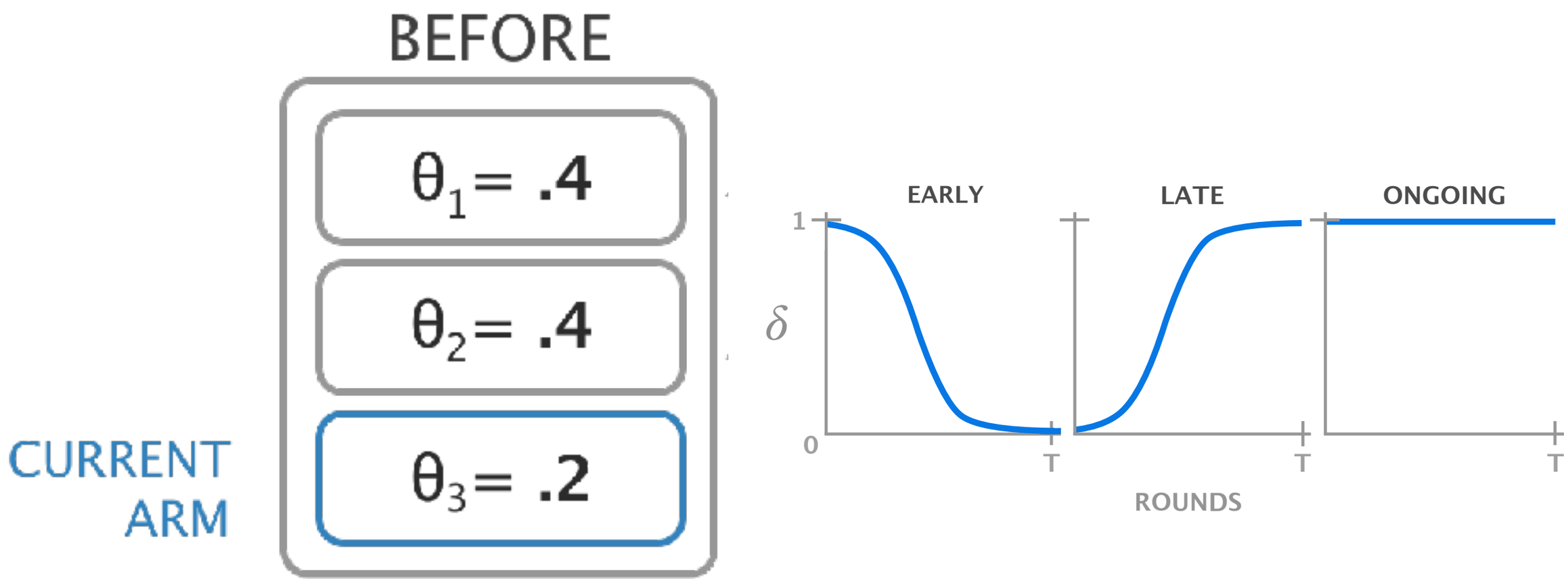
convergent

ConsensUs: Supporting Multi-Criteria Group Decisions by Visualizing Points of Disagreement

WEICHEN LIU, University of California San Diego
SIJIA XIAO, Georgia Institute of Technology
JACOB T. BROWNE, University of California San Diego
MING YANG, Cornell University
STEVEN P. DOW, University of California San Diego

Use constraints to shift the probability of exploring

- Thompson sampling probabilities θ_i represent likelihood of choosing arm i



Use constraints to shift the probability of exploring

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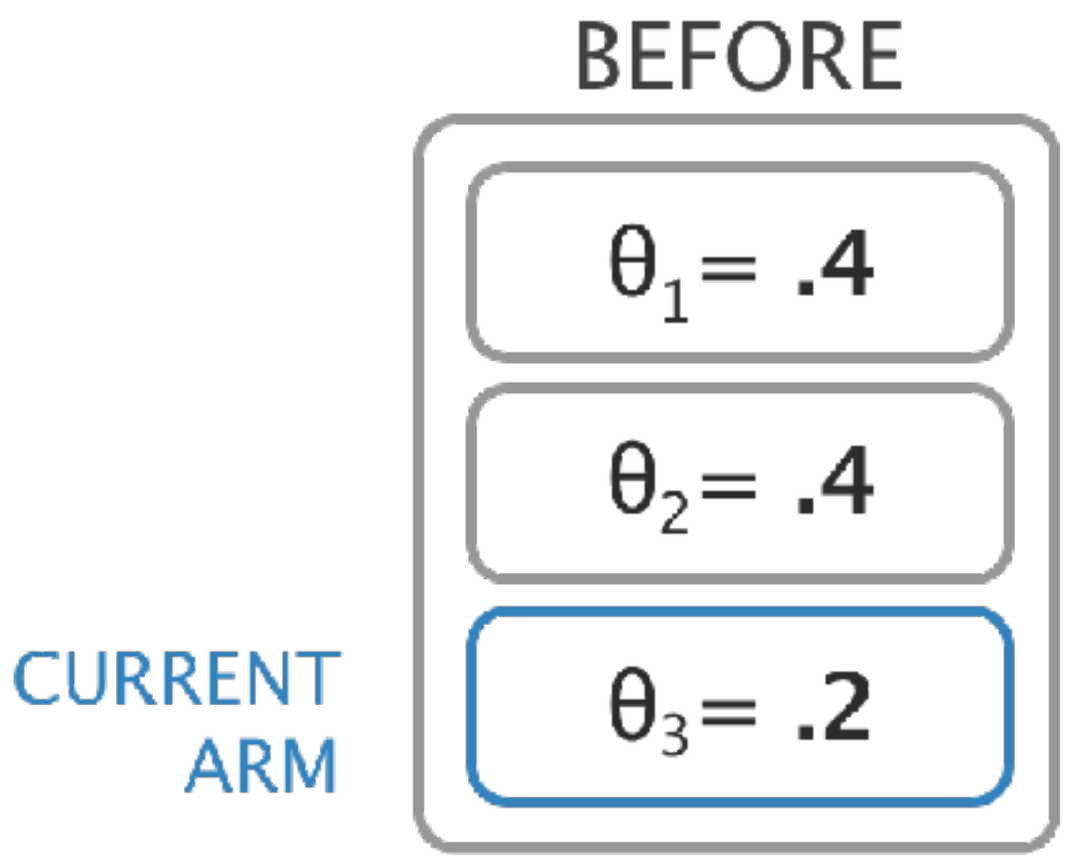
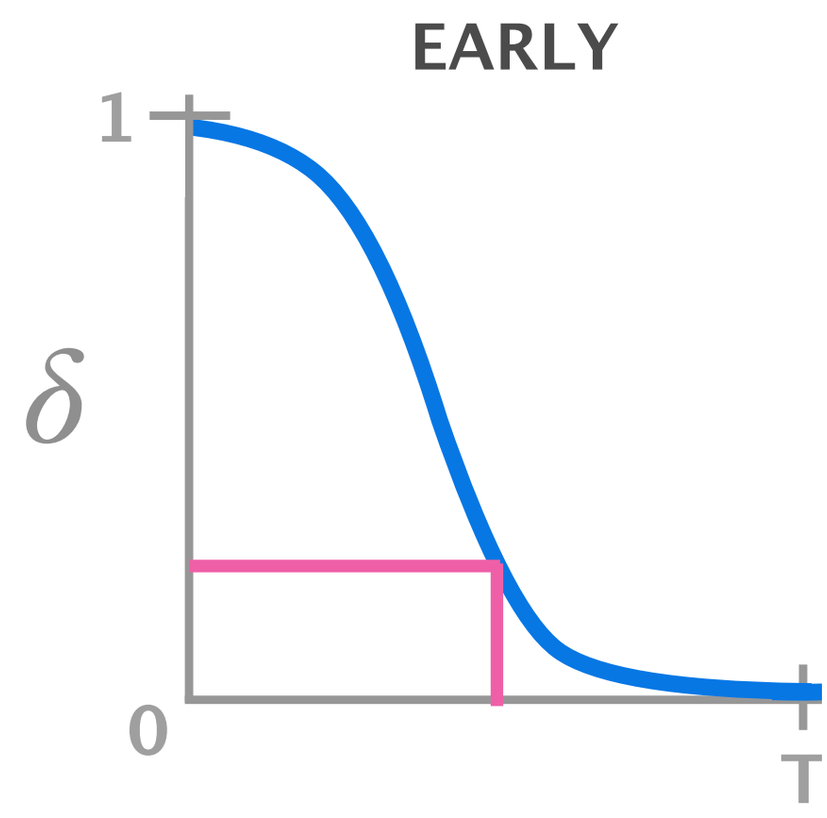
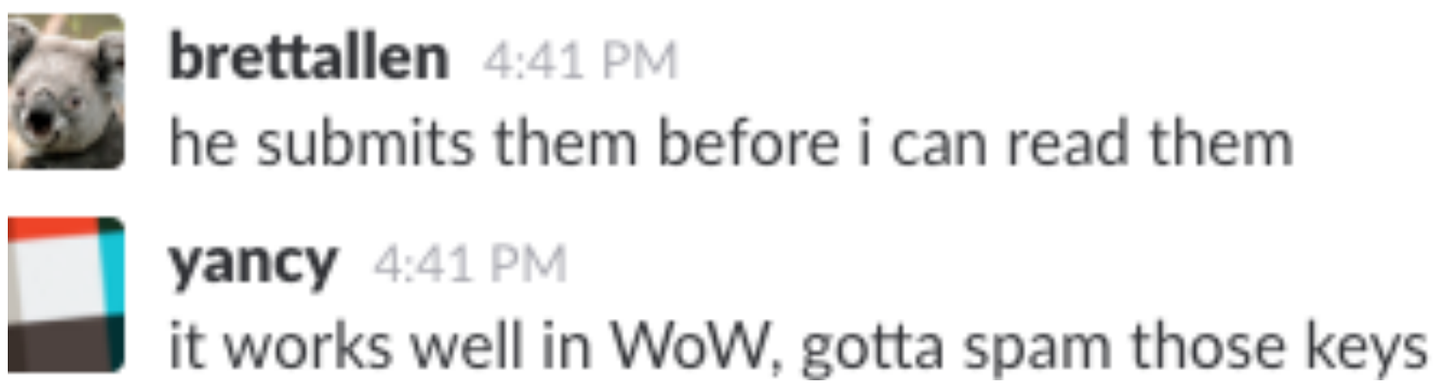




Teams demonstrated polarizing performance in other conditions

Collectively-chosen:

- Lack of coordination, chaotic behavior
- Members sometimes stepped up to lead or coordinate



bbrookes03 5:36 PM
Console: relief, game /// Compound: facility, interest, reaction/// Conduct: Etiquette, music, operate

raine 5:36 PM
console relief game/ compound facility operate interest /conduct etiquette music reactions?

Brookes makes more sense

rzmarie 5:37 PM
Ok, go with Brookes, ya?

raine 5:37 PM
yep

rzmarie 5:37 PM
!submit relief, game