

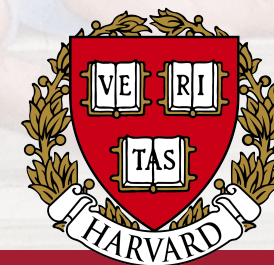
June 2024

Manon Revel

Deliberative Technologies, Computational Democracy,
and Peace-building in Polarised Contexts

Employee Fellow
Harvard University | Berkman Klein Center

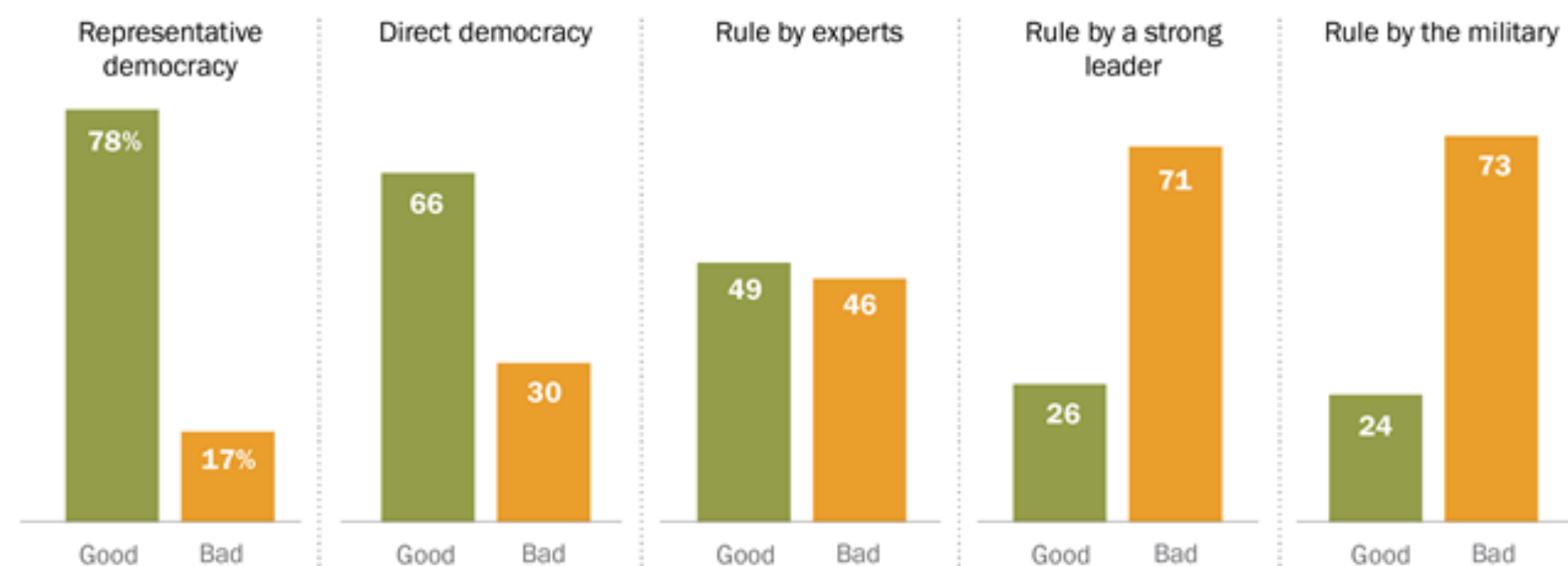
Deliberative Technologies, Computational Democracy and Peace-building





Widespread support for representative and direct democracy, but many are also open to nondemocratic alternatives

Would ___ be a good or bad way of governing our country?



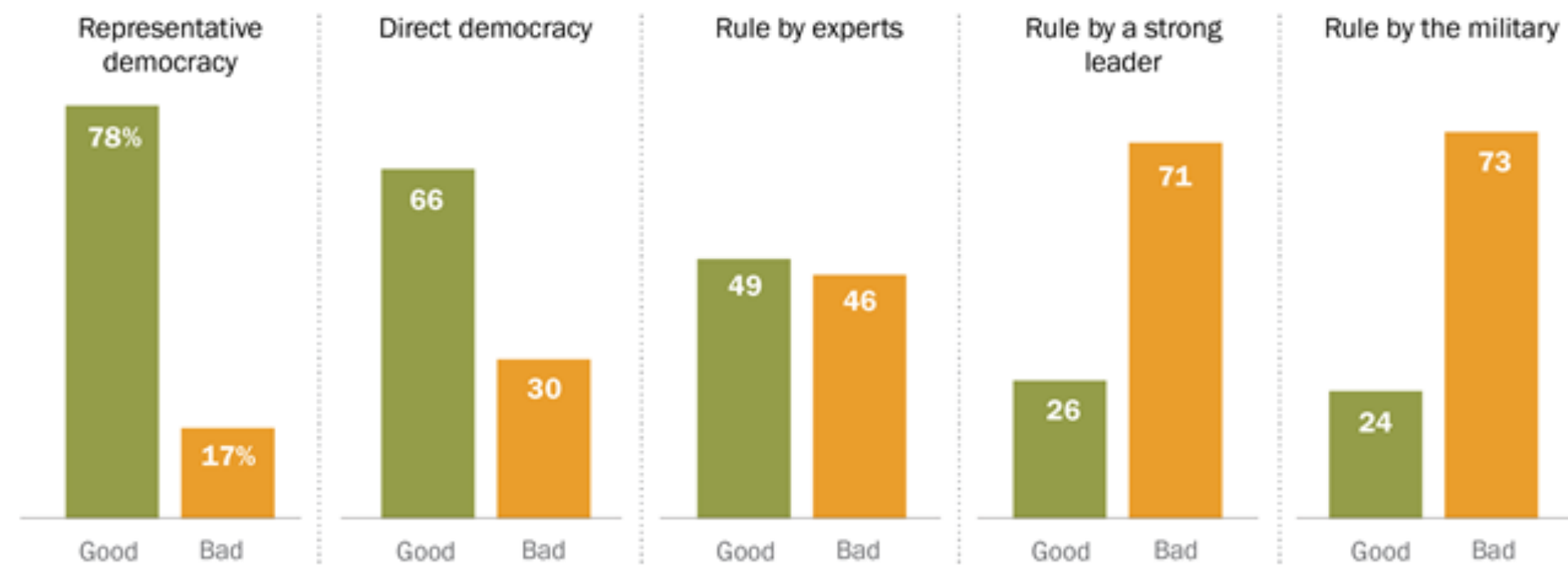
Note: Percentages are global medians based on 38 countries. Full question wordings for political systems: Representative democracy, "A democratic system where representatives elected by citizens decide what becomes law"; Direct democracy, "A democratic system where citizens, not elected officials, vote directly on major national issues to decide what becomes law"; Rule by experts, "Experts, not elected officials, make decisions according to what they think is best for the country"; Rule by a strong leader, "A system in which a strong leader can make decisions without interference from parliament or the courts"; Rule by the military, "The military rules the country."

Source: Spring 2017 Global Attitudes Survey. Q29a-e.

PEW RESEARCH CENTER

Widespread support for representative and direct democracy, but many are also open to nondemocratic alternatives

Would ___ be a good or bad way of governing our country?



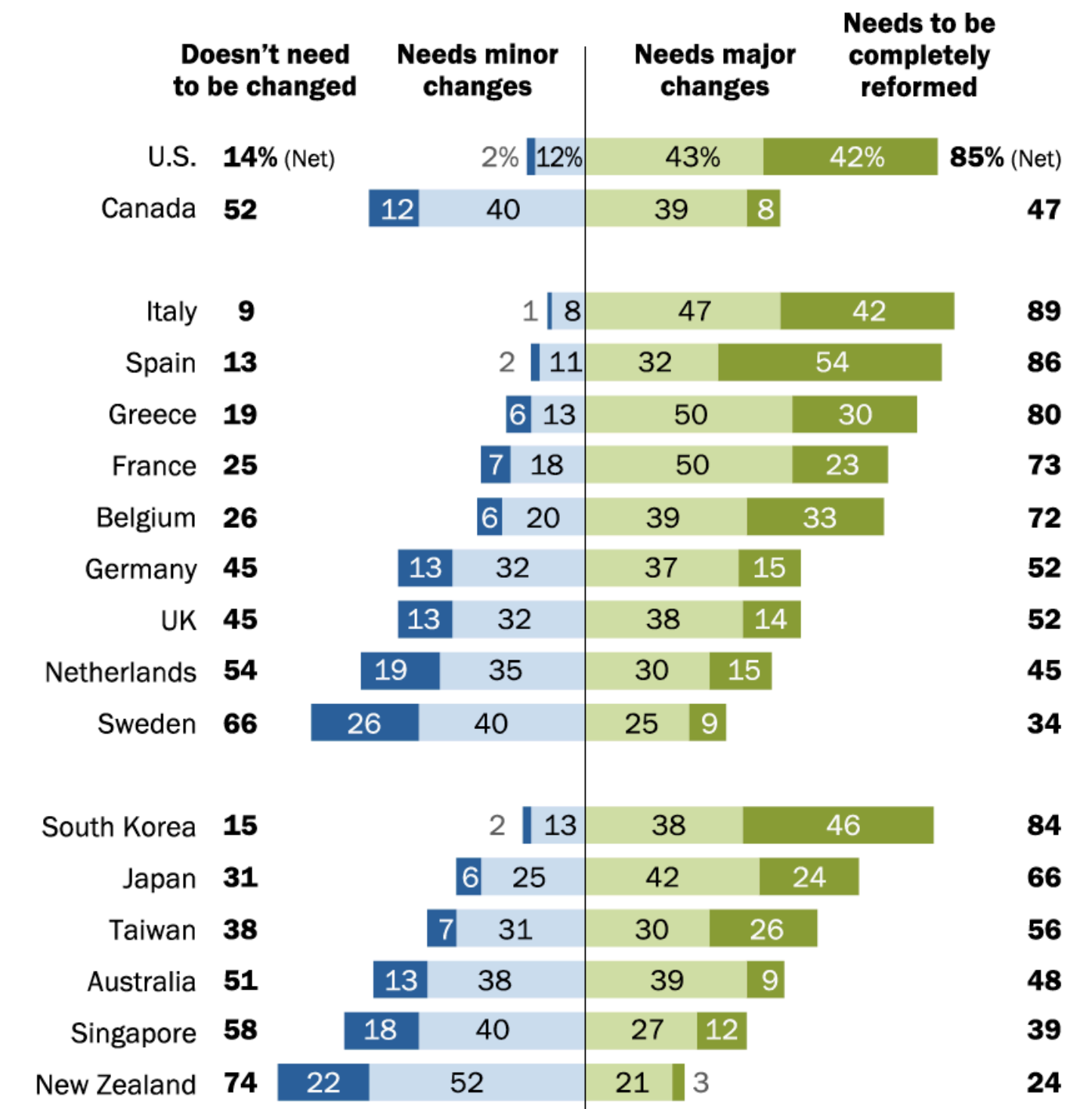
Note: Percentages are global medians based on 38 countries. Full question wordings for political systems: Representative democracy, "A democratic system where representatives elected by citizens decide what becomes law"; Direct democracy, "A democratic system where citizens, not elected officials, vote directly on major national issues to decide what becomes law"; Rule by experts, "Experts, not elected officials, make decisions according to what they think is best for the country"; Rule by a strong leader, "A system in which a strong leader can make decisions without interference from parliament or the courts"; Rule by the military, "The military rules the country."

Source: Spring 2017 Global Attitudes Survey. Q29a-e.

PEW RESEARCH CENTER

Large shares in many publics say their political system needs reform

% who say the political system in (survey public) ...



Note: Those who did not answer not shown.

Source: Spring 2021 Global Attitudes Survey. Q13c.

"Citizens in Advanced Economies Want Significant Changes to Their Political Systems"

PEW RESEARCH CENTER

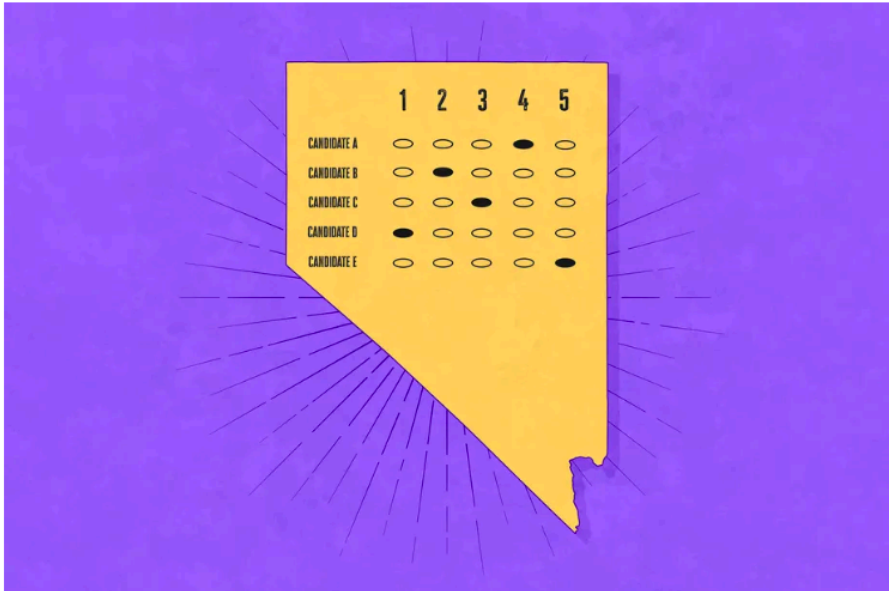
The plan to save America by killing the partisan primary

It’s on the ballot in Nevada, and it may be coming soon to a state near you.

By Andrew Prokop | andrew@vox.com | Nov 4, 2022, 7:00am EDT

Vox

Elections shouldn't be confusing



Bitá Honarvar/Vox; Getty Images

Nevada voters will be tasked with assessing those questions when they go to the polls Tuesday, to vote on “**Question 3**” — a proposed overhaul of the state’s election system that would effectively kill the partisan primary (the elections in which Democratic and Republican voters choose their party nominees).

Instead, Nevada would have a nonpartisan primary, from which the top five candidates of any party would emerge to the general election. The general election would then be conducted under **ranked-choice voting** (which lets people vote for multiple candidates for each office, ranked in order of their preference).

The plan to save America by killing the partisan primary



Vox
University of Chicago News



It's on the ballot in Nevada
By Andrew Prokop | andrew@vox.com

Does the Electoral College need to be reformed?



Bitu Honar

Nevada voters will be taking
Tuesday, to vote on “Qualified
would effectively kill the
voters choose their par

Instead, Nevada would
party would emerge to
under ranked-choice v
ranked in order of their

It's on the ballot in Nevada
By Andrew Prokop | andrew@vox.com



Bitia Honar

Nevada voters will be taking a referendum on Tuesday, to vote on "Qualified Choice" which would effectively kill the partisan primary so voters choose their party.

Instead, Nevada would have a nonpartisan primary where a new party would emerge to represent voters under ranked-choice voting. Voters would rank in order of their preference.

Does the Electoral College need to be

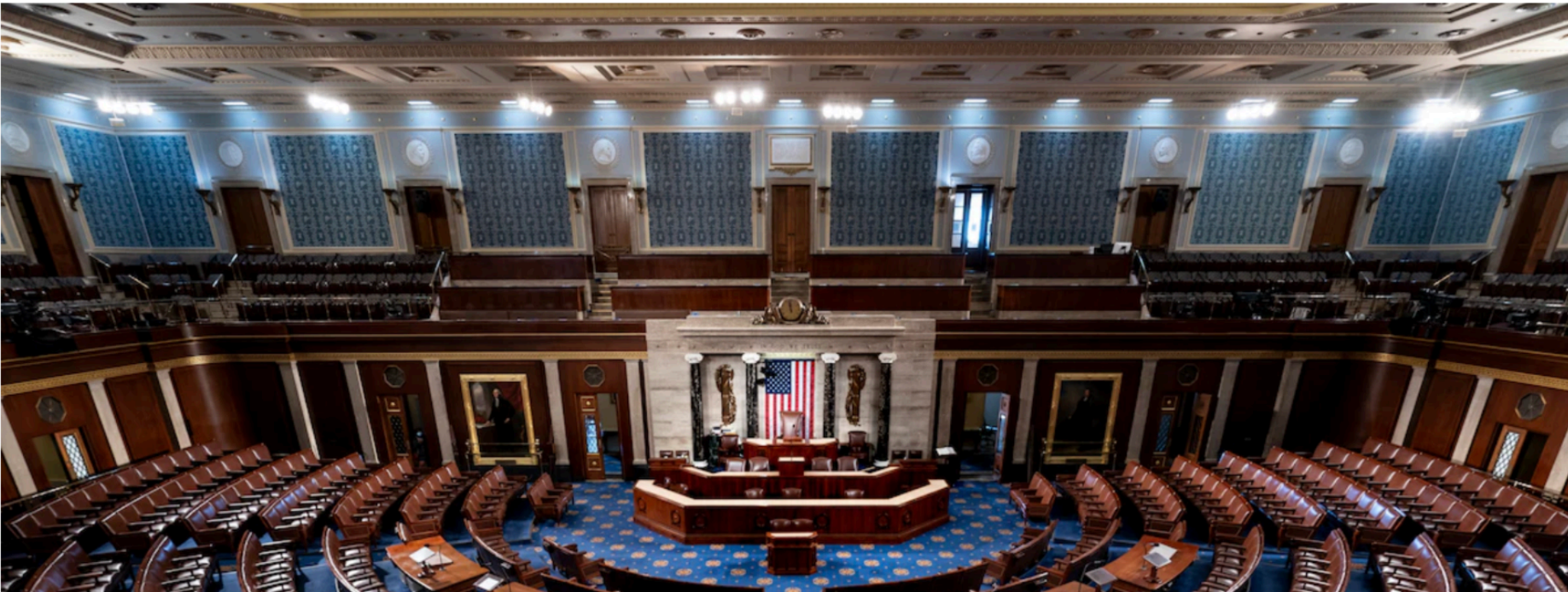
The Washington Post
Democracy Dies in Darkness

Opinion | How big should the House be? Here's what readers suggested.



By Danielle Allen
Contributing columnist | [+ Follow](#)

March 30, 2023 at 4:05 p.m. EDT



It's on the ballot in Nevada
By Andrew Prokop | andrew@vox.com

Does the Electoral College need to be

The Washington Post
Democracy Dies in Darkness

Opinion | How Here's what



By Danielle Allen
Contributing columnist | + Follow

March 30, 2023 at 4:05 p.m. EDT



THE NEW YORKER

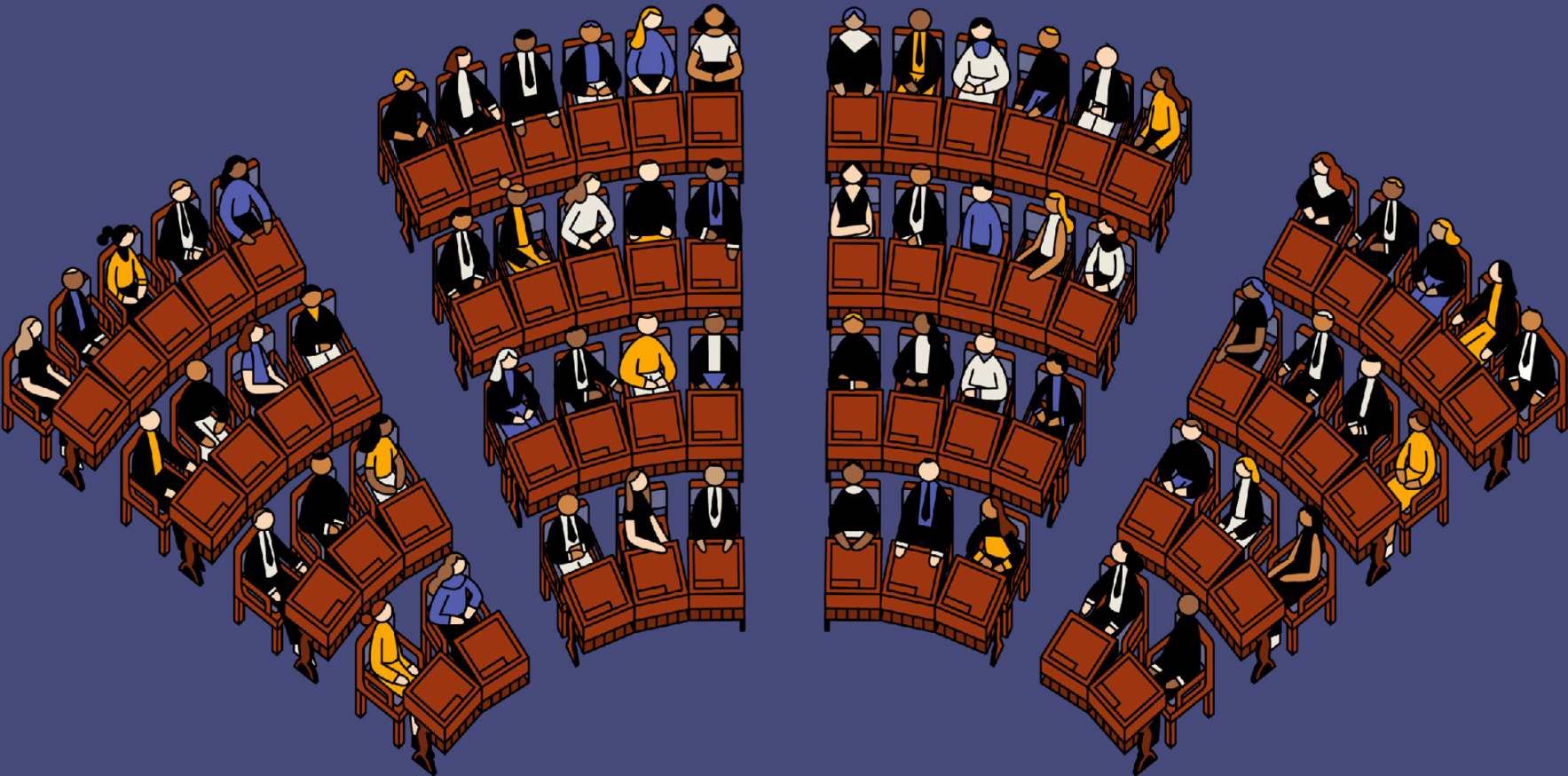
 The Future of Democracy is an exploration of democracy in America. View the series »

THE FUTURE OF DEMOCRACY

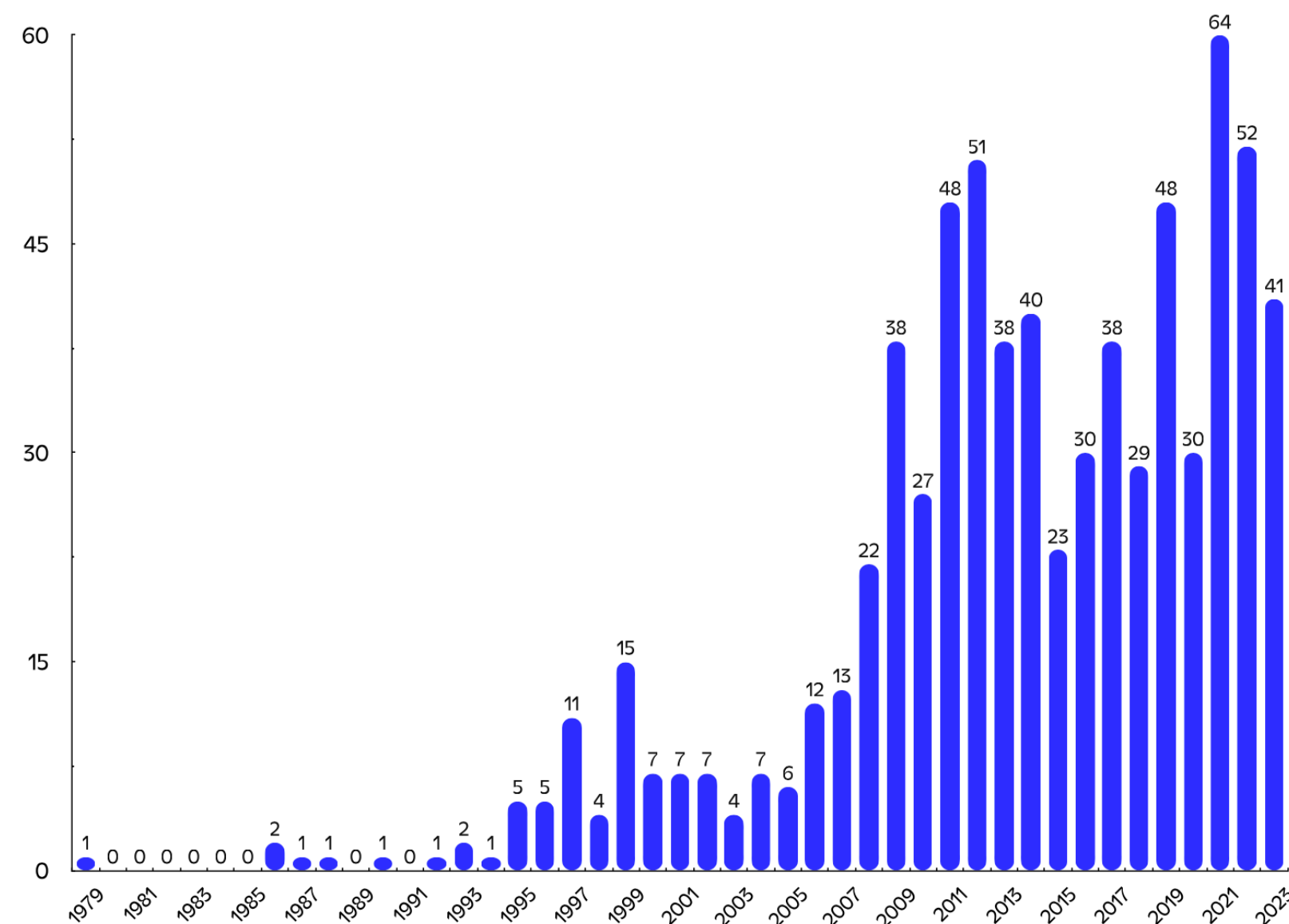
POLITICS WITHOUT POLITICIANS

The political scientist Hélène Landemore asks, *If government is for the people, why can't the people do the governing?*

By Nathan Heller
February 19, 2020



The “deliberative wave” has been building since the 1980s, gaining momentum since 2010



Number of representative deliberative processes per year, 1986 – October 2023¹. Note: n=733; Processes that spanned over multiple years are noted by the year of their completion (except for permanent ongoing processes) Source: OECD Database of Representative Deliberative Processes and Institutions (2023).

DemNext



Assembling an
Assembly Guide



[click](#)

Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

DemNext



Claudia Chwalizs

 [click](#)



Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

Inclusion and
Equality
(Landemore's
Democracy)

DemNext



Claudia Chwalizs

 [click](#)



Set-Up

- Framing
- Setting
- Group Building

Inclusion and
Equality
(Landemore's
Democracy)

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

DemNext



Claudia Chwalizs

 [click](#)



Inclusion and
Equality
(Landmore's
Democracy)

Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

DemNext



Claudia Chwalizs

 [click](#)



Course Outline

1

Political Philosophy and Democratic Representation

2

Mathematical Theories for Representation

3

Algorithms for Bridging (by Luke Thorburn)

4

Algorithms for Deliberation

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

2

Mathematical Theories for Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

3

Algorithms for Bridging (by Luke Thorburn)

Sortedness

Why care?

Mechanisms

Two properties

4

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

Course Outline

1

Political Philosophy and Democratic Representation

2

Mathematical Theories for Representation

3

Algorithms for Bridging (by Luke Thorburn)

4

Algorithms for Deliberation

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

WHY DO WE NEED GOVERNANCE?

Question for all:

Why do we need governance?

WHY DO WE NEED GOVERNANCE?

During the time men live without a common power to keep them all in awe, they are in that condition which is called war; and such a war as is of every man against every man.

Leviathan, Thomas Hobbes

WHY DO WE NEED GOVERNANCE?

If Men were angels, no government would be necessary. If angels were to govern men, neither external nor internal controls on government would be necessary. In framing a government which is to be administered by men over men, the great difficulty lies in this: you must first enable the government to control the governed; and the next place, oblige it to control itself.

Federalist 51, James Madison

WHY DO WE NEED GOVERNANCE?

The most valuable lands on the globe, the lands that yield the highest rent, are not lands of surpassing natural fertility but lands to which a surpassing utility has been given by the increase of population.

The Unbounded Savannah, Henry George

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

GOVERNANCE AND REPRESENTATION

Question for all:

As we reflect on and build deliberative technologies
— are we representatives? Of whom? Are we *good*
representatives?

GOVERNANCE AND REPRESENTATION

Question for all:

Can you think of a context in which you have been represented or you represented someone and let us know whether you think you acted as a trustee or a delegate?

GOVERNANCE AND REPRESENTATION

The dimension of political representation by Hannah Pitkin (The Concept of Representation)

- Formalistic
- Substantive
- Descriptive
- Symbolic

GOVERNANCE AND REPRESENTATION

Question for all:

Thinking back at the example that you mentioned earlier — which of these dimensions do you think were reflected?

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

DEMOCRATIC REPRESENTATION

Question for all:

Would you say that these instances of representation
were *democratic*?

DEMOCRATIC REPRESENTATION

We shall overcome because the arc of the moral universe is long, but it bends toward justice.

“Remaining Awake Through a Great Revolution.” Speech given at the National Cathedral, March 31, 1968.

Dr. Martin Luther King Jr.

DEMOCRATIC REPRESENTATION

*We hold these truths to be **self-evident**, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.*

Preamble of Declaration of Independence, Thomas Jefferson

DEMOCRATIC REPRESENTATION

The great desire to give the country a new order where every section of the community would have some practical power to play in the people's government

Facing Mt. Kenya, Jomo Kenyatta

DEMOCRATIC REPRESENTATION

The fundamental idea of democratic legitimacy is that the authorization to exercise state power must arise from the collective decisions of the members of a society who are governed by that power

Democracy and Liberty, Joshua Cohen

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

ELECTORAL DEMOCRACY

Question for all:

If I tell you what constitutes the core of democratic representation, what is the very first word that comes to your mind?

Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

DemNext



Claudia Chwalizs

 click



Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

Inclusion and
Equality
(Landemore's
Democracy)

DemNext



Claudia Chwalizs

 [click](#)



Set-Up

- Framing
- Setting
- Group Building

Inclusion and
Equality
(Landemore's
Democracy)

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

DemNext



Claudia Chwalizs

 [click](#)



Inclusion and
Equality
(Landmore's
Democracy)

Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

DemNext



Claudia Chwalizs

 [click](#)



1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

1

Political Philosophy and Democratic Representation

Why do we need governance?

Governance and representation

Democratic representation

Electoral democracy

Deliberative democracy

DELIBERATIVE DEMOCRACY

Electoral Democracy	Deliberative Democracy
Conflict on a plurality of private interests	Finding the common grounds and public interest (Habermas)
Cannot be coerced by decision if does not have a say	Cannot be coerced by decision if cannot reasonable understand the governing reason (Rawls)
Majority vote (Dahl)	Consensus oriented
Select best representatives (Schumpeter)	Tap into cognitive diversity (Landemore, Aristotle)
One-person-one-vote	Equal opportunity to access political influence (Knight and Johnson); One-person-one-voice (Revel)

DELIBERATIVE DEMOCRACY

Question for all:

What are potential failure modes of deliberative democracy?

Course Outline

1

Political Philosophy and Democratic Representation

2

Mathematical Theories for Representation

3

Algorithms for Bridging (by Luke Thorburn)

4

Algorithms for Deliberation

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

In this section, we will
care about making *good*
decisions, for some
standard of *good*

DIRECT DEMOCRACY

DIRECT DEMOCRACY

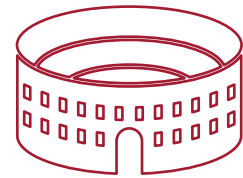
- ✦ N agents independently vote on $\{0,1\}$ where 1 is the ground truth

DIRECT DEMOCRACY

- ✦ N agents independently vote on $\{0,1\}$ where 1 is the **ground truth**
- ✦ Person i votes **correctly** with **probability** p_i , $\mathbb{P}(X_i = 1) = p_i$

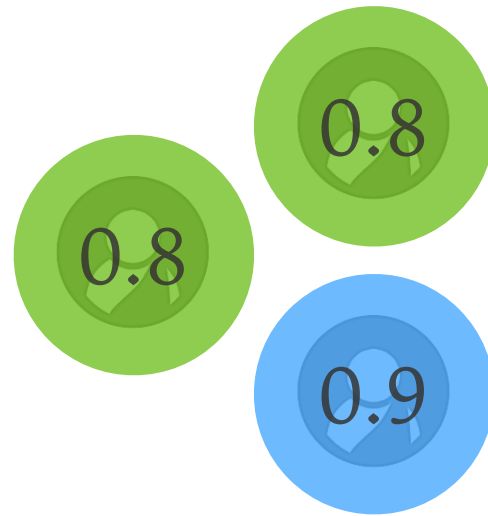
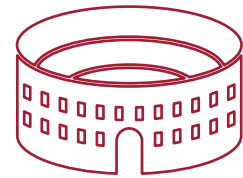
DIRECT DEMOCRACY

- ✦ N agents independently vote on $\{0,1\}$ where 1 is the **ground truth**
- ✦ Person i votes **correctly** with **probability** p_i , $\mathbb{P}(X_i = 1) = p_i$



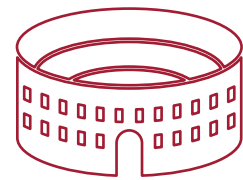
DIRECT DEMOCRACY

- ✦ N agents independently vote on $\{0,1\}$ where 1 is the **ground truth**
- ✦ Person i votes **correctly** with **probability** p_i , $\mathbb{P}(X_i = 1) = p_i$



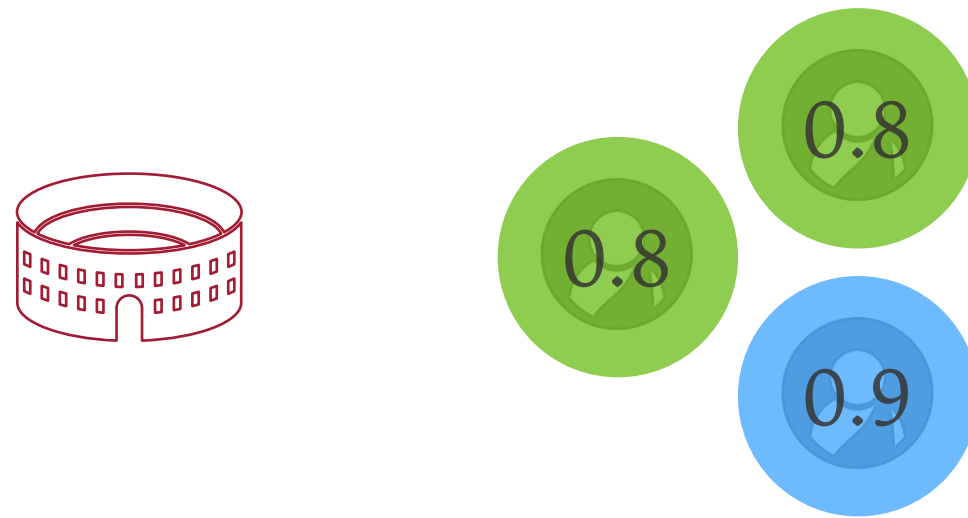
DIRECT DEMOCRACY

- ✦ N agents independently vote on $\{0,1\}$ where 1 is the **ground truth**
- ✦ Person i votes **correctly** with **probability** p_i , $\mathbb{P}(X_i = 1) = p_i$



DIRECT DEMOCRACY

- ✦ N agents independently vote on $\{0,1\}$ where 1 is the **ground truth**
- ✦ Person i votes **correctly** with **probability** p_i , $\mathbb{P}(X_i = 1) = p_i$



$P[\text{majority in } \text{parliament icon} \text{ is correct}] = 0.92$

DIRECT DEMOCRACY

- ✦ N agents independently vote on $\{0,1\}$ where 1 is the **ground truth**
- ✦ Person i votes **correctly** with **probability** p_i , $\mathbb{P}(X_i = 1) = p_i$



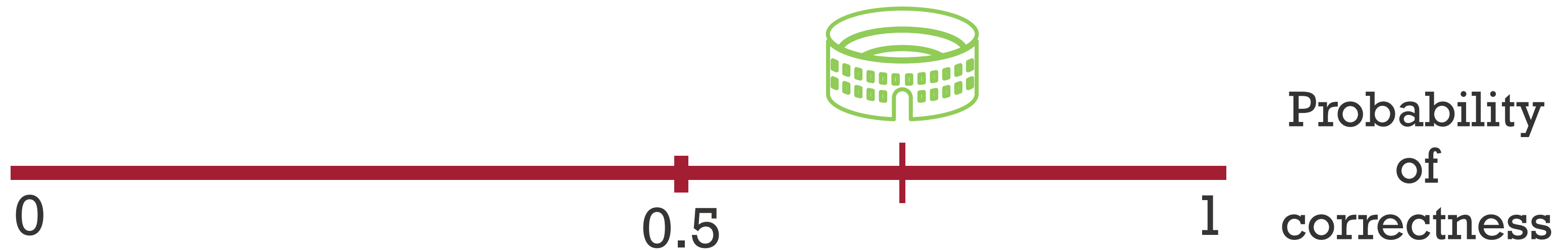
$P[\text{majority in } \text{parliament icon} \text{ is correct}] = 0.92$

$P[\text{blue node is correct}] = 0.9$

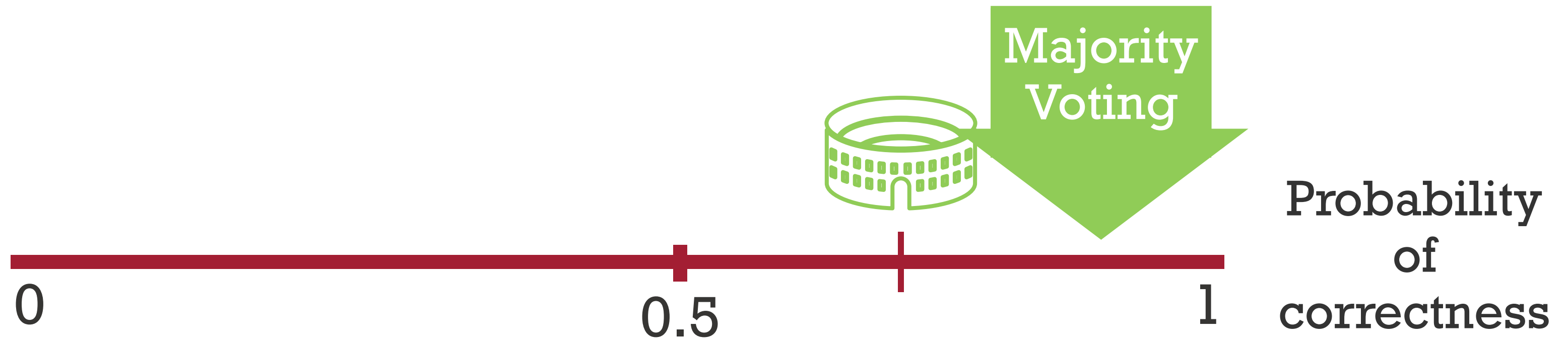
CONDORCET JURY THEOREM



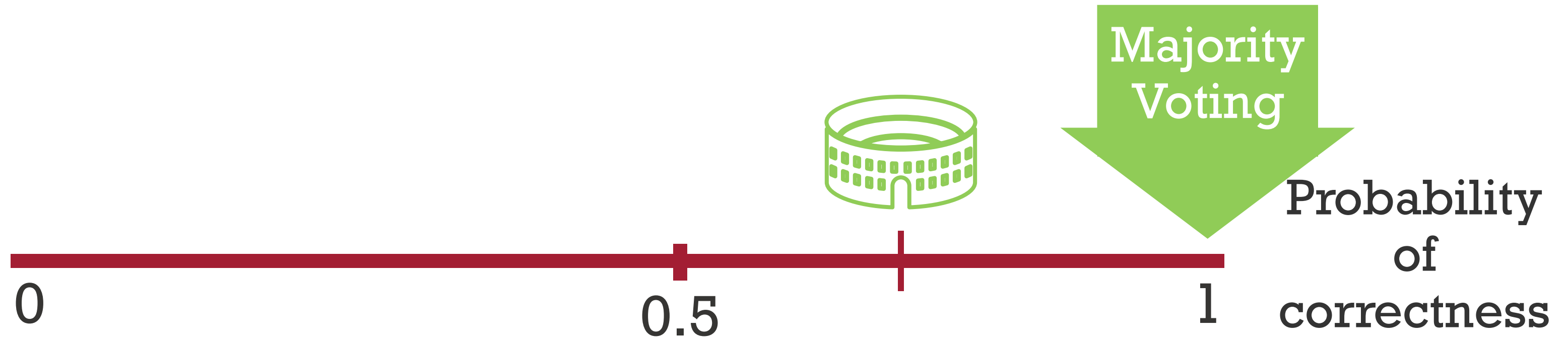
CONDORCET JURY THEOREM



CONDORCET JURY THEOREM



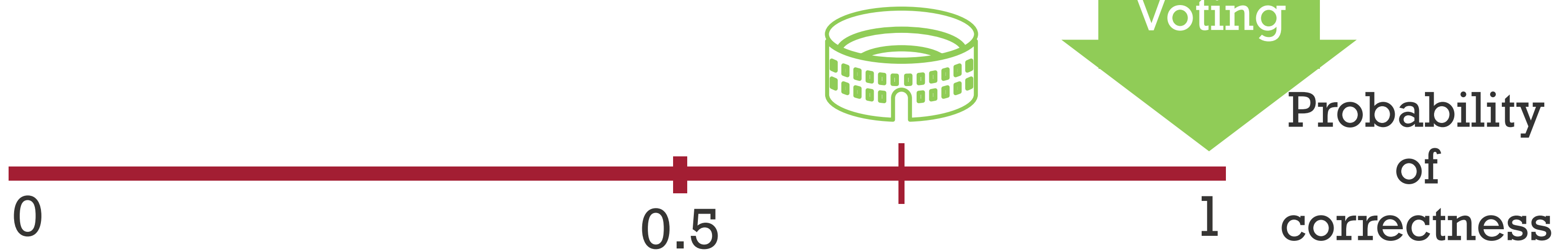
CONDORCET JURY THEOREM



CONDORCET JURY THEOREM

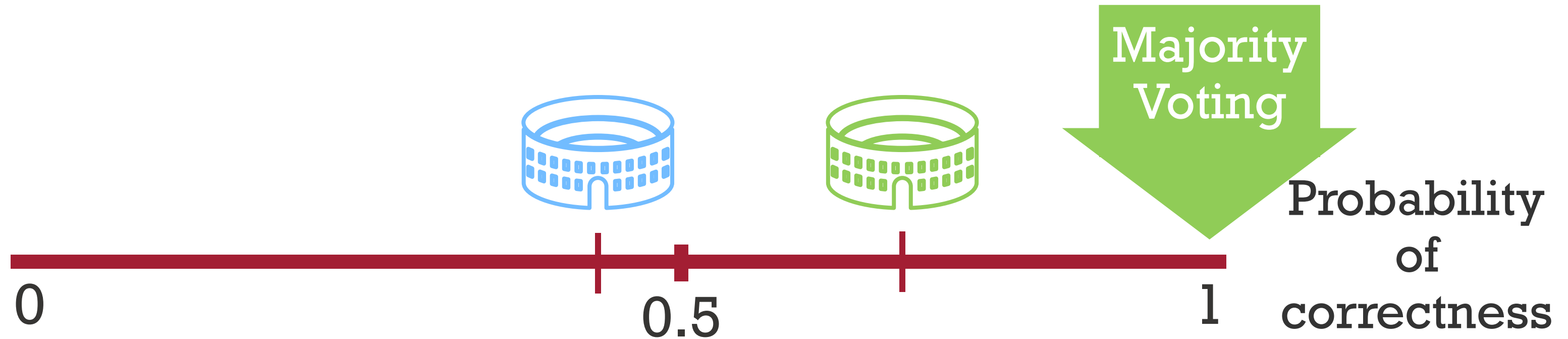
$$\mathbb{P} \left(\sum_{i=1}^n X_i > \frac{n}{2} \right)$$

Majority
Voting



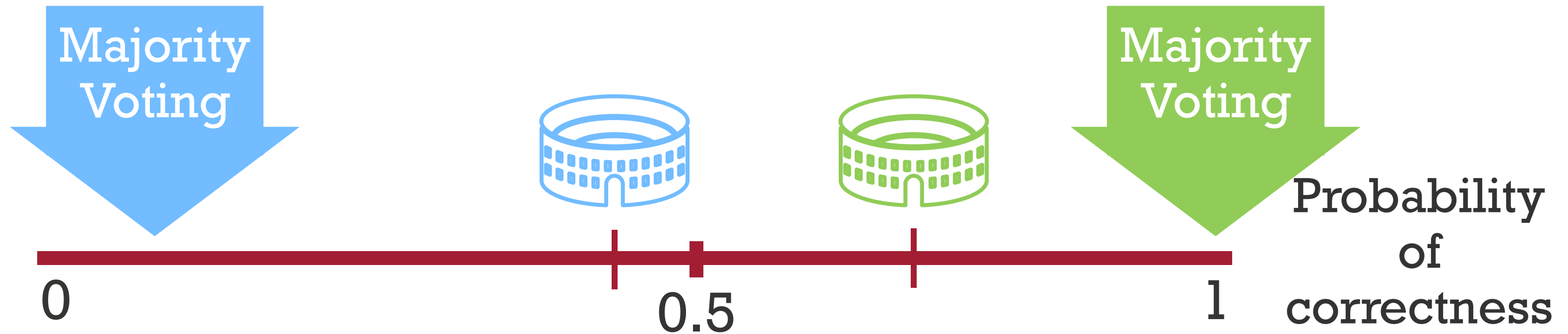
CONDORCET JURY THEOREM

$$\mathbb{P} \left(\sum_{i=1}^n X_i > \frac{n}{2} \right)$$



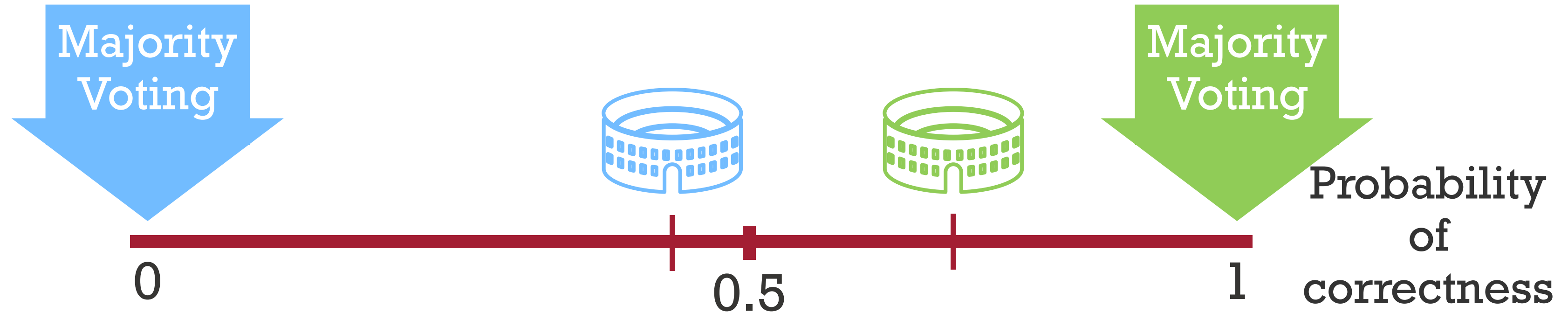
CONDORCET JURY THEOREM

$$\mathbb{P} \left(\sum_{i=1}^n X_i > \frac{n}{2} \right)$$



CONDORCET JURY THEOREM

$$\mathbb{P} \left(\sum_{i=1}^n X_i > \frac{n}{2} \right)$$



2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

WEIGHTED MAJORITY AND OPTIMAL RULES

WEIGHTED MAJORITY AND OPTIMAL RULES

- ♦ H: Can assign any weight to votes and can reverse votes

$$\mathbb{P} \left(\sum_{i=1}^n \log \left(\frac{p_i}{1-p_i} \right) X_i > \frac{C}{2} \right)$$



Nitzan, S., & Paroush, J. (1984).
The significance of
independent decisions in
uncertain dichotomous choice
situations. *Theory and Decision*,
17(1), 47-60.

WEIGHTED MAJORITY AND OPTIMAL RULES

- ♦ H: Can assign any weight to votes and can reverse votes

$$\mathbb{P} \left(\sum_{i=1}^n \log \left(\frac{p_i}{1-p_i} \right) X_i > \frac{C}{2} \right)$$



Nitzan, S., & Paroush, J. (1984).
The significance of
independent decisions in
uncertain dichotomous choice
situations. *Theory and Decision*,
17(1), 47-60.

- ♦ H: Can pick the best experts in the group

$$\mathbb{P} \left(\sum_{i=1}^{n/k} X_i > \frac{n}{2k} \right)$$

WEIGHTED MAJORITY AND OPTIMAL RULES

- ♦ H: Can assign any weight to votes and can reverse votes

$$\mathbb{P} \left(\sum_{i=1}^n \log \left(\frac{p_i}{1-p_i} \right) X_i > \frac{C}{2} \right)$$



Nitzan, S., & Paroush, J. (1984).
The significance of
independent decisions in
uncertain dichotomous choice
situations. *Theory and Decision*,
17(1), 47-60.

- ♦ H: Can pick the best experts in the group

$$\mathbb{P} \left(\sum_{i=1}^{n/k} X_i > \frac{n}{2k} \right)$$

- ♦ H: The distribution of expertise varies with the group size

$$\mathbb{P} \left(X_{(1)} = 1 \right)$$

WEIGHTED MAJORITY AND OPTIMAL RULES

- ♦ H: Can assign any weight to votes and can reverse votes

$$\mathbb{P} \left(\sum_{i=1}^n \log \left(\frac{p_i}{1-p_i} \right) X_i > \frac{C}{2} \right)$$



Nitzan, S., & Paroush, J. (1984).
The significance of
independent decisions in
uncertain dichotomous choice
situations. *Theory and Decision*,
17(1), 47-60.

- ♦ H: Can pick the best experts in the group

$$\mathbb{P} \left(\sum_{i=1}^{n/k} X_i > \frac{n}{2k} \right)$$

- ♦ H: The distribution of expertise varies with the group size

$$\mathbb{P} \left(X_{(1)} = 1 \right)$$



Revel, M., Lin, T., & Halpern, D.
(2022, June). How Many
Representatives Do We Need?
The Optimal Size of a Congress
Voting on Binary Issues. In
*Proceedings of the AAAI
Conference on Artificial
Intelligence* (Vol. 36, No. 9, pp.
9431-9438).

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

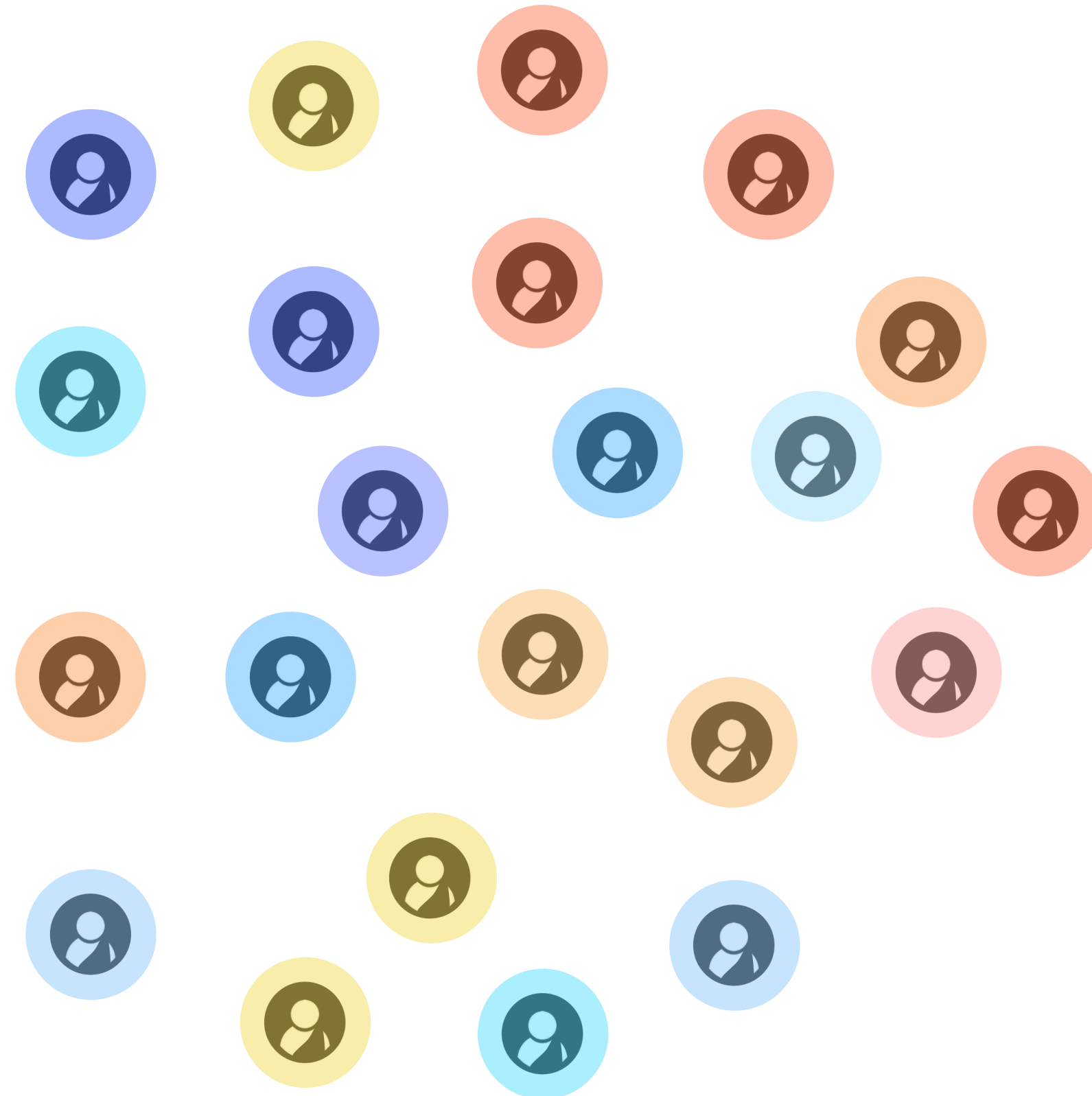
Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

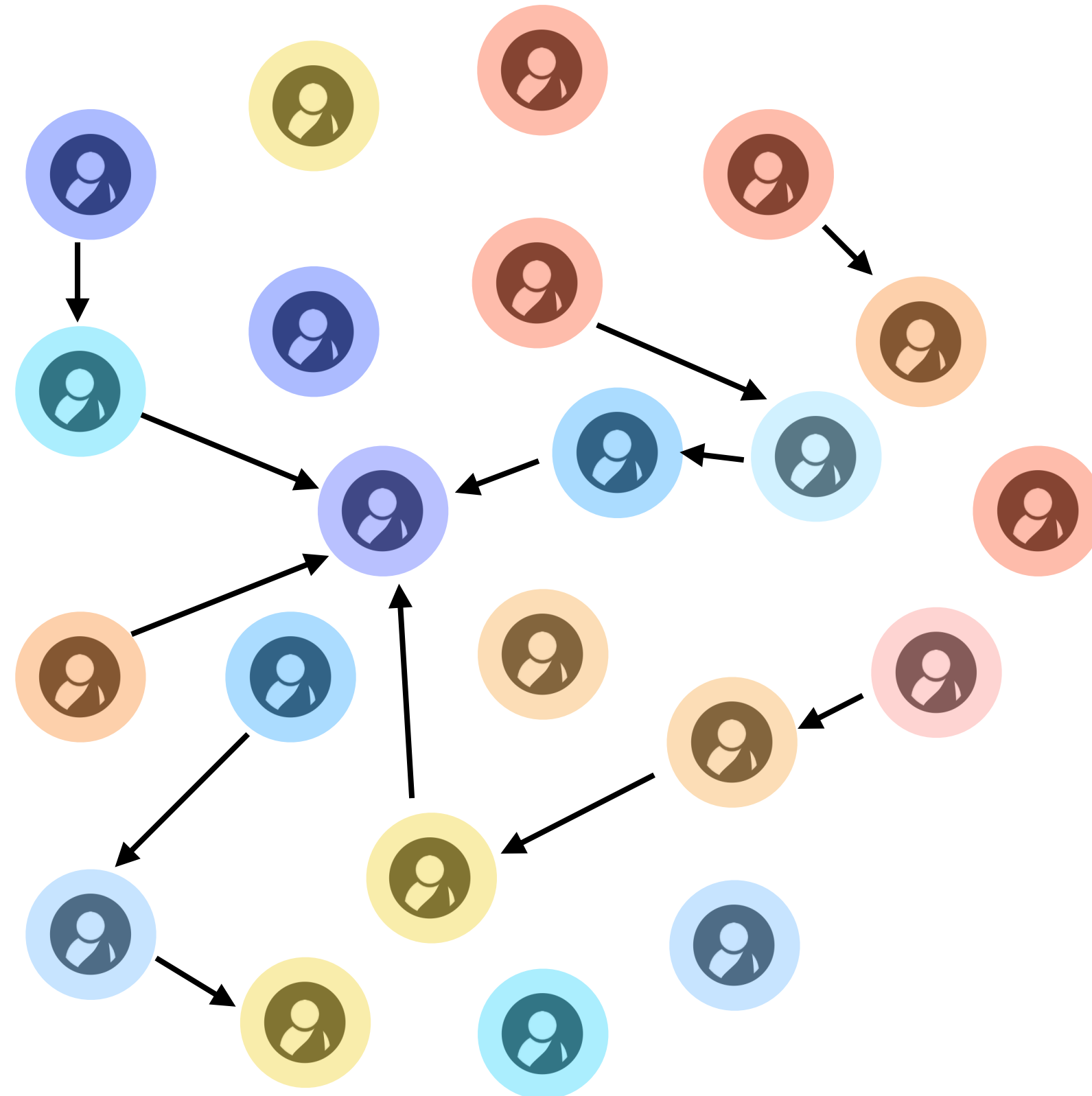
Selection Methods for Multi-Winner Elections

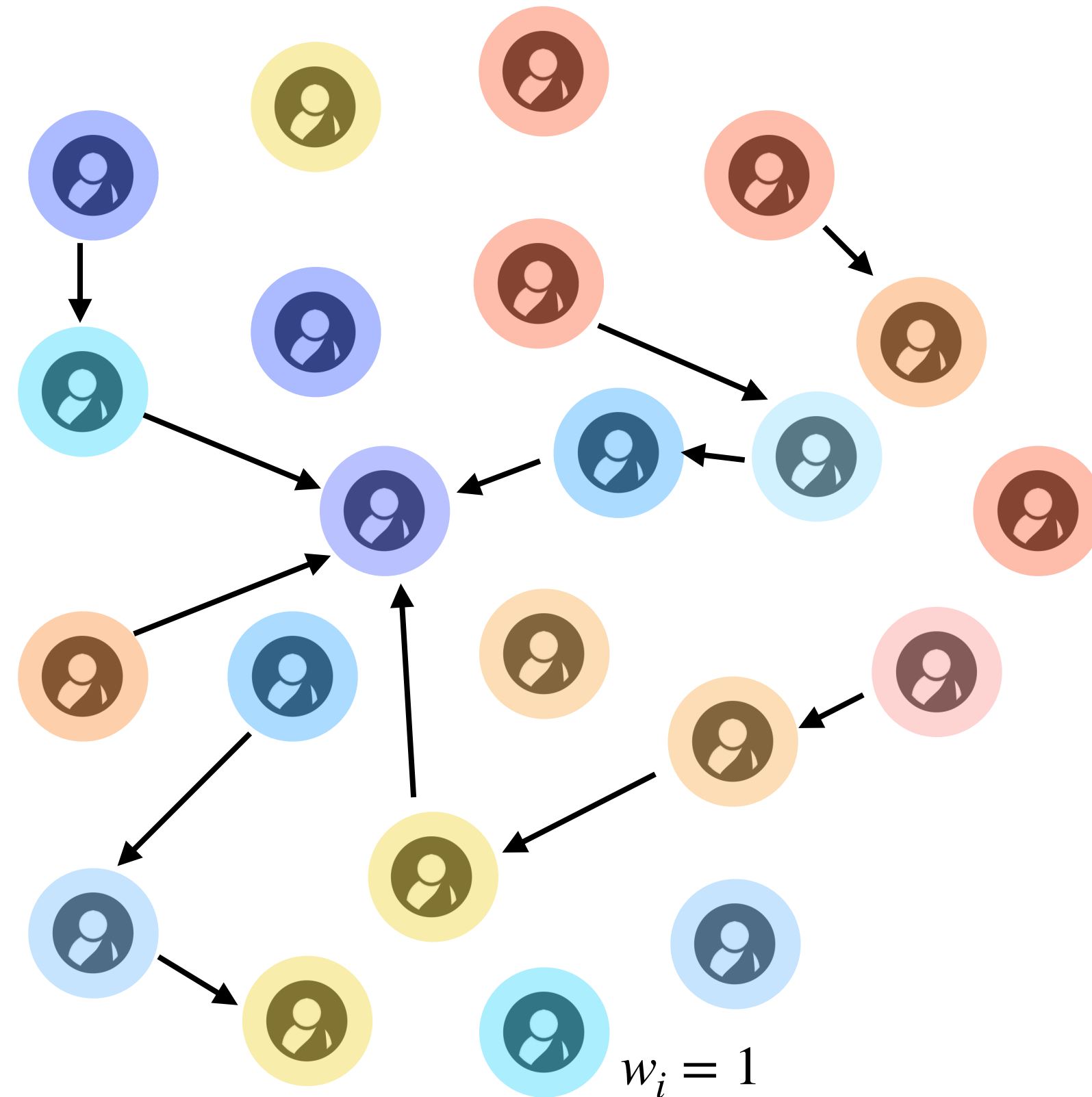
Selection Methods for Sortition

LIQUID DEMOCRACY

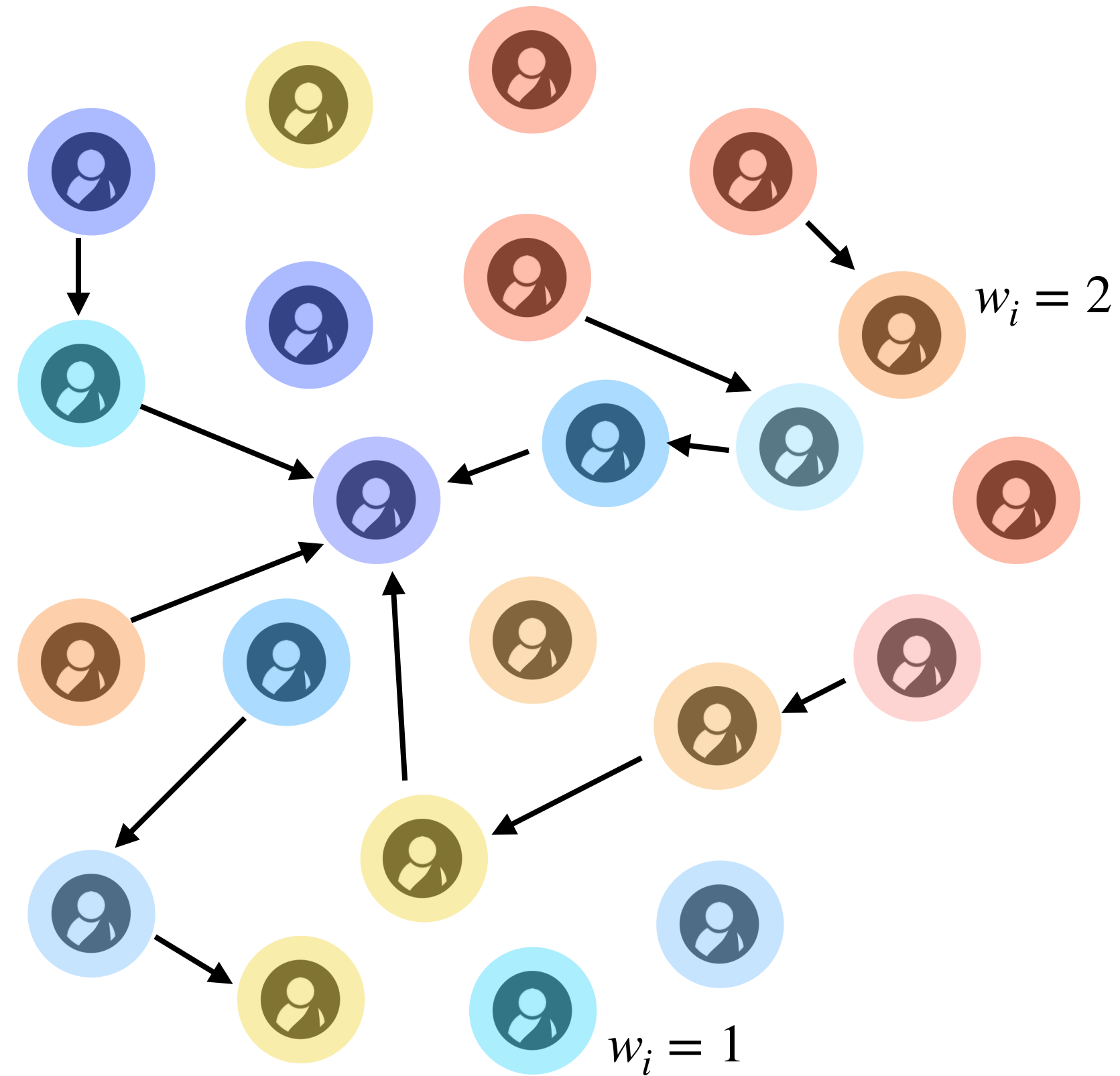


LIQUID DEMOCRACY

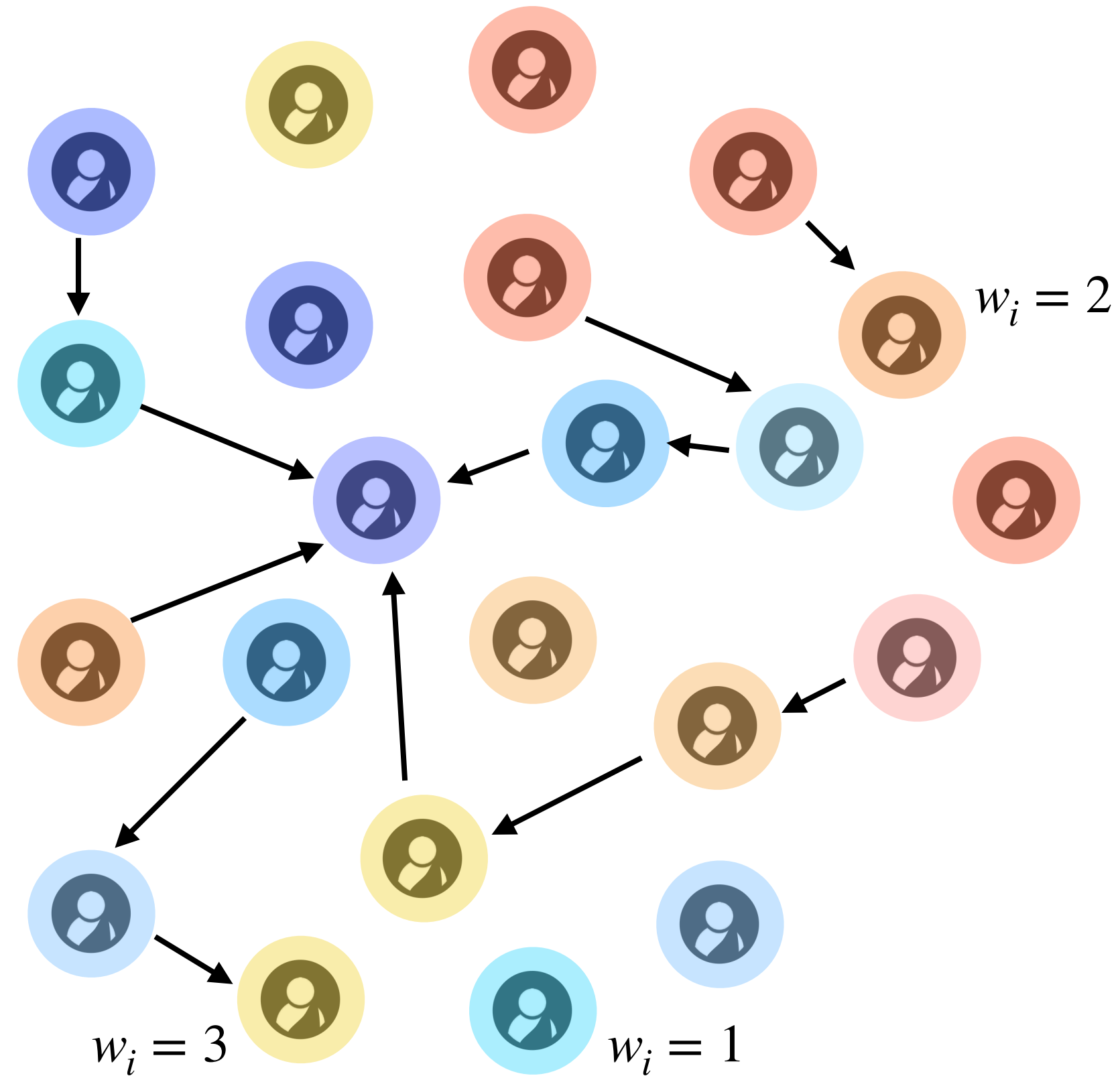




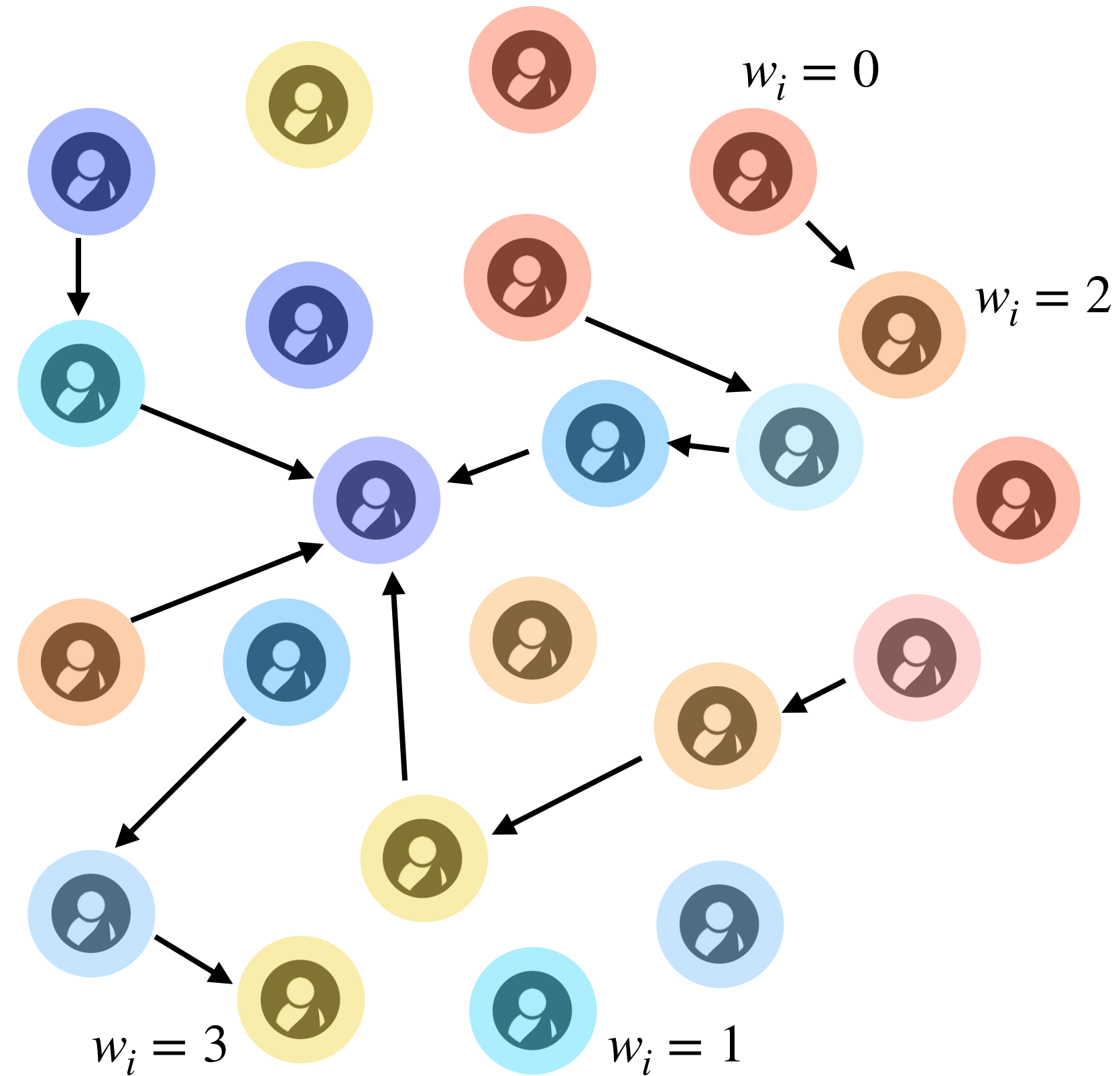
LIQUID DEMOCRACY



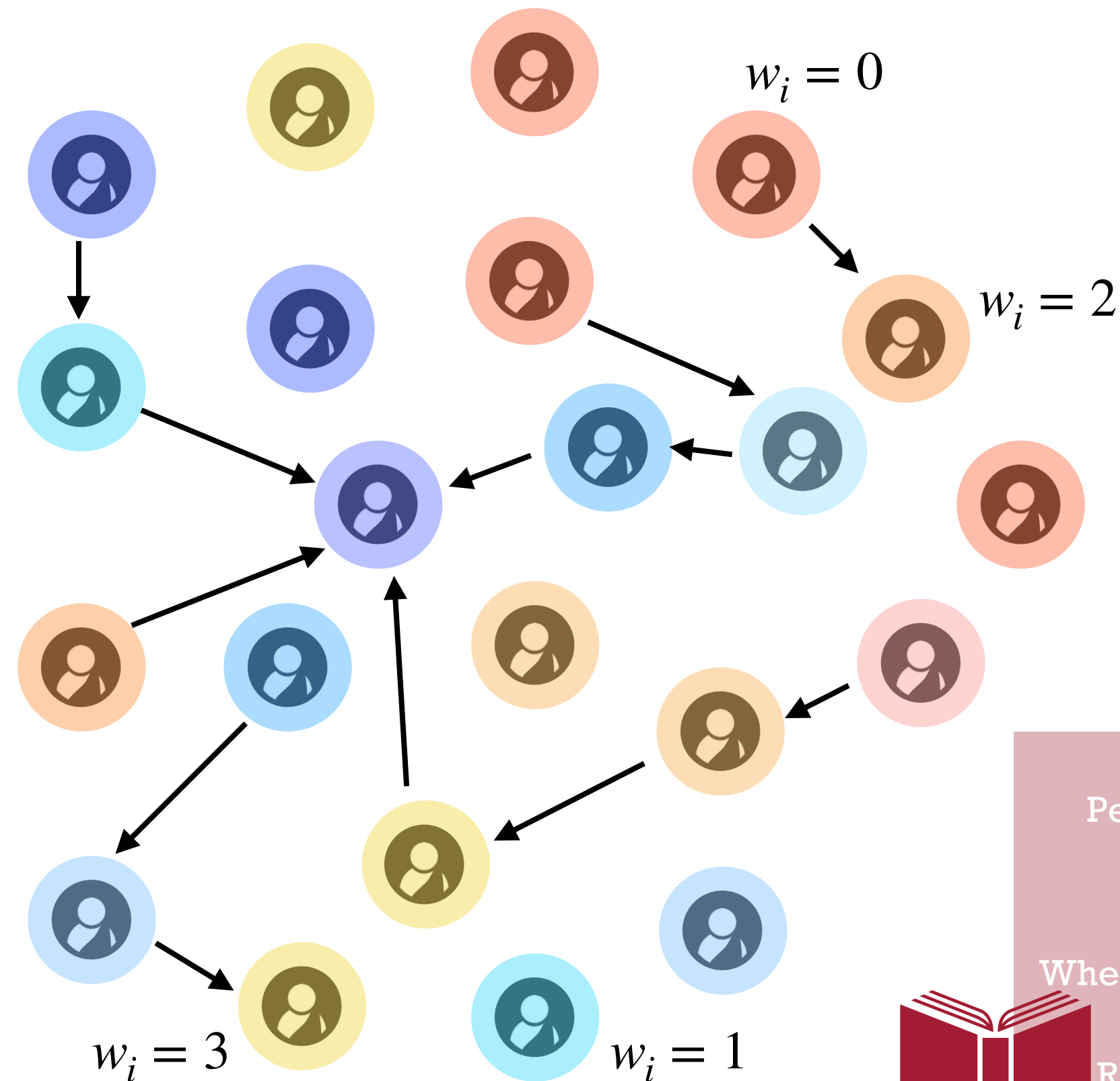
LIQUID DEMOCRACY



LIQUID DEMOCRACY



LIQUID DEMOCRACY



Liquid Democracy: An Algorithmic Perspective, KAHNG, MACKENZIE, PROCACCIA

A contribution to the critique of Liquid Democracy, CARAGIANNIS AND MICHA

When can Liquid Democracy unveil the truth?

BECKER, D'ANGELO, DELFAREZ, GILBERT

Rational Delegations in Liquid Democracy, BLOEMBERGER, GROSSI AND LECKNER





$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$



$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$



$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

0.95

0.6

0.7

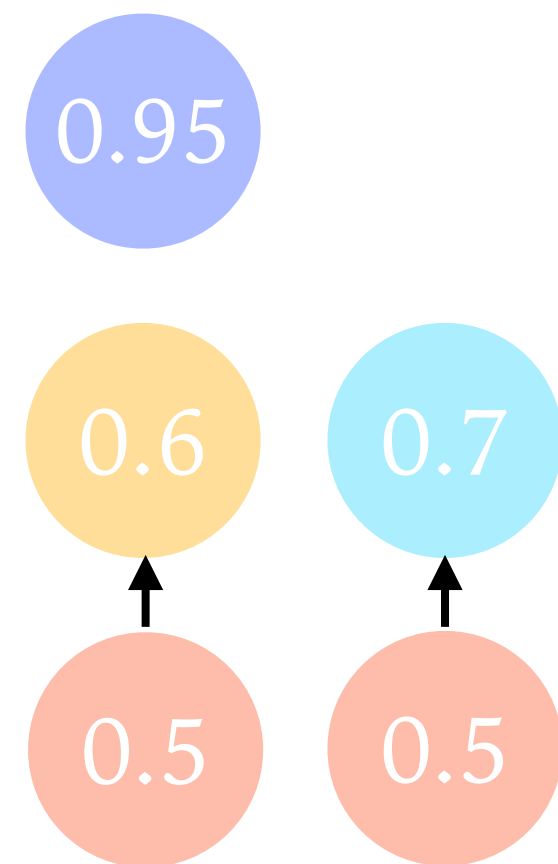
0.5

0.5

0.77

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$



0.77

0.85

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

0.95

0.6

0.5

0.7

0.5

0.95

0.6

0.5

0.7

0.5

0.95

0.6

0.5

0.7

0.5

0.77

0.83

0.85

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

0.95

0.6

0.5

0.7

0.5

0.95

0.6

0.5

0.7

0.5

0.95

0.6

0.5

0.7

0.5

0.95

0.6

0.5

0.7

0.5

0.73

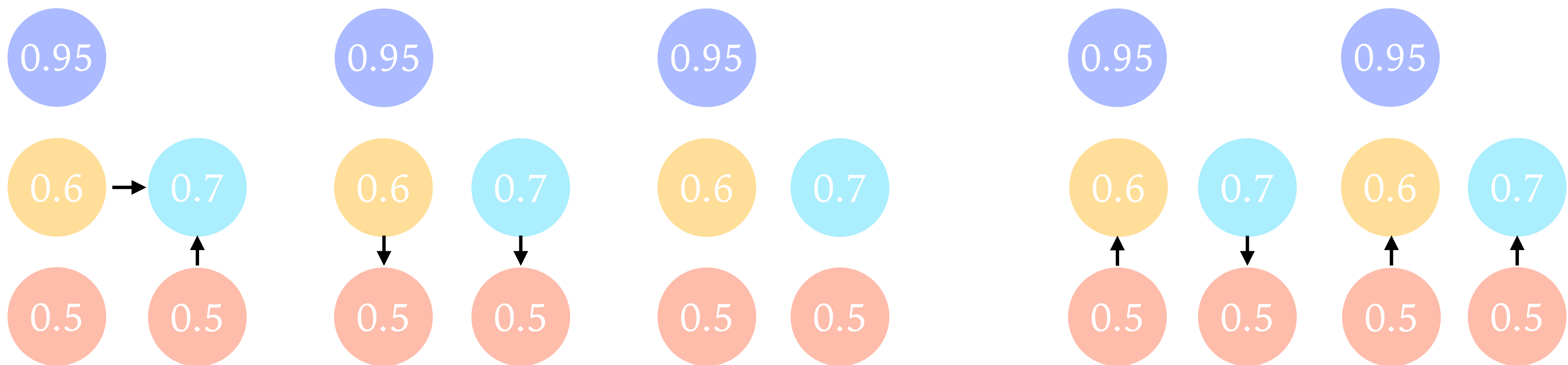
0.77

0.83

0.85

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$



0.70

0.73

0.77

0.83

0.85

$$\mathbb{P}\left(\sum_{i=1}^n w_i X_i > \frac{n}{2}\right)$$

LIQUID DEMOCRACY

- ✦ With the right amount of power concentration and relative expertise, vote delegation can be worth it  [click](#)

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

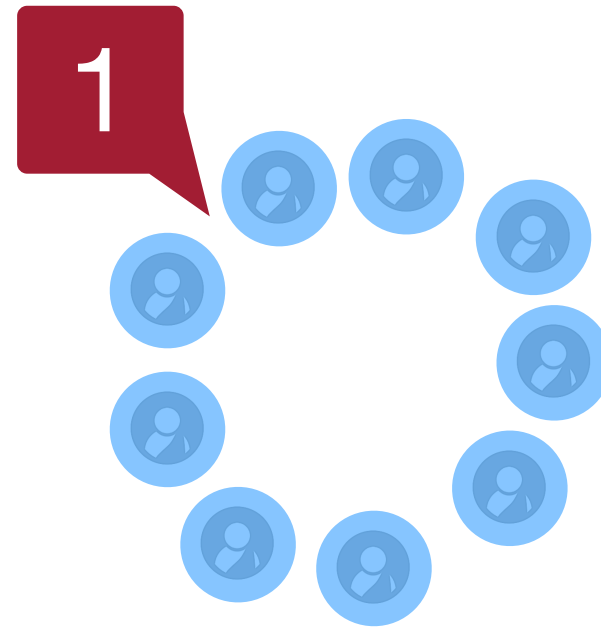
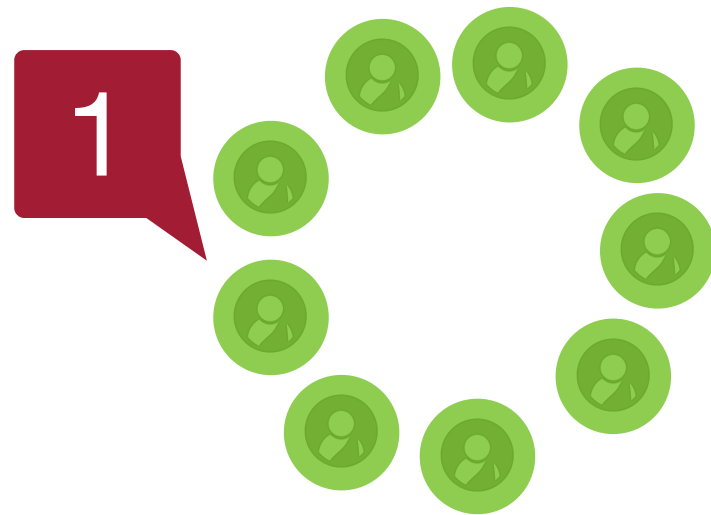
Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

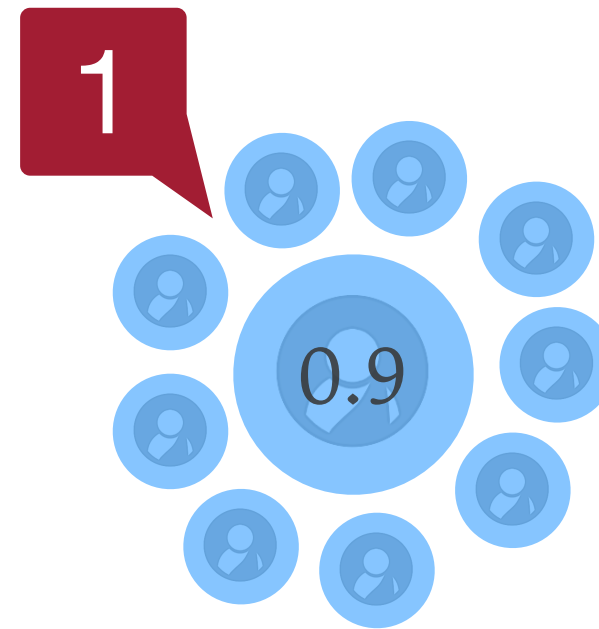
Selection Methods for Multi-Winner Elections

Selection Methods for Sortition


DEPENDENT VOTES



DEPENDENT VOTES



DEPENDENT VOTES

- ✦ Correlation is manageable up to a certain threshold
- ✦ A law of large number for correlated votes can be derived by looking at the weighted influence that voters have on the outcome  [click](#)

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

In this section, we will
care about *fair* decision
making-processes, for
some standard of *fairness*

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

VOTING METHODS

- ♦ There are three candidates at an election. Let's call them a, b and c.



VOTING METHODS

- ♦ There are three candidates at an election. Let's call them a, b and c.

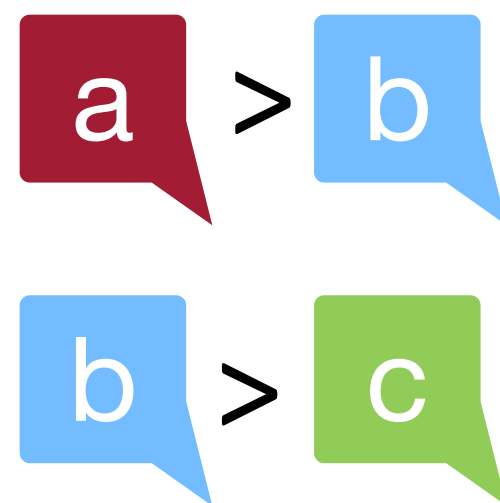


$$a > b$$



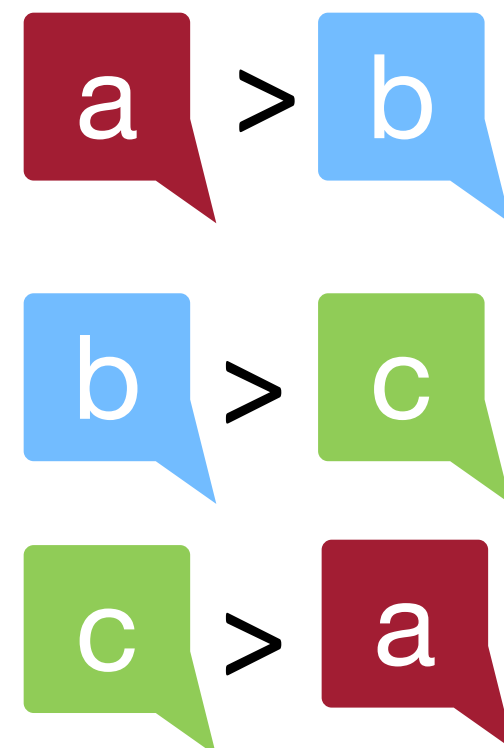
VOTING METHODS

- ♦ There are three candidates at an election. Let's call them a, b and c.



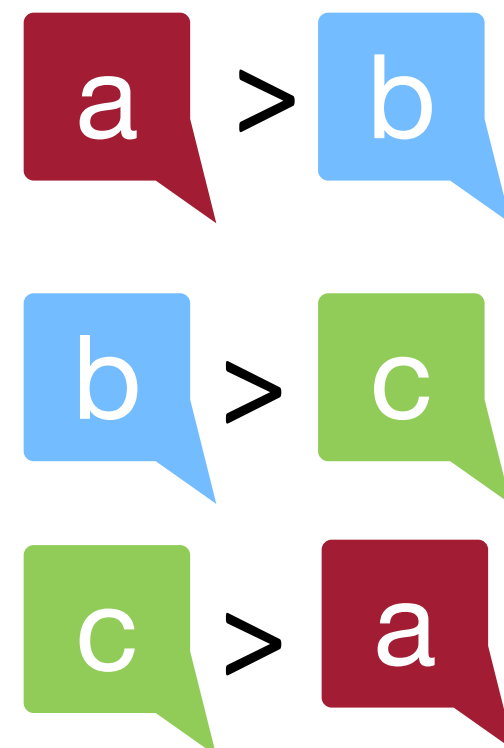
VOTING METHODS

- ♦ There are three candidates at an election. Let's call them a, b and c.



VOTING METHODS

- There are three candidates at an election. Let's call them a, b and c.



VOTING BEYOND MAJORITY



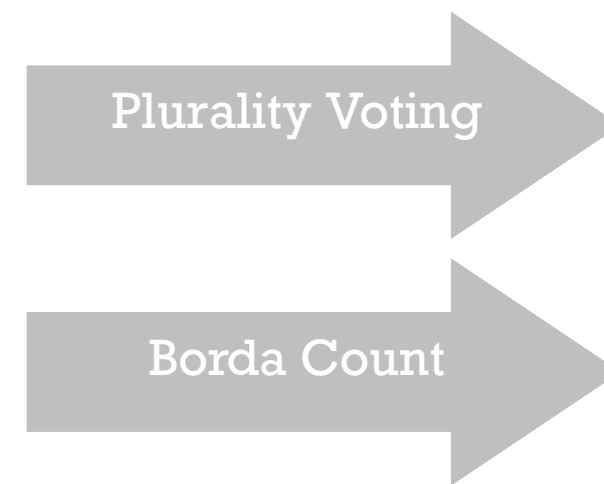
VOTING BEYOND MAJORITY



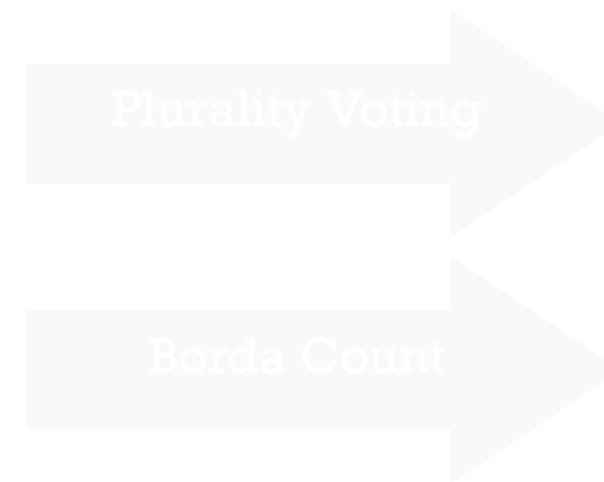
VOTING BEYOND MAJORITY



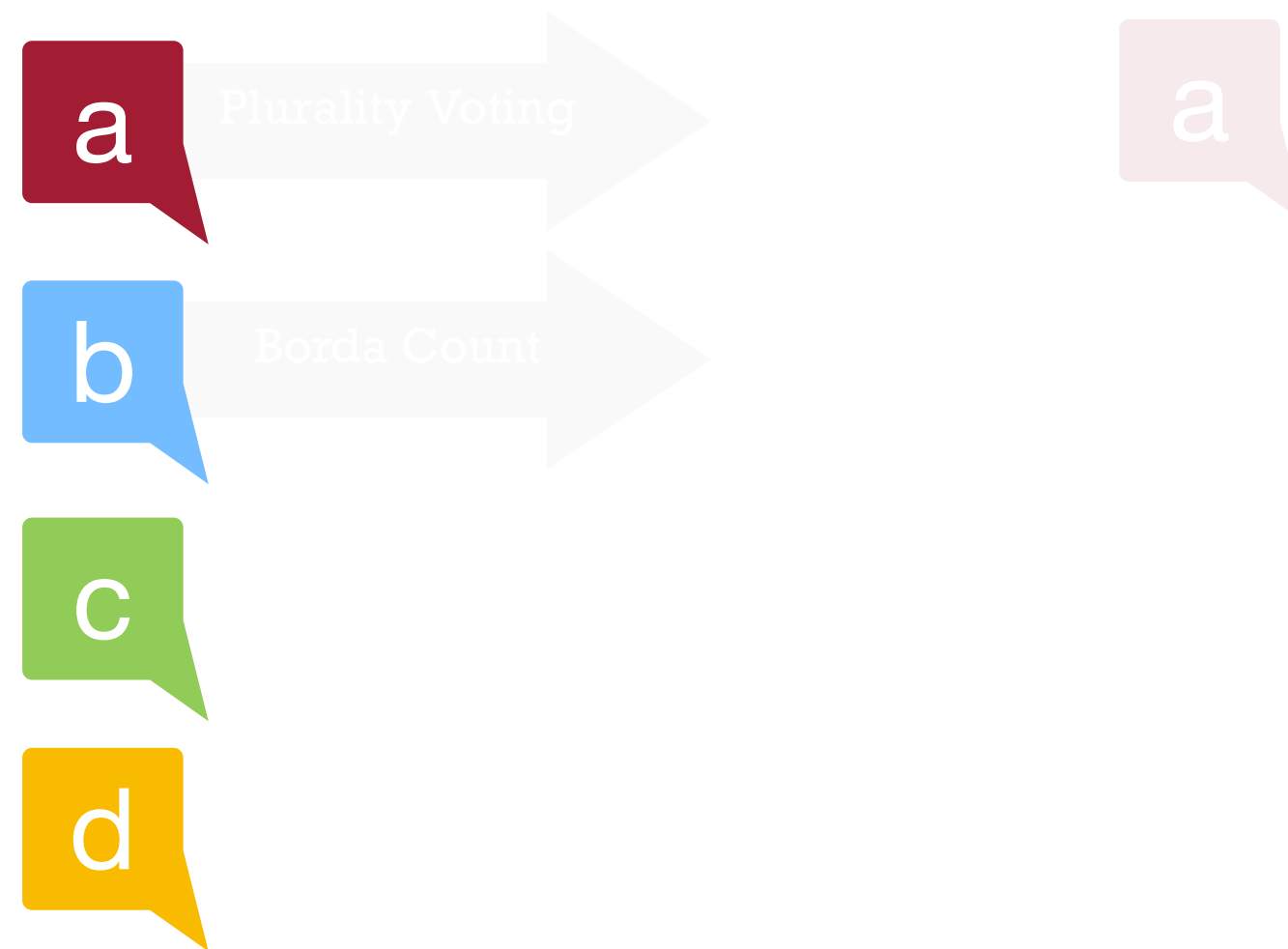
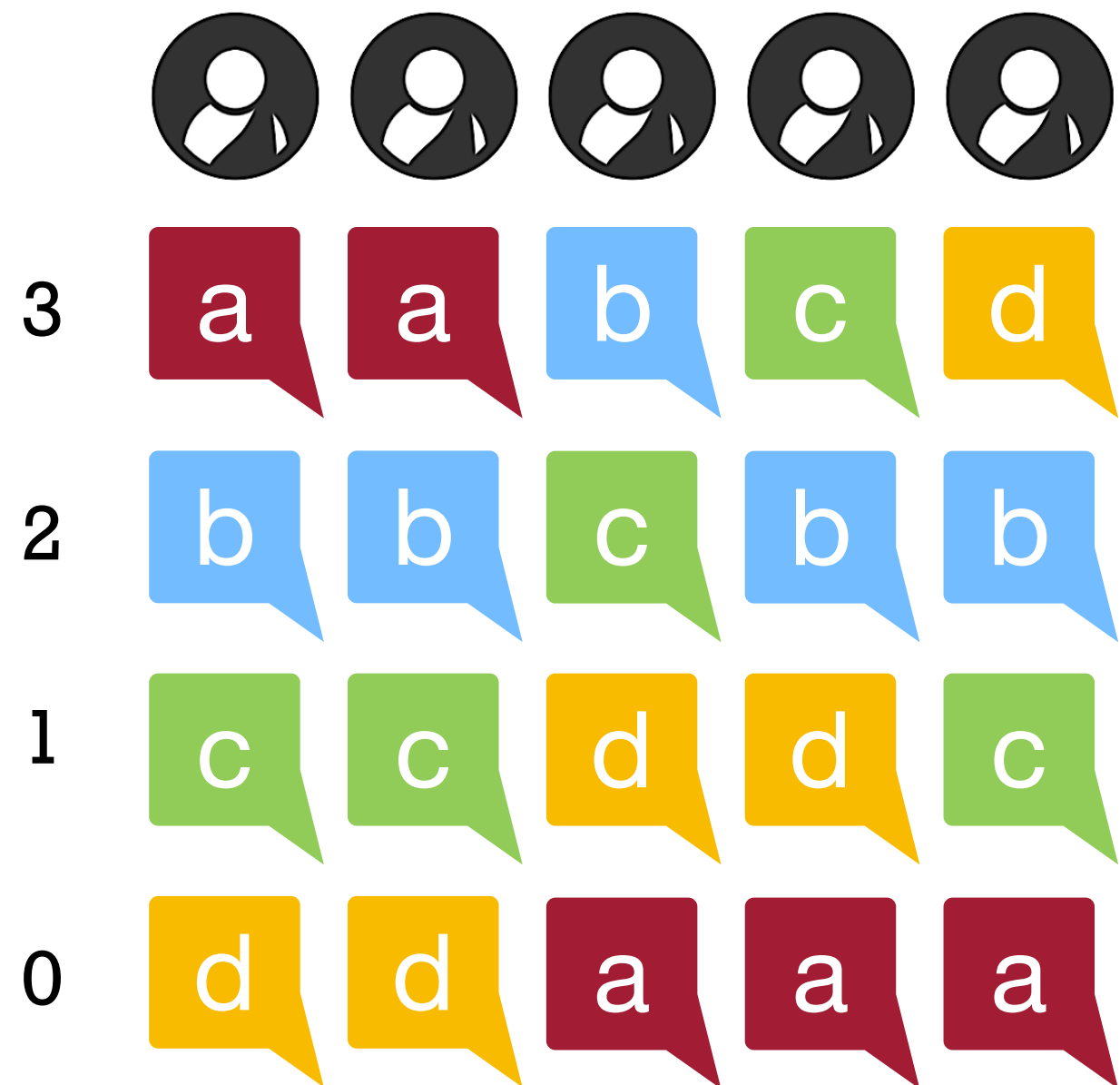
VOTING BEYOND MAJORITY



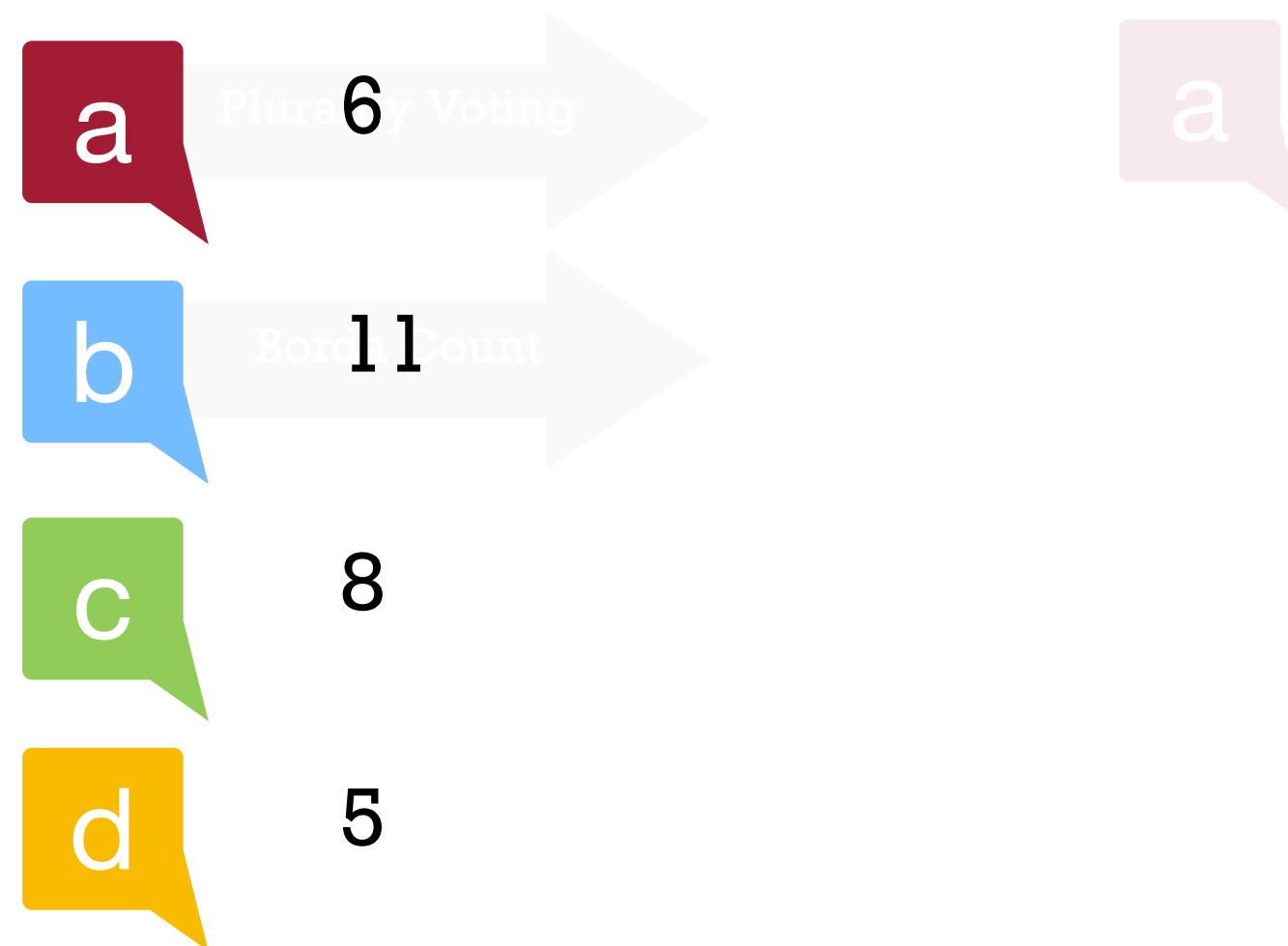
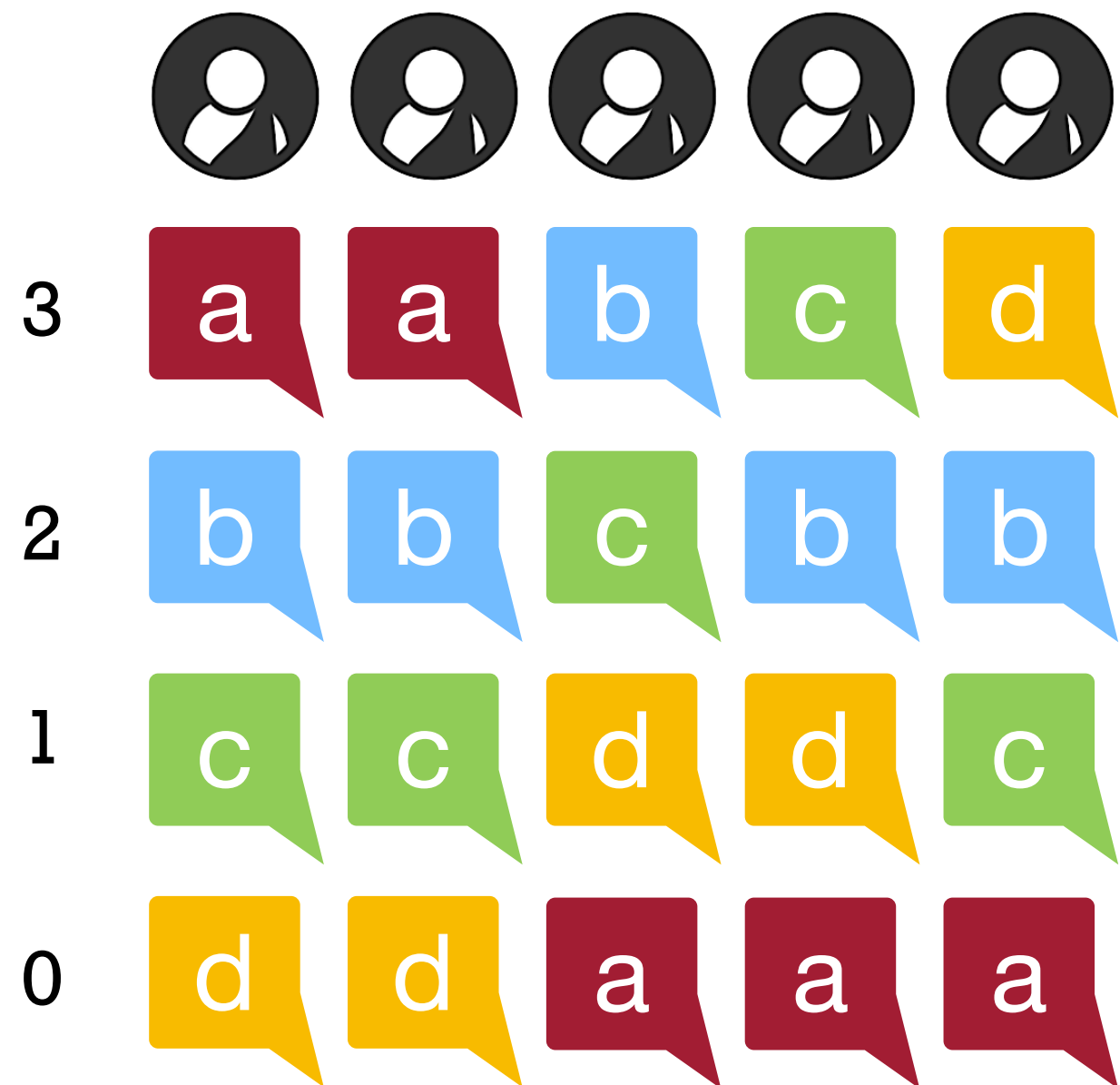
VOTING BEYOND MAJORITY



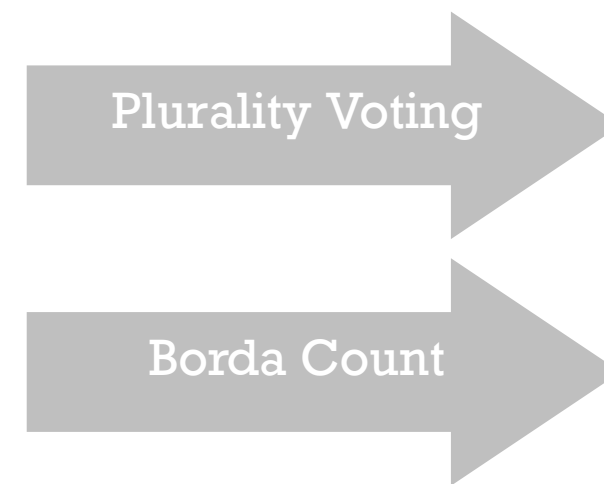
VOTING BEYOND MAJORITY



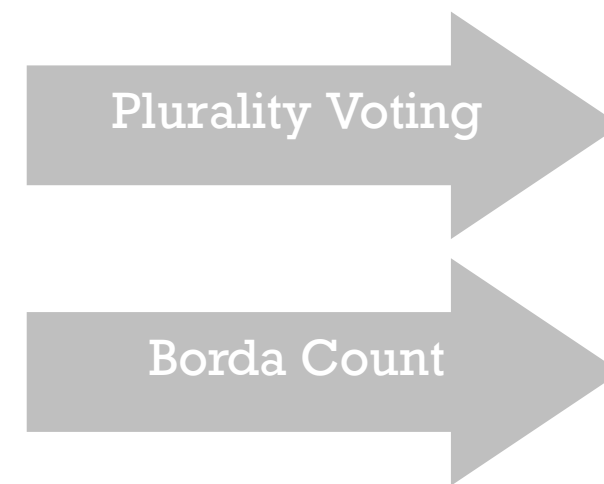
VOTING BEYOND MAJORITY



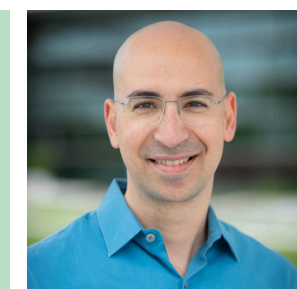
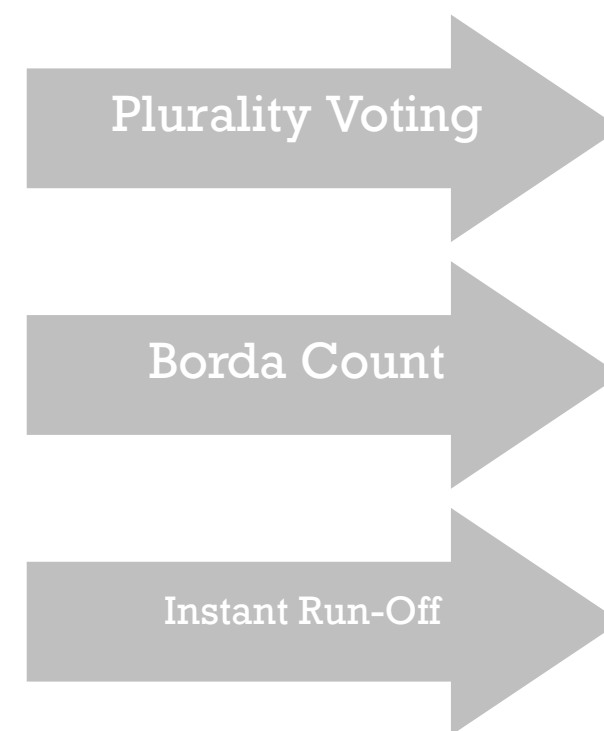
VOTING BEYOND MAJORITY



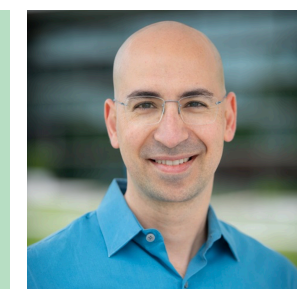
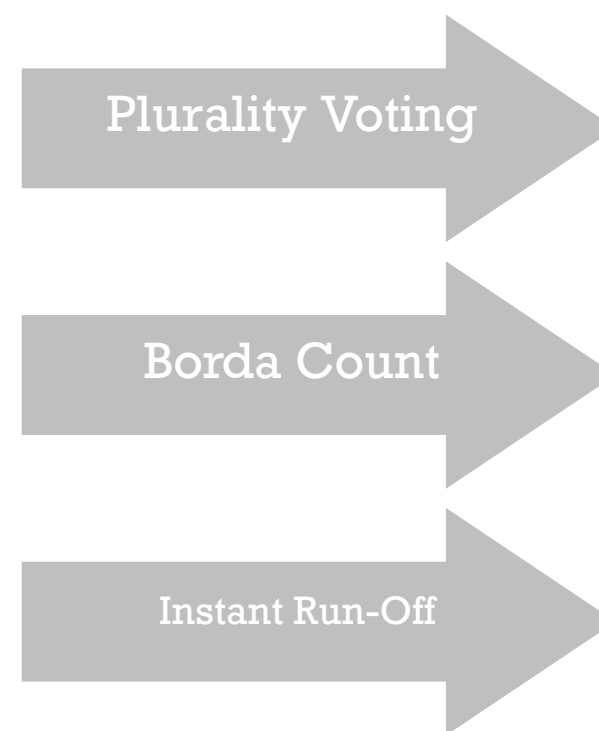
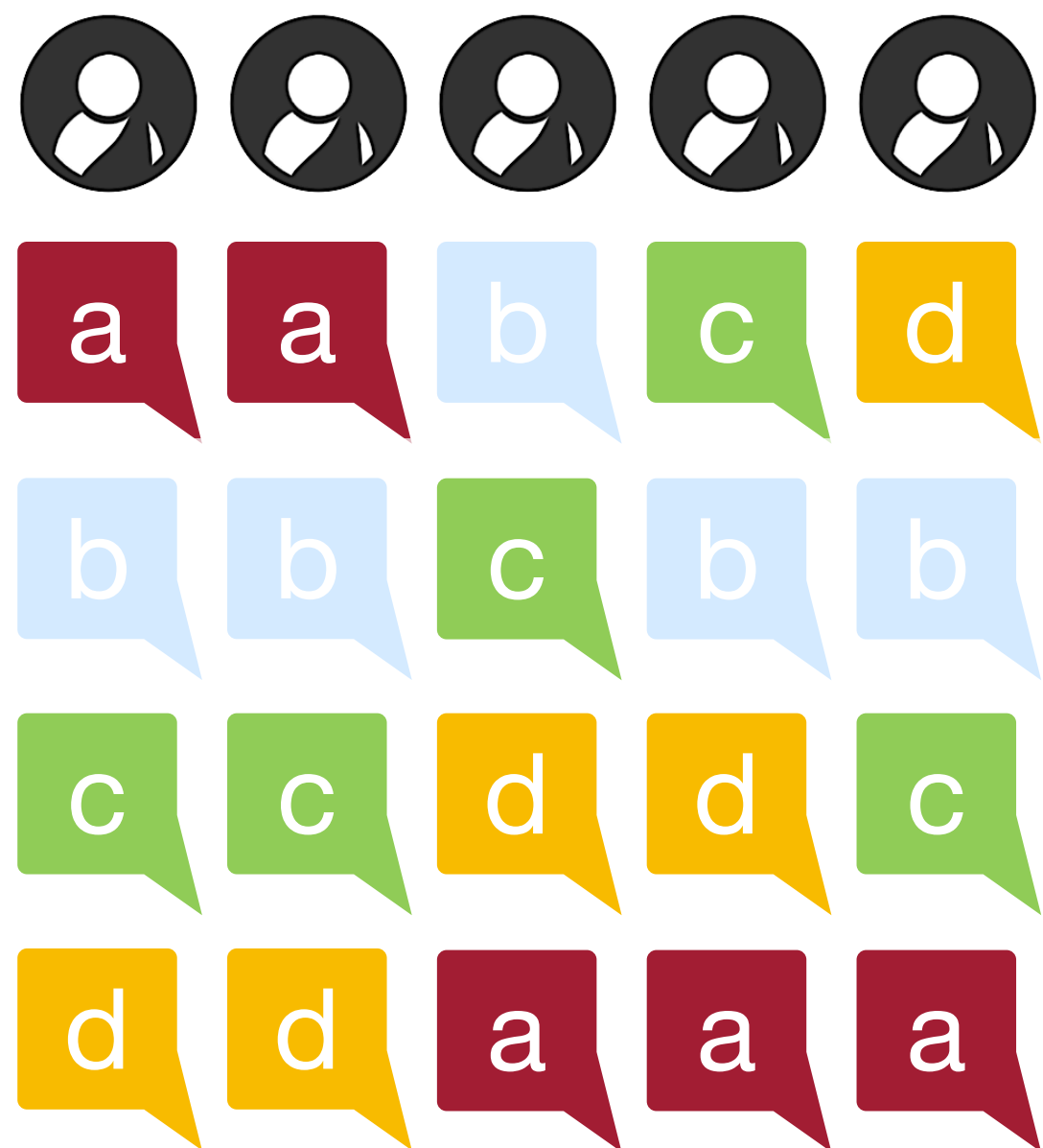
VOTING BEYOND MAJORITY



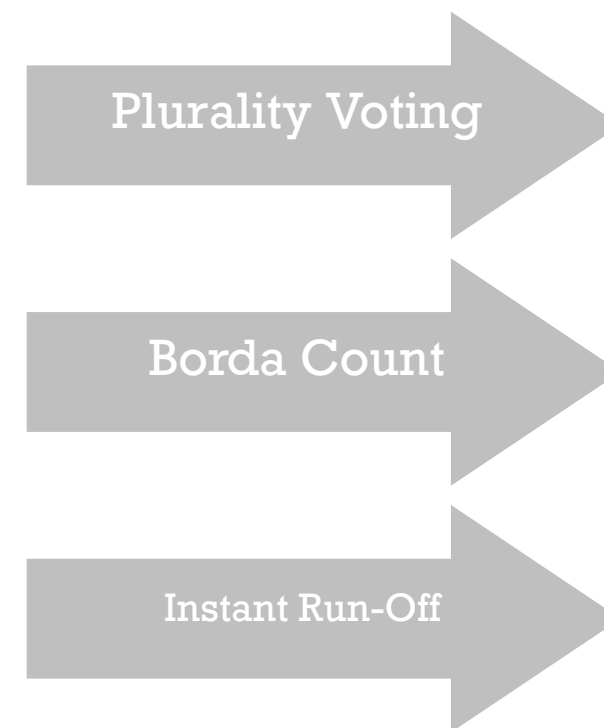
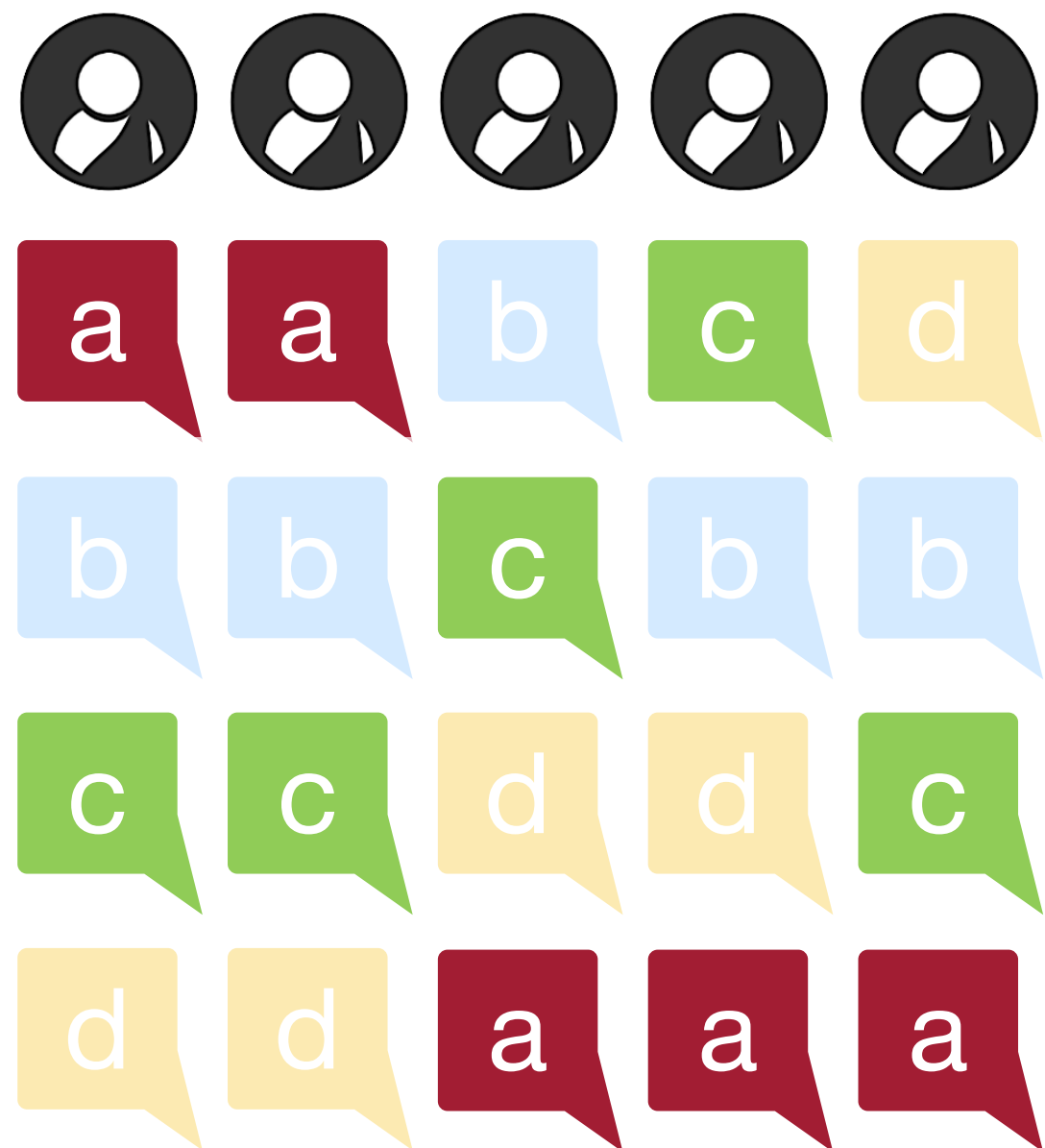
VOTING BEYOND MAJORITY



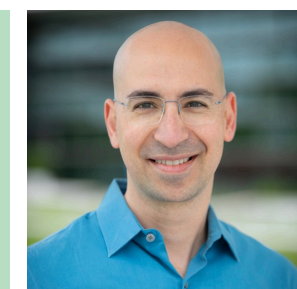
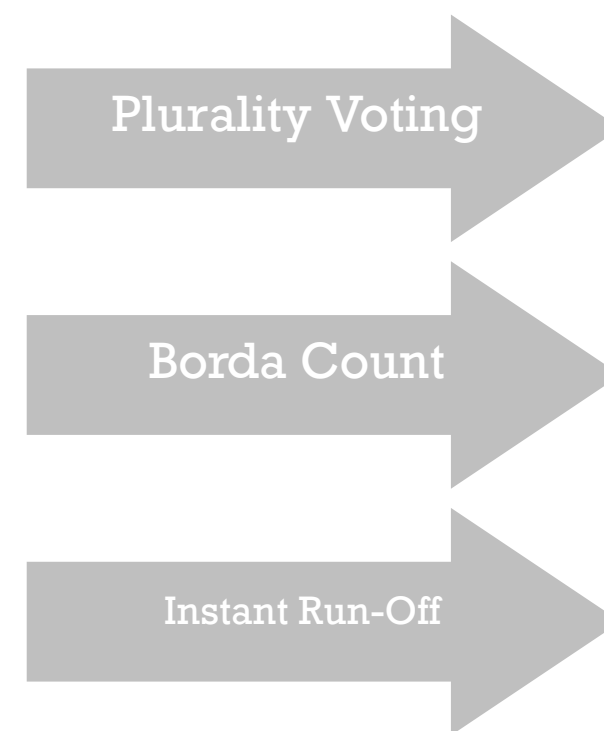
VOTING BEYOND MAJORITY



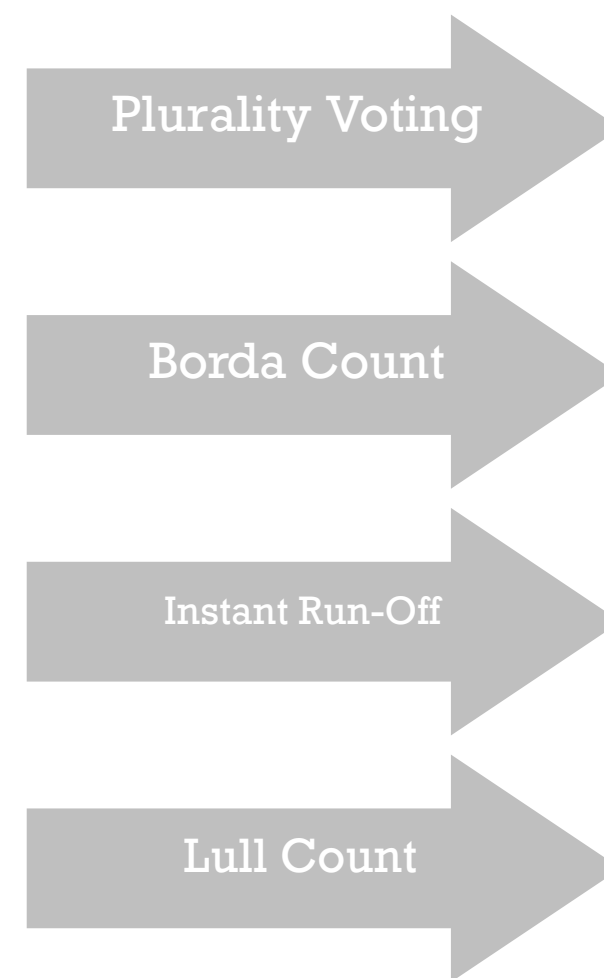
VOTING BEYOND MAJORITY



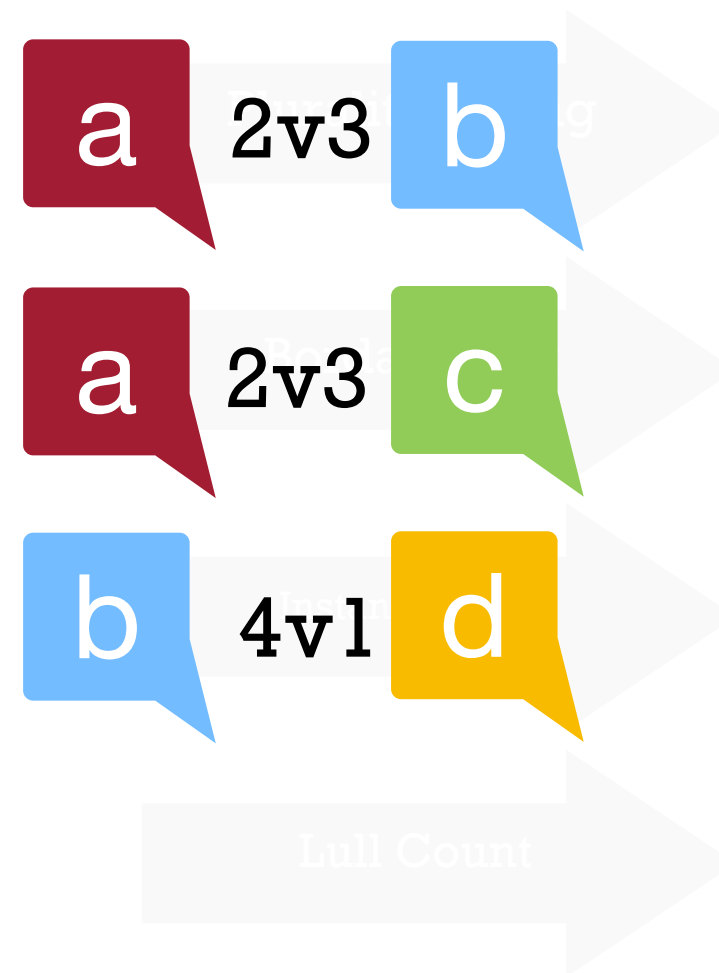
VOTING BEYOND MAJORITY



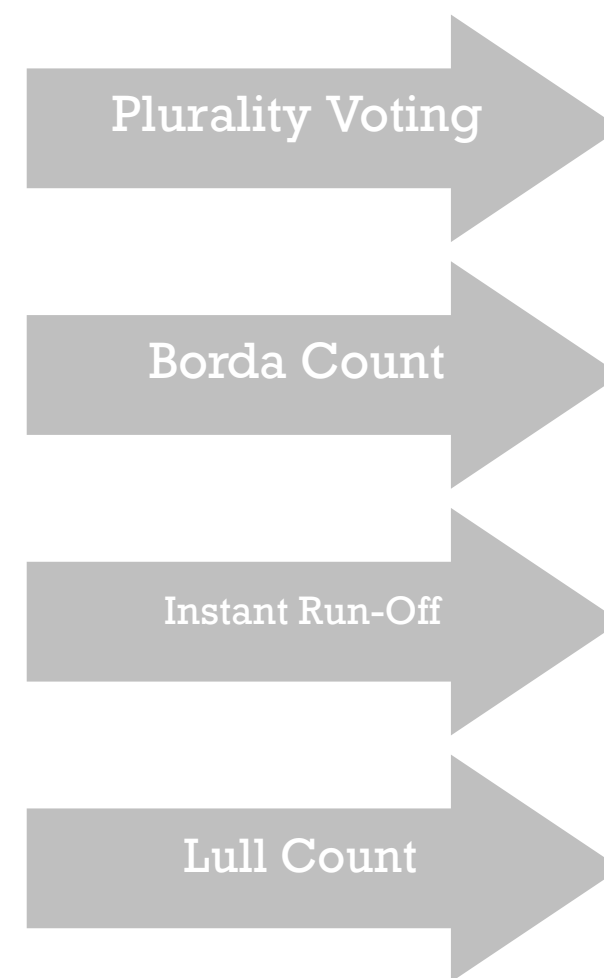
VOTING BEYOND MAJORITY



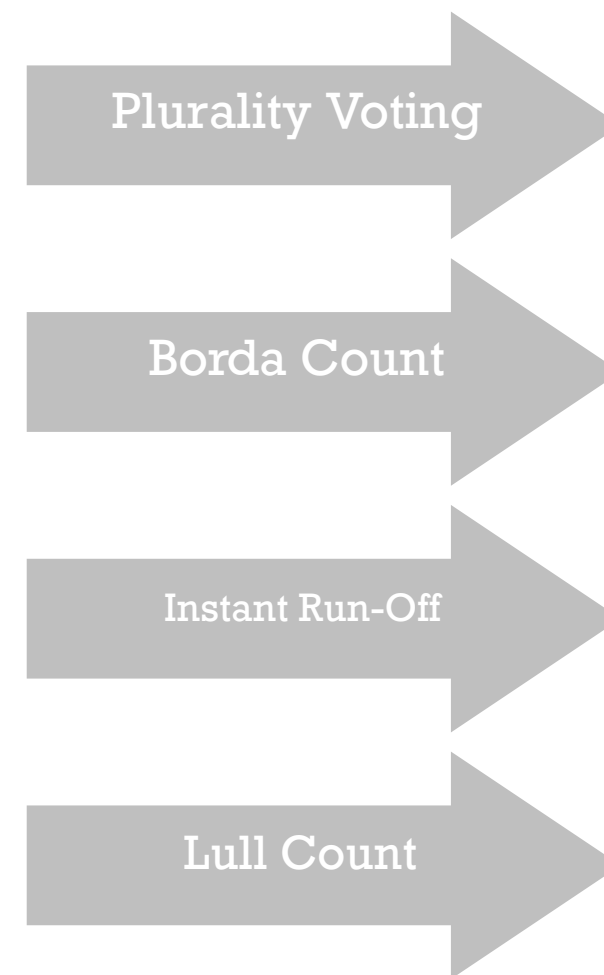
VOTING BEYOND MAJORITY



VOTING BEYOND MAJORITY



VOTING BEYOND MAJORITY



VOTING BEYOND MAJORITY



VOTING BEYOND MAJORITY



- ✦ **Condorcet-winner:** a majority of voters support this candidate over any other in a head-to-head comparison



VOTING BEYOND MAJORITY



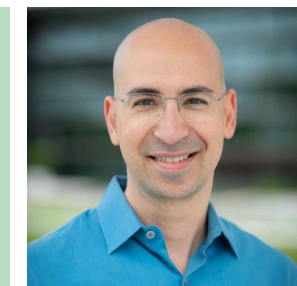
- ✦ **Condorcet-winner:** a majority of voters support this candidate over any other in a head-to-head comparison
 - ✦ Plurality: ✖



VOTING BEYOND MAJORITY



- ✦ **Condorcet-winner:** a majority of voters support this candidate over any other in a head-to-head comparison
 - ✦ Plurality: ✗
 - ✦ Borda Count: ✓ but ✗



VOTING BEYOND MAJORITY

				
a	a	b	c	d
b	b	c	b	b
c	c	d	d	c
d	d	a	a	a

- ✦ **Condorcet-winner:** a majority of voters support this candidate over any other in a head-to-head comparison
 - ✦ Plurality: ✗
 - ✦ Borda Count: ✓ but ✗
 - ✦ Instant-Runoff: ✗



VOTING BEYOND MAJORITY

				
a	a	b	c	d
b	b	c	b	b
c	c	d	d	c
d	d	a	a	a


- ✦ **Condorcet-winner:** a majority of voters support this candidate over any other in a head-to-head comparison
 - ✦ Plurality: ✗
 - ✦ Borda Count: ✓ but ✗
 - ✦ Instant-Runoff: ✗
 - ✦ Lull's Rule: ✓



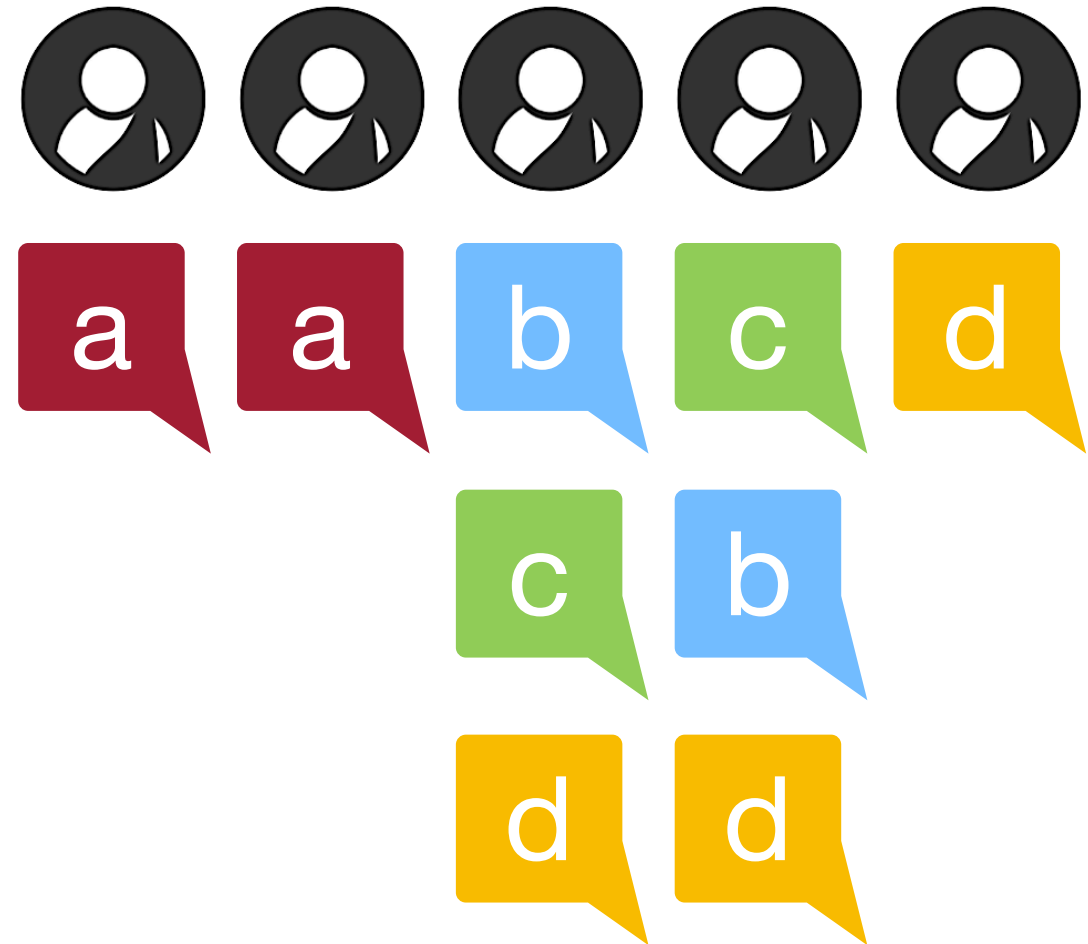
VOTING BEYOND MAJORITY

Comparison of single-winner voting systems [hide]															
Criterion	Majority	Majority loser	Mutual majority	Condorcet winner ^[Tn 1]	Condorcet loser	Smith ^[Tn 1]	ISDA ^[Tn 1]	LIIA	IIA ^[Tn 1]	Cloneproof	Monotone	Participation	Later-no-harm ^[Tn 1]	Later-no-help ^[Tn 1]	No favorite betrayal ^[Tn 1]
Method															
Anti-plurality	No	Yes	No	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes
Approval	Yes	No	No	No	No	No	No	Yes	Yes ^[Tn 2]	Yes	Yes	Yes	No	Yes	Yes
Baldwin	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
Black	Yes	Yes	No	Yes	Yes	No	No	No	No	No	Yes	No	No	No	No
Borda count	No	Yes	No	No	Yes	No	No	No	No	No	Yes	Yes	No	Yes	No
Bucklin	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	No	No	Yes	No
Coombs	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No	No	No	No	Yes
Copeland	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No
Dodgson	Yes	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No
Highest median	Yes	Yes ^[Tn 3]	No ^[Tn 4]	No	No	No	No	Yes	Yes ^[Tn 2]	Yes	Yes	No ^[Tn 5]	No	Yes	Yes
Instant-runoff	Yes	Yes	Yes	No	Yes	No	No	No	No	Yes	No	No	Yes	Yes	No
Kemeny–Young	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No	No
Minimax	Yes	No	No	Yes ^[Tn 6]	No	No	No	No	No	No	Yes	No	No ^[Tn 6]	No	No
Nanson	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
Plurality	Yes	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Random ballot ^[Tn 7]	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ranked pairs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No ^[Tn 5]	No	No	No
Runoff	Yes	Yes	No	No	Yes	No	No	No	No	No	No	No	Yes	Yes	No
Schulze	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No ^[Tn 5]	No	No	No
Score	No	No	No	No	No	No	No	Yes	Yes ^[Tn 2]	Yes	Yes	Yes	No	Yes	Yes
Sortition ^[Tn 8]	No	No	No	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
STAR	No	Yes	No	No	Yes	No	No	No	No	No	Yes	No	No	No	No
Tideman alternative	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No	No	No

Wikipedia - Electoral Systems

 [click](#)

VOTING BEYOND MAJORITY



2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

APPROVAL VOTING AND COMMITTEE ELECTIONS

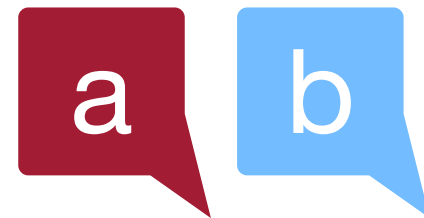


5 voters and 2 seats

APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats

1 + 1



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats

1 + 1 1 + 1



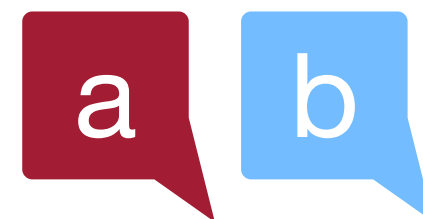
APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats



1 + 1 1 + 1 1 + 1

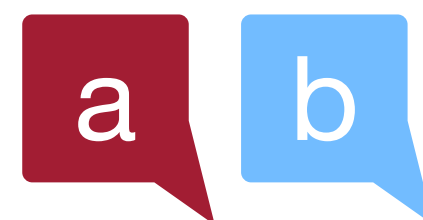


APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats

1 + 1 1 + 1 1 + 1 0 + 0



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats



1 + 1 1 + 1 1 + 1 0 + 0 0 + 0



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats

1 + 1 1 + 1 1 + 1 0 + 0 0 + 0



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats

1 + 1 1 + 1 1 + 1 0 + 0 0 + 0

1 + 0 1 + 0 1 + 0 1 + 0 1 + 0



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats



1 + 1	1 + 1	1 + 1	0 + 0	0 + 0
1 + 0	1 + 0	1 + 0	1 + 0	1 + 0



APPROVAL VOTING AND COMMITTEE ELECTIONS



1 + 1 1 + 1 1 + 1 0 + 0 0 + 0

1 + 0 1 + 0 1 + 0 1 + 0 1 + 0

5 voters and 2 seats



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats



$1 + 1$	$1 + 1$	$1 + 1$	$0 + 0$	$0 + 0$
$1 + 1/2$	$1 + 1/2$	$1 + 1/2$	$0 + 0$	$0 + 0$

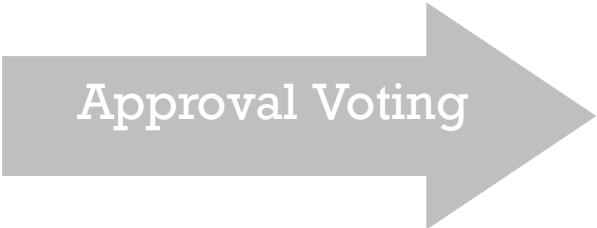
$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$
---------	---------	---------	---------	---------



APPROVAL VOTING AND COMMITTEE ELECTIONS

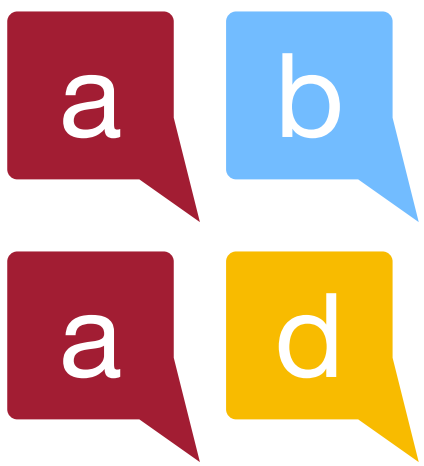


5 voters and 2 seats



$1 + 1$	$1 + 1$	$1 + 1$	$0 + 0$	$0 + 0$
$1 + 1/2$	$1 + 1/2$	$1 + 1/2$	$0 + 0$	$0 + 0$

$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$
$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$



APPROVAL VOTING AND COMMITTEE ELECTIONS



5 voters and 2 seats



$1 + 1$	$1 + 1$	$1 + 1$	$0 + 0$	$0 + 0$
$1 + 1/2$	$1 + 1/2$	$1 + 1/2$	$0 + 0$	$0 + 0$

$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$
$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$	$1 + 0$



APPROVAL VOTING AND COMMITTEE ELECTIONS

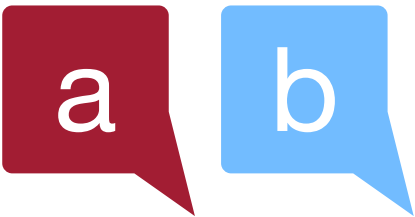


5 voters and 2 seats



1 + 1	1 + 1	1 + 1	0 + 0	0 + 0
1 + 1/2	1 + 1/2	1 + 1/2	0 + 0	0 + 0

1 + 0	1 + 0	1 + 0	1 + 0	1 + 0
1 + 0	1 + 0	1 + 0	1 + 0	1 + 0



JUSTIFIED REPRESENTATION

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).



JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

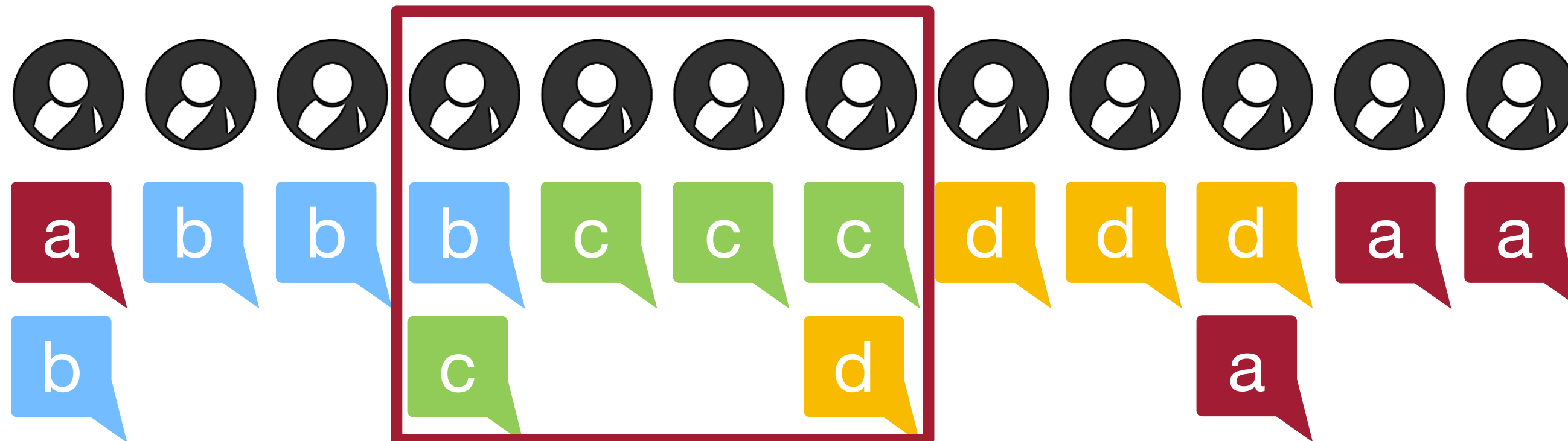
- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

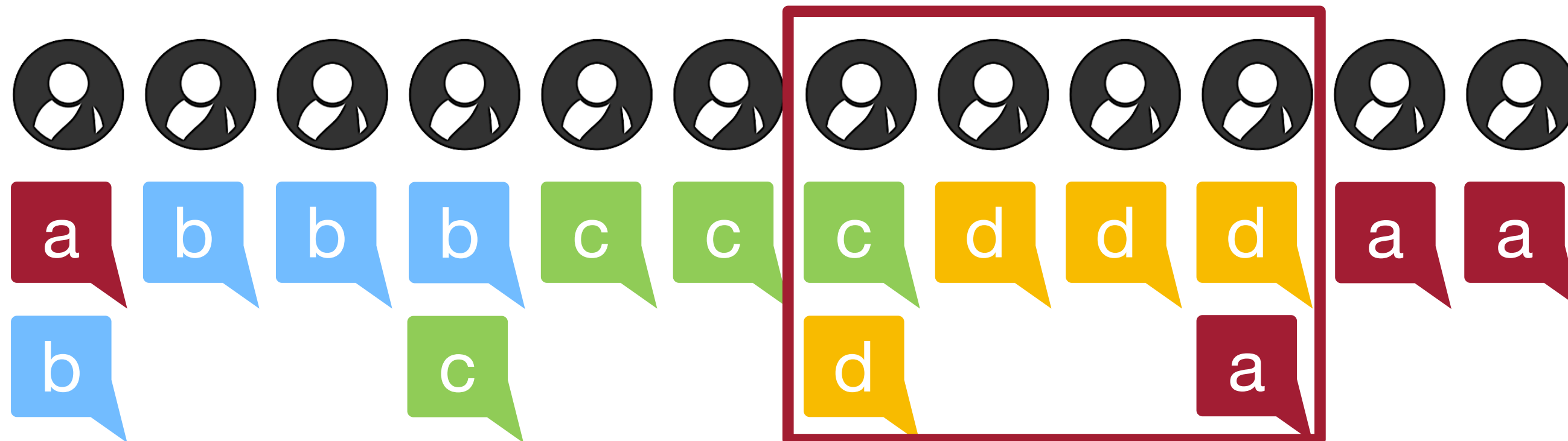
- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

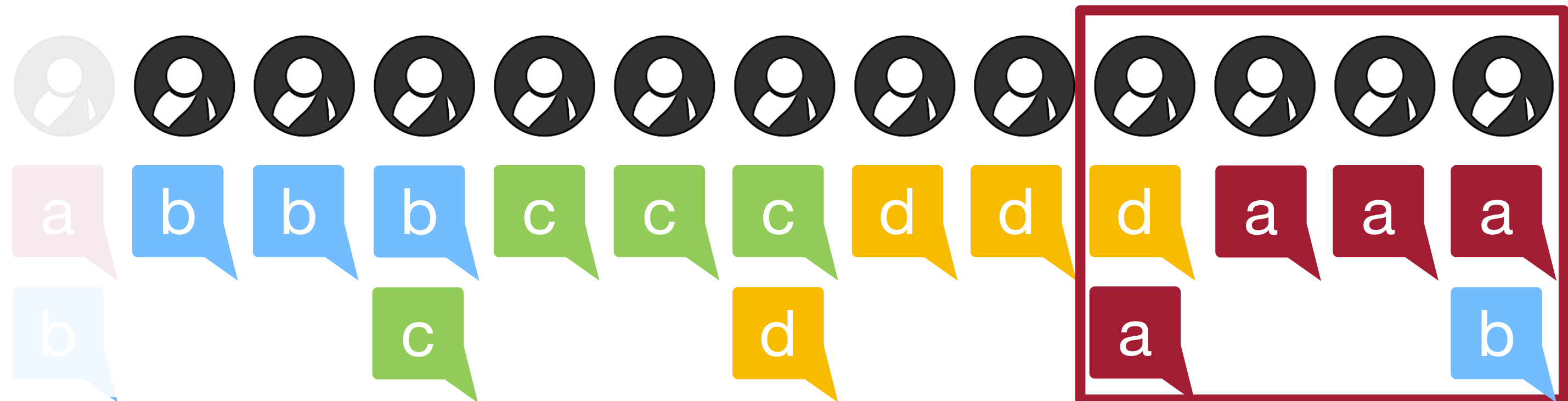
- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size mn/k that approves a set of m candidates, these candidates should be selected in the committee (such that the size of the group is mn/k).



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.

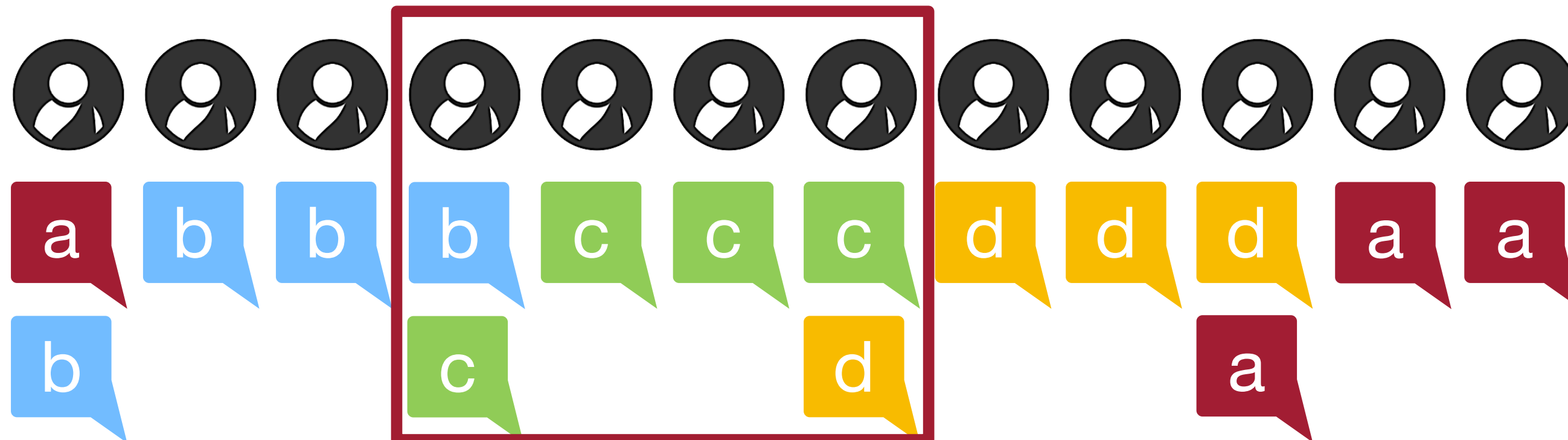


a

$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.

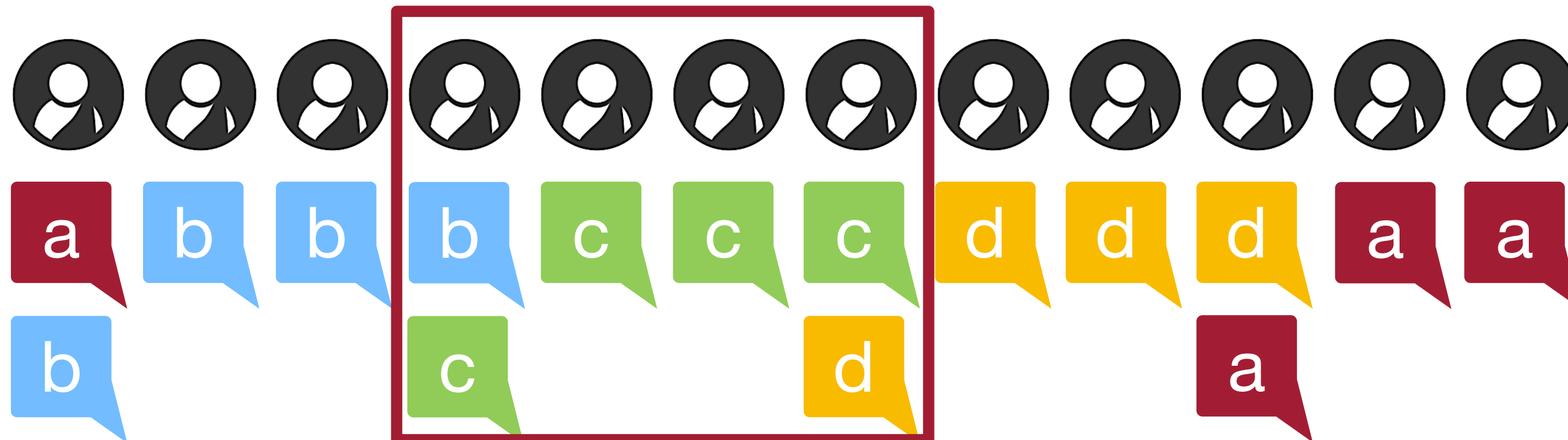


a

$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

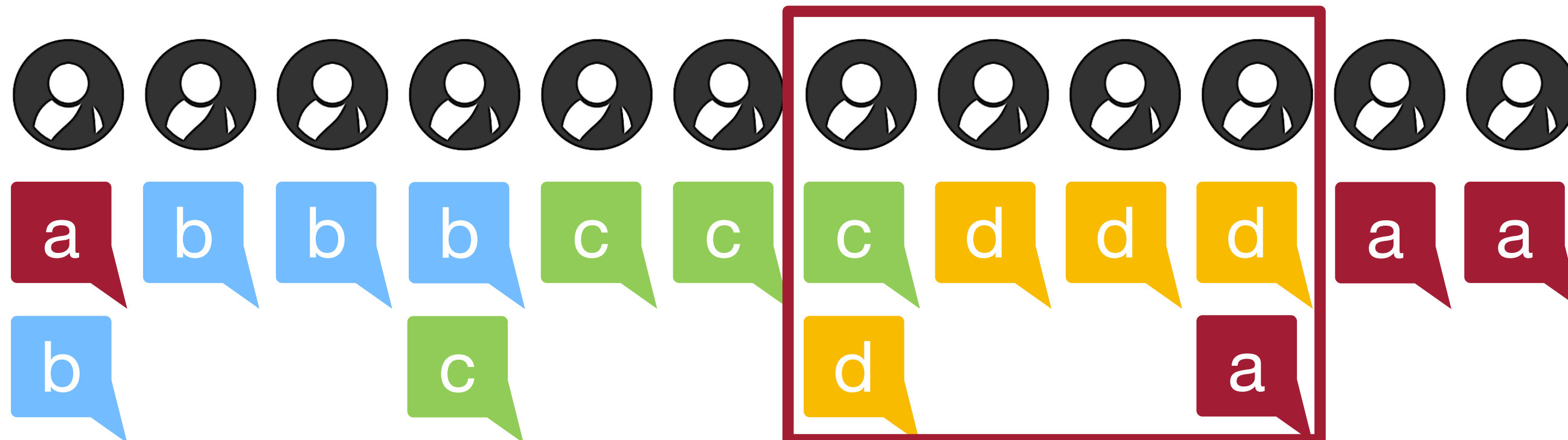
- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

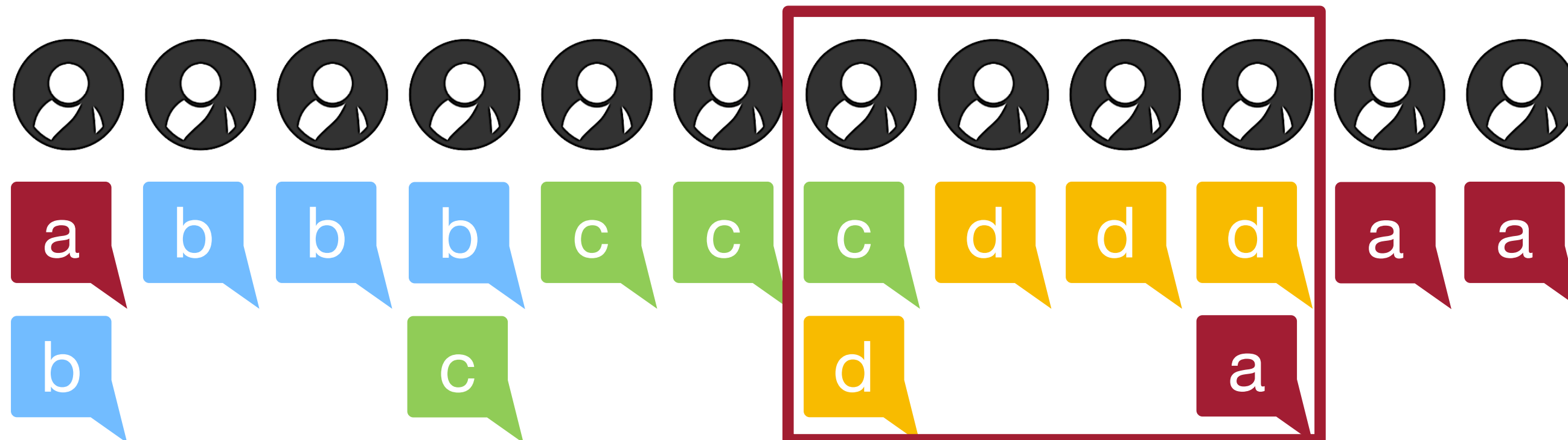
- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

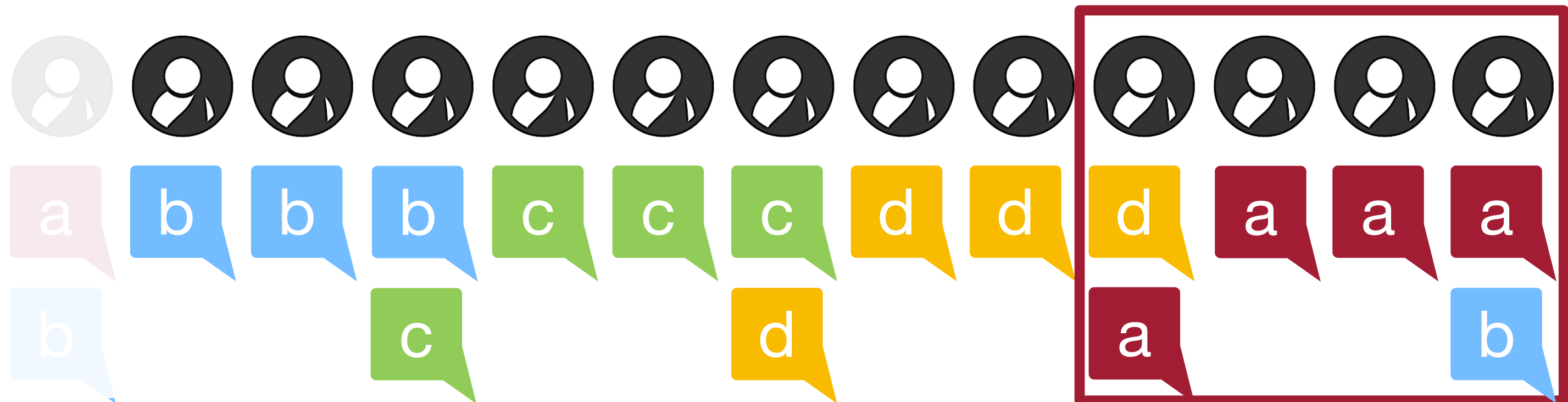
- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



$n = 12$ voters and $k = 3$ seats

JUSTIFIED REPRESENTATION

- ✦ In a committee of size k with n voters, if there exists a group of size n/k that approves a candidate, one member of that group at least should have a candidate of their choosing in the committee.



$n = 12$ voters and $k = 3$ seats

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

Selection Methods for Sortition

2

Mathematical Theories of Representation

Epistemic Considerations in Decision

On Direct Democracy

On Optimal Decision Rules

On Liquid Democracy

On Assumptions and Applicability

Procedural Considerations in Selection

Selection Methods for Single-Winner Elections

Selection Methods for Multi-Winner Elections

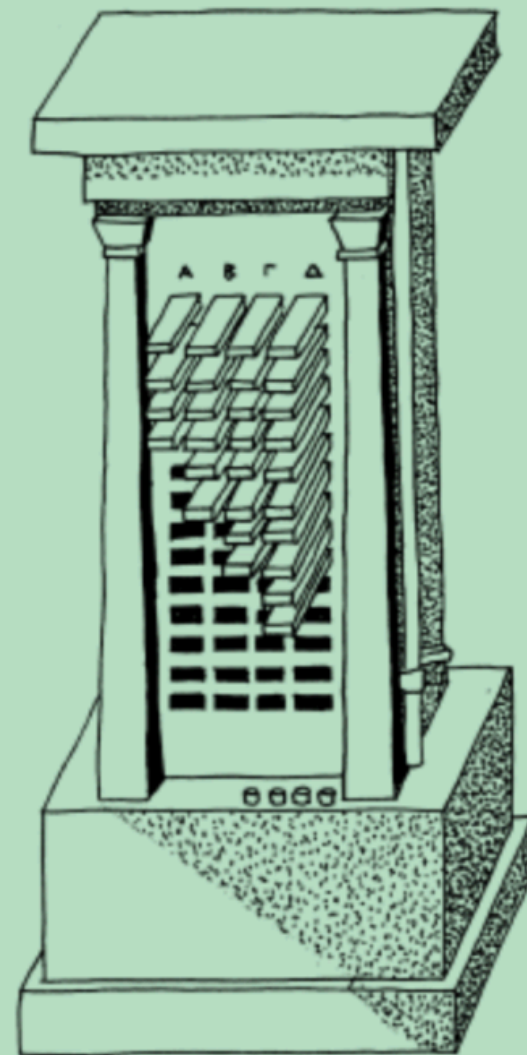
Selection Methods for Sortition

SORTITION

Kleroterion

κληρόω: to assign by lot

02. Representation by lottery (sortition)



Learn more →

DemNext



Assembling an
Assembly Guide



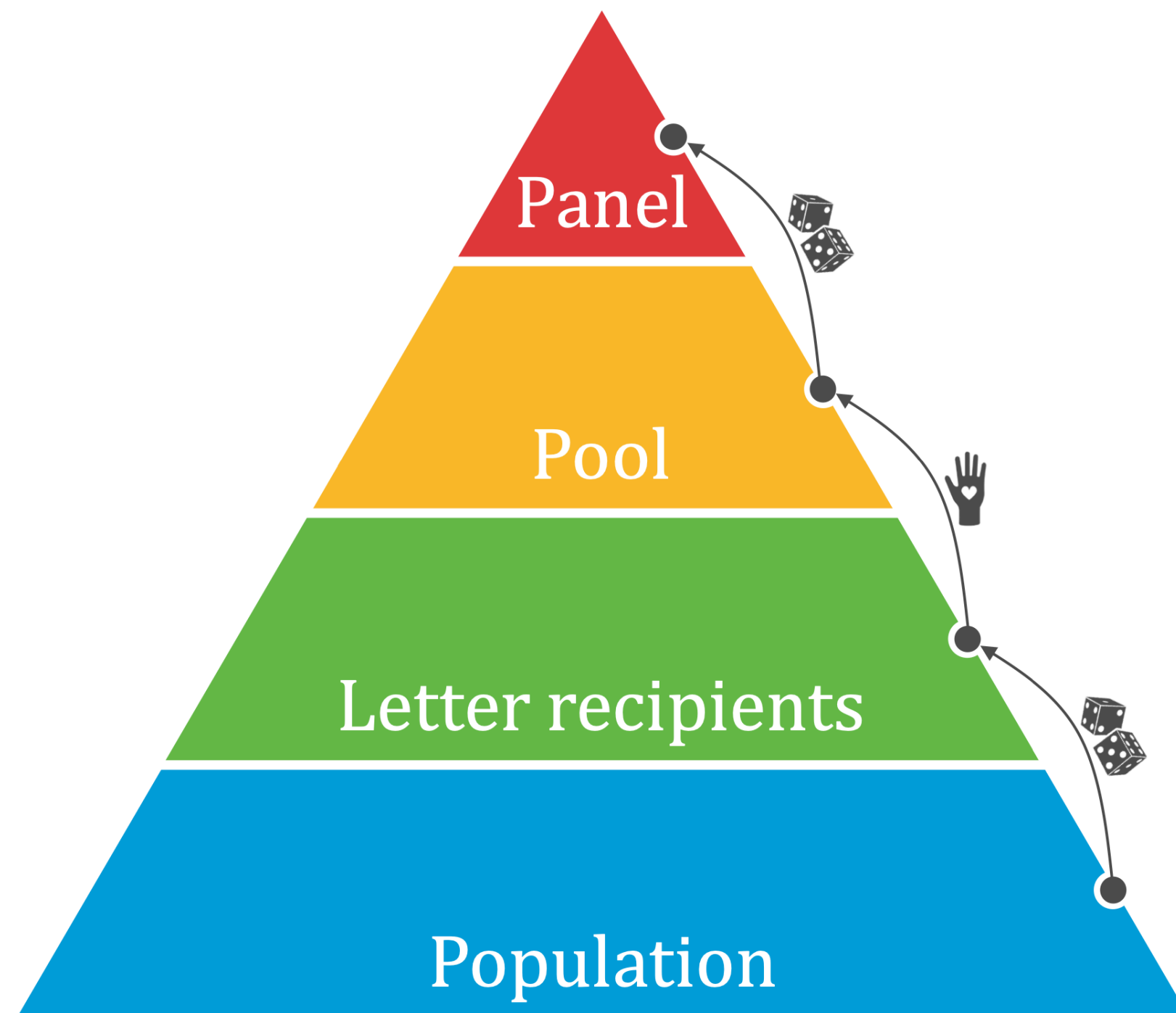
[click](#)

QUOTA-BASED SORTITION

Ariel Procaccia's Class
Optimized Democracy



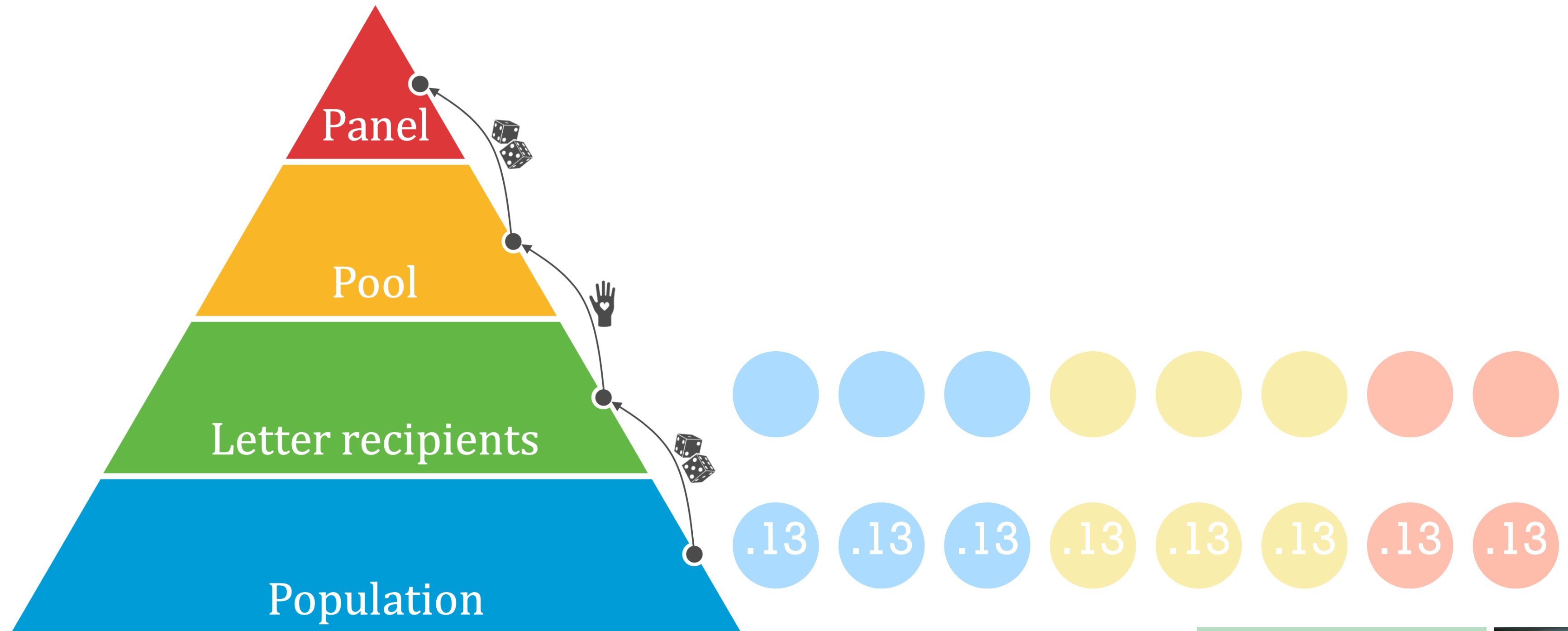
QUOTA-BASED SORTITION



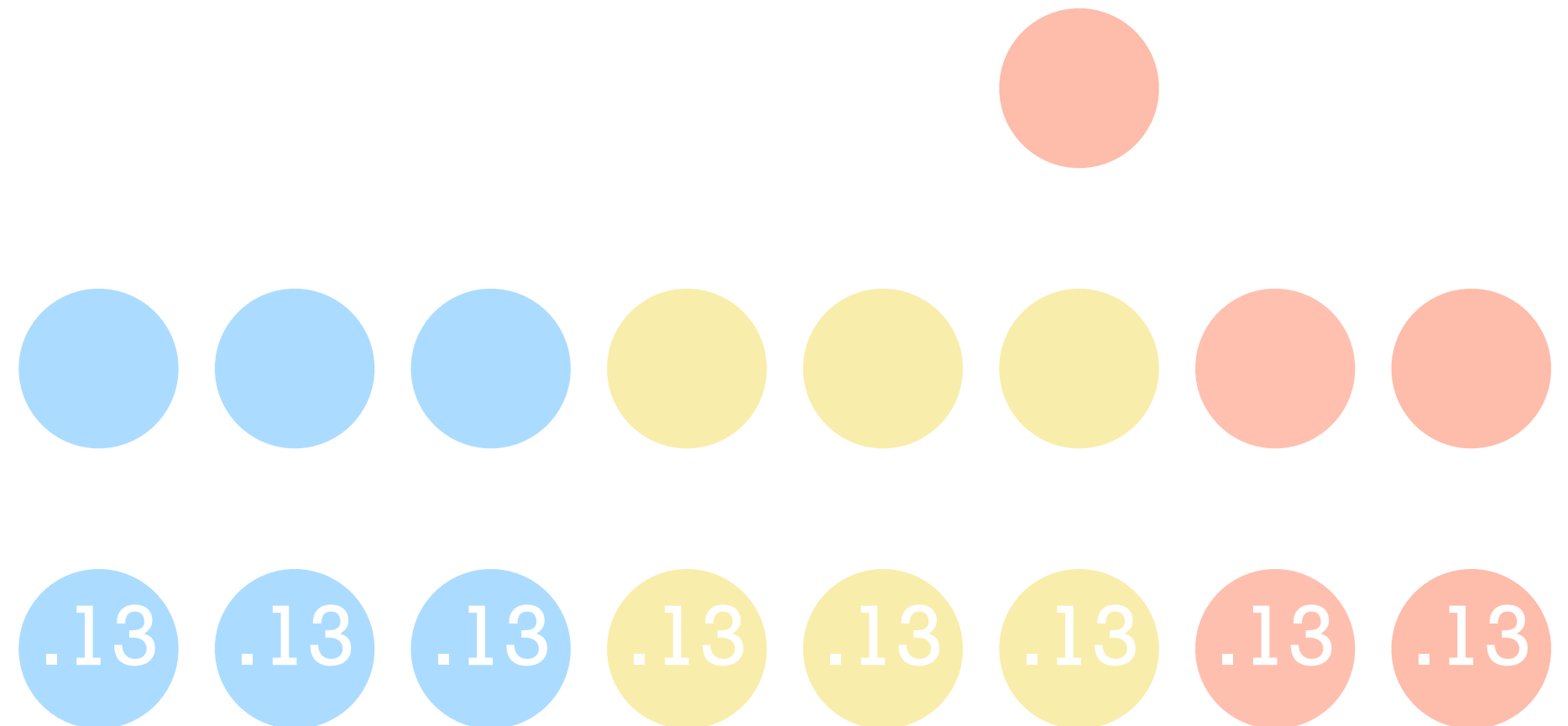
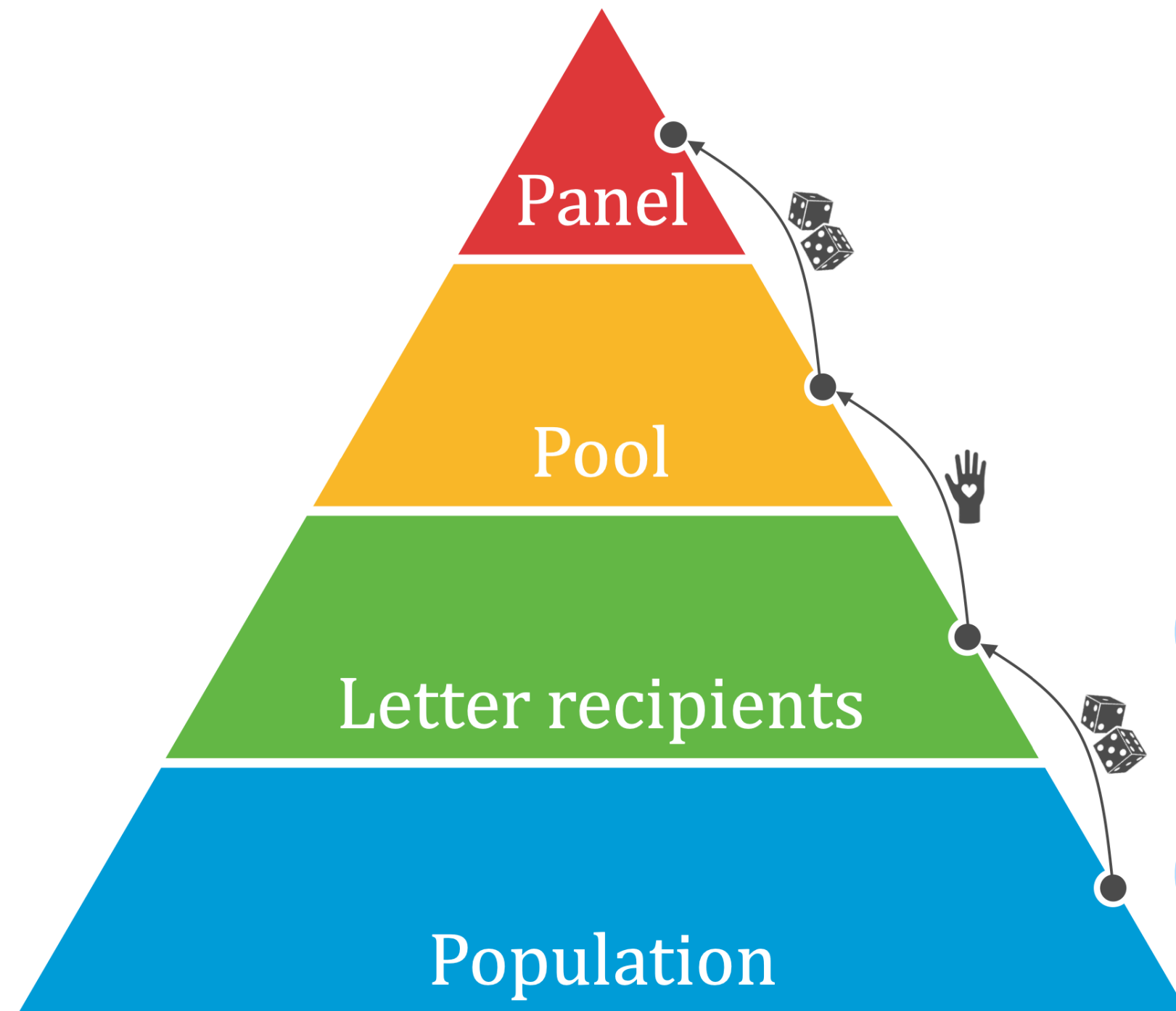
Ariel Procaccia's Class
Optimized Democracy



QUOTA-BASED SORTITION



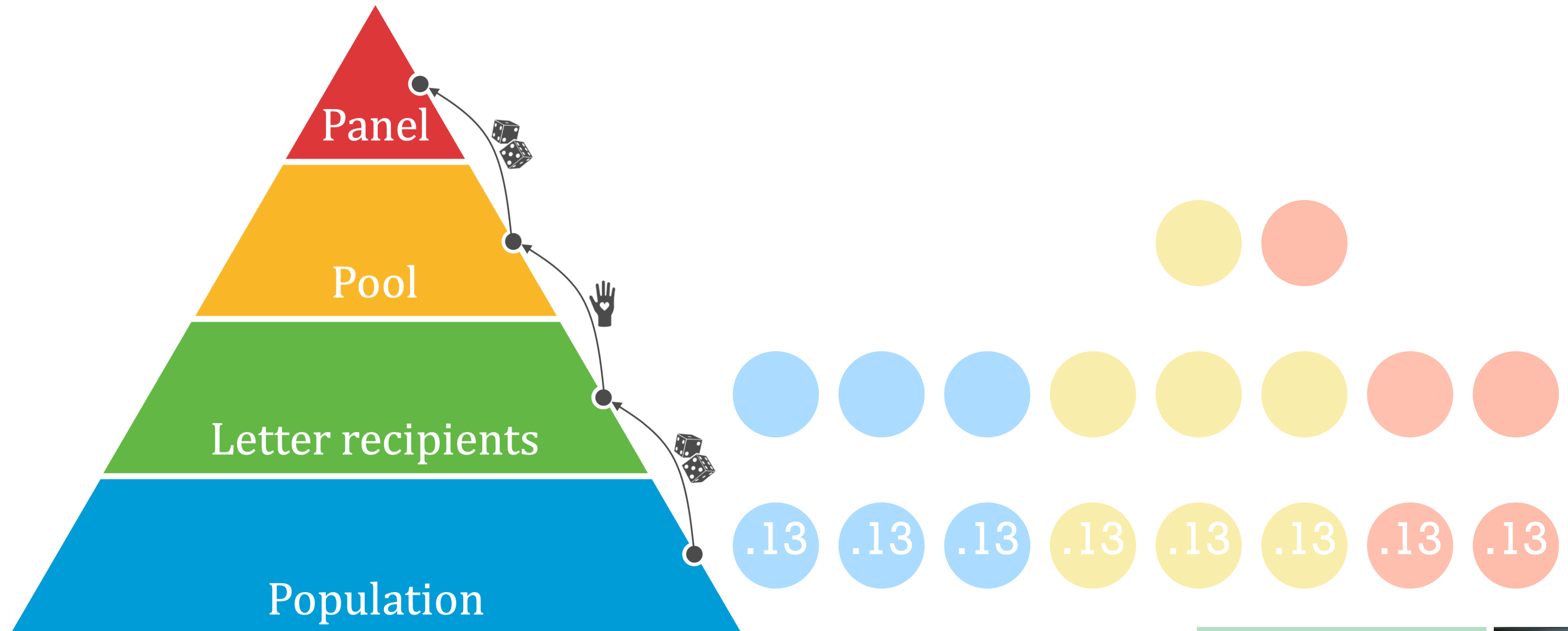
QUOTA-BASED SORTITION



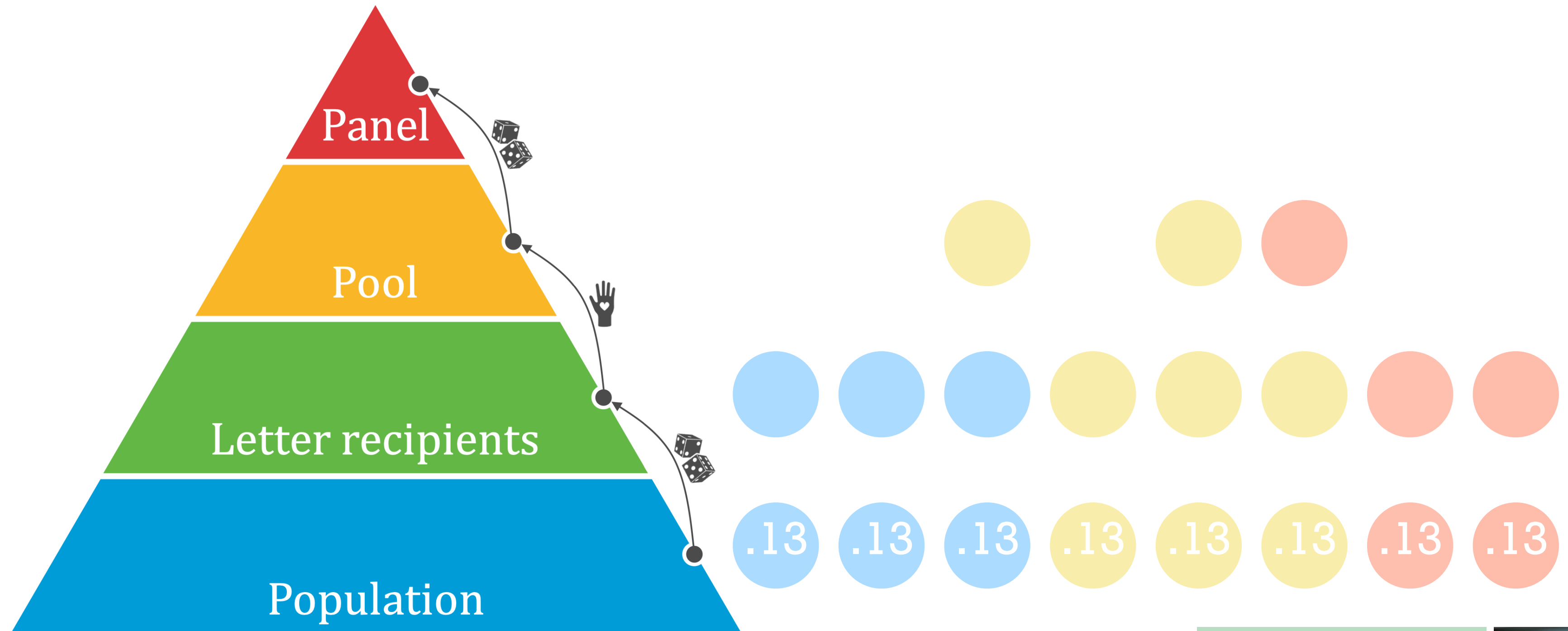
Ariel Procaccia's Class
Optimized Democracy



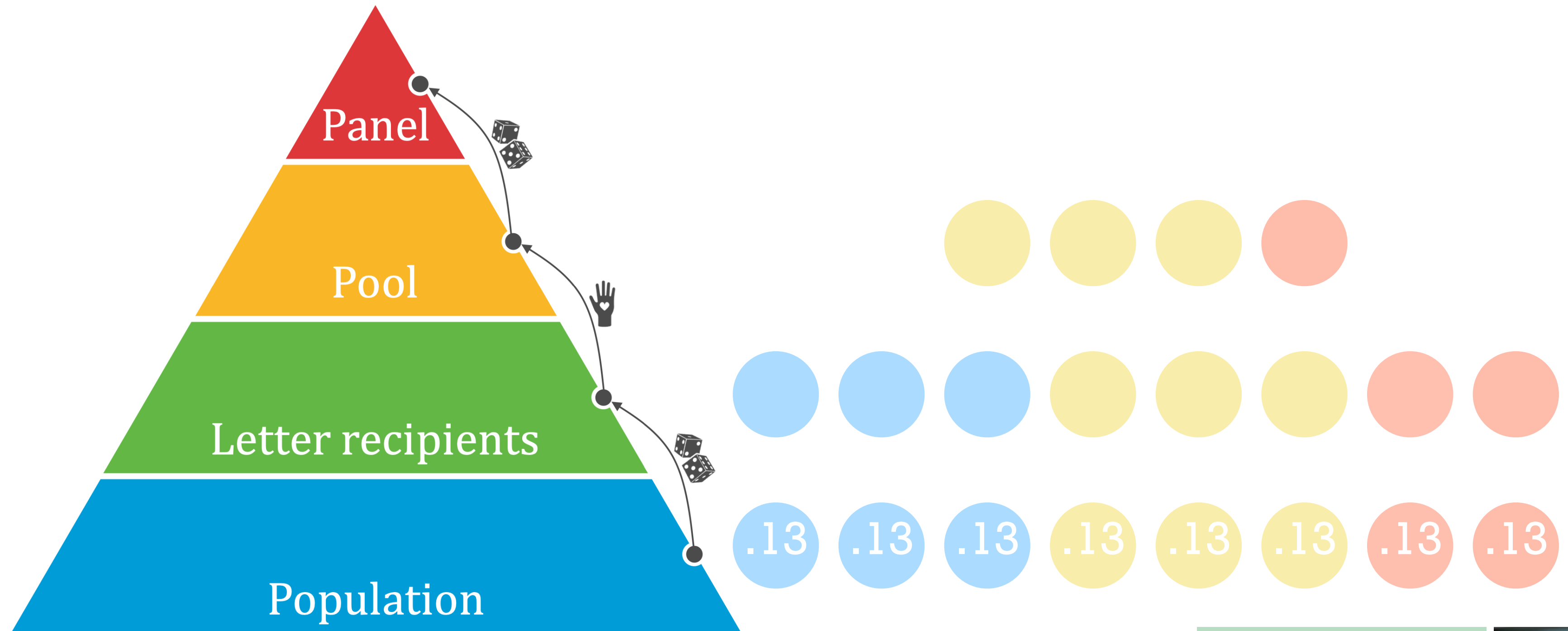
QUOTA-BASED SORTITION



QUOTA-BASED SORTITION



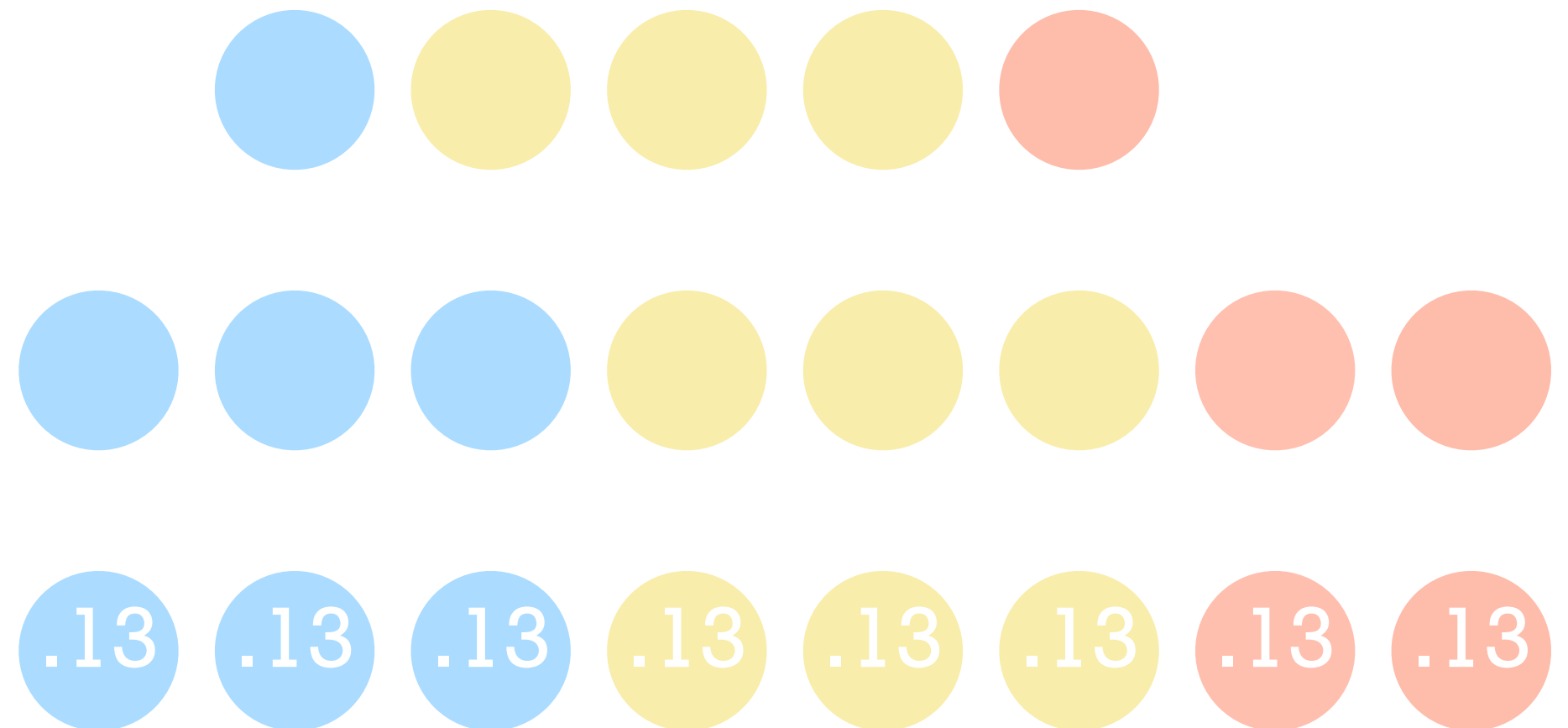
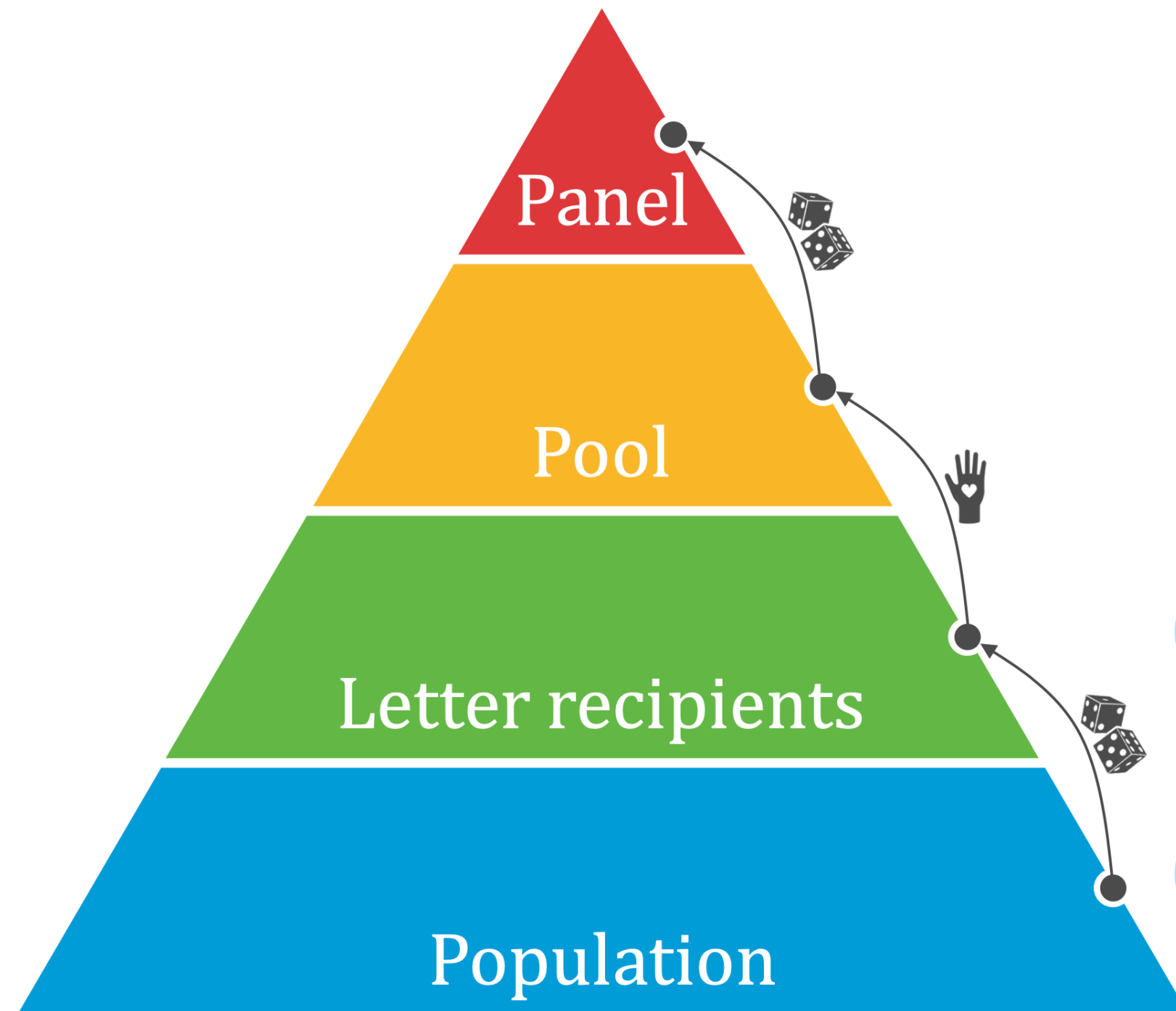
QUOTA-BASED SORTITION



Ariel Procaccia's Class
Optimized Democracy



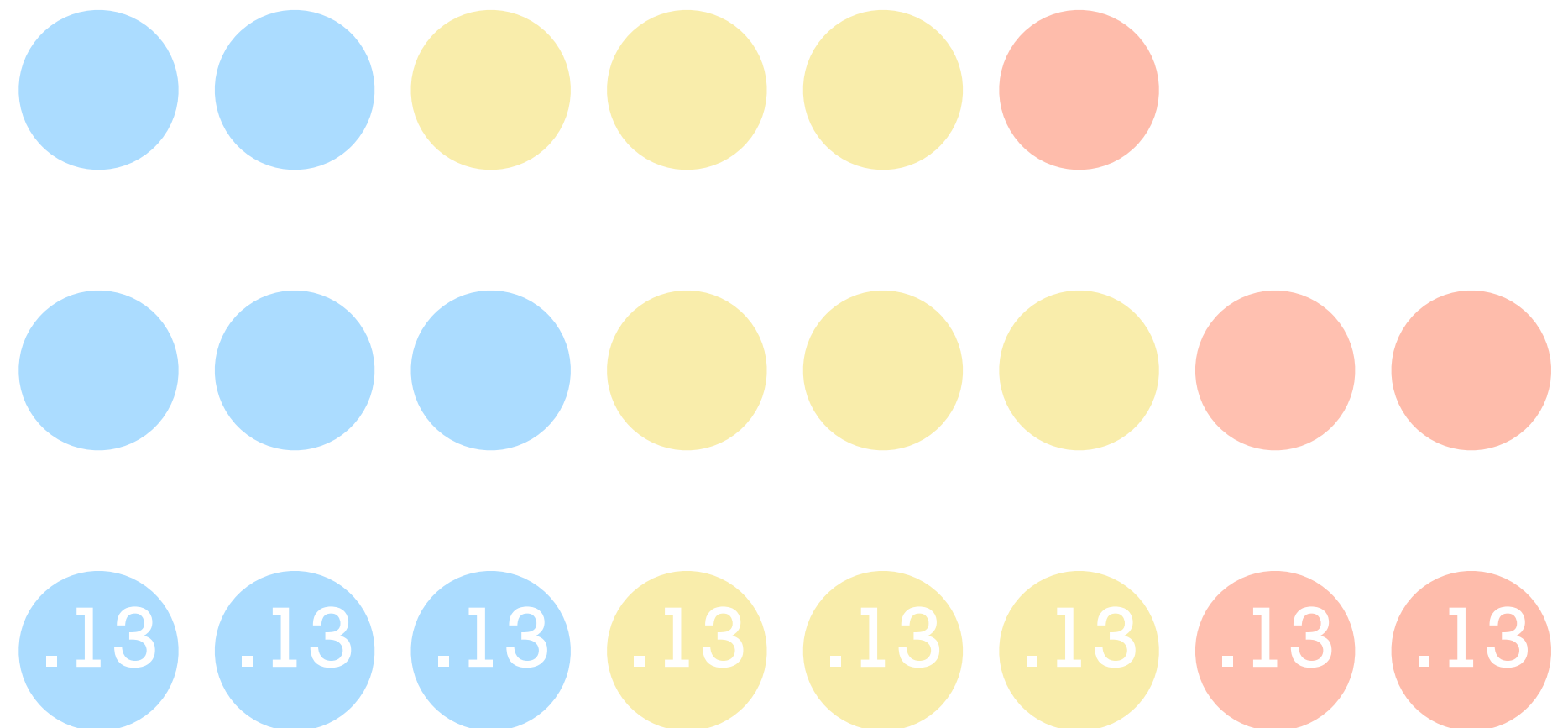
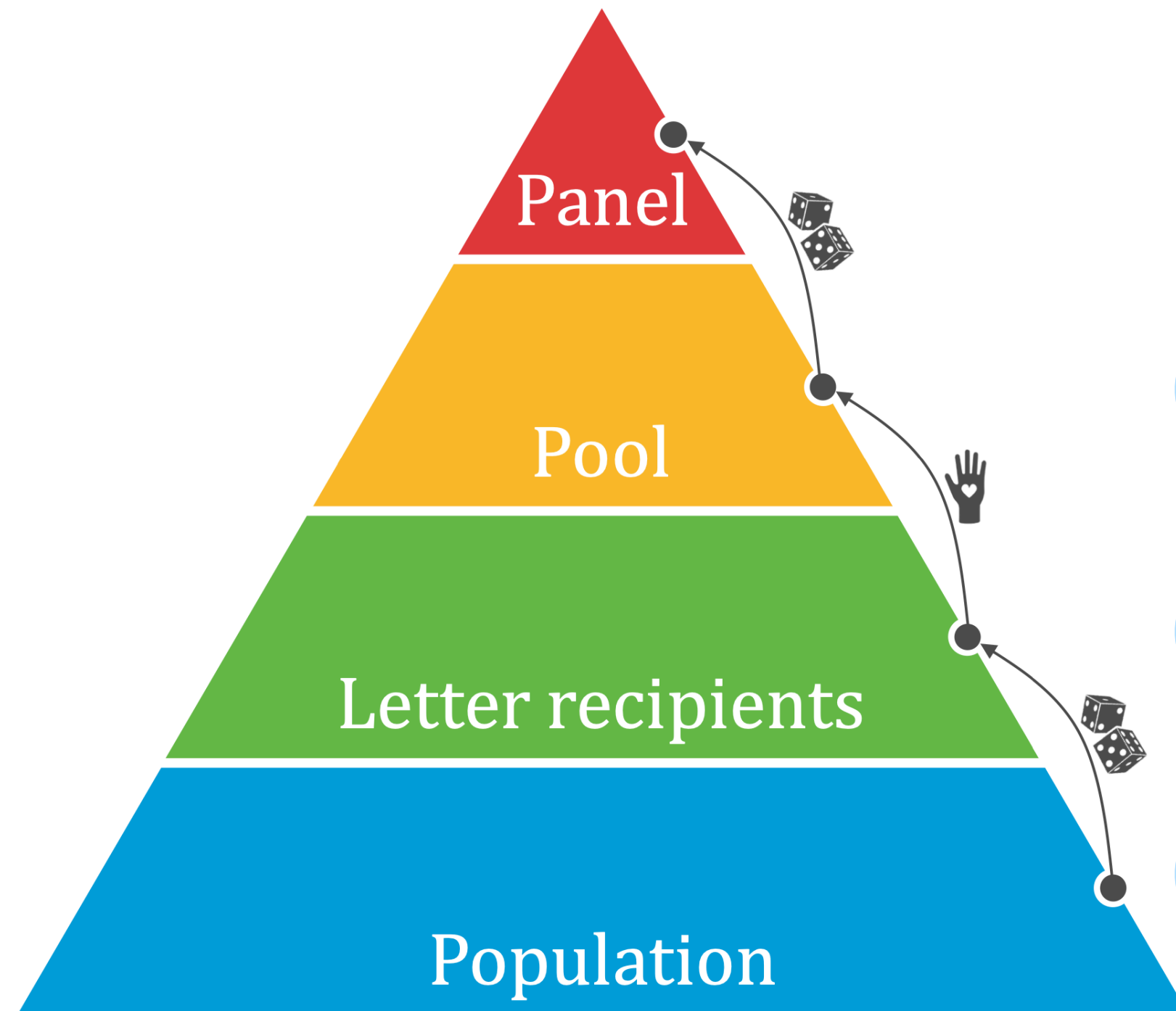
QUOTA-BASED SORTITION



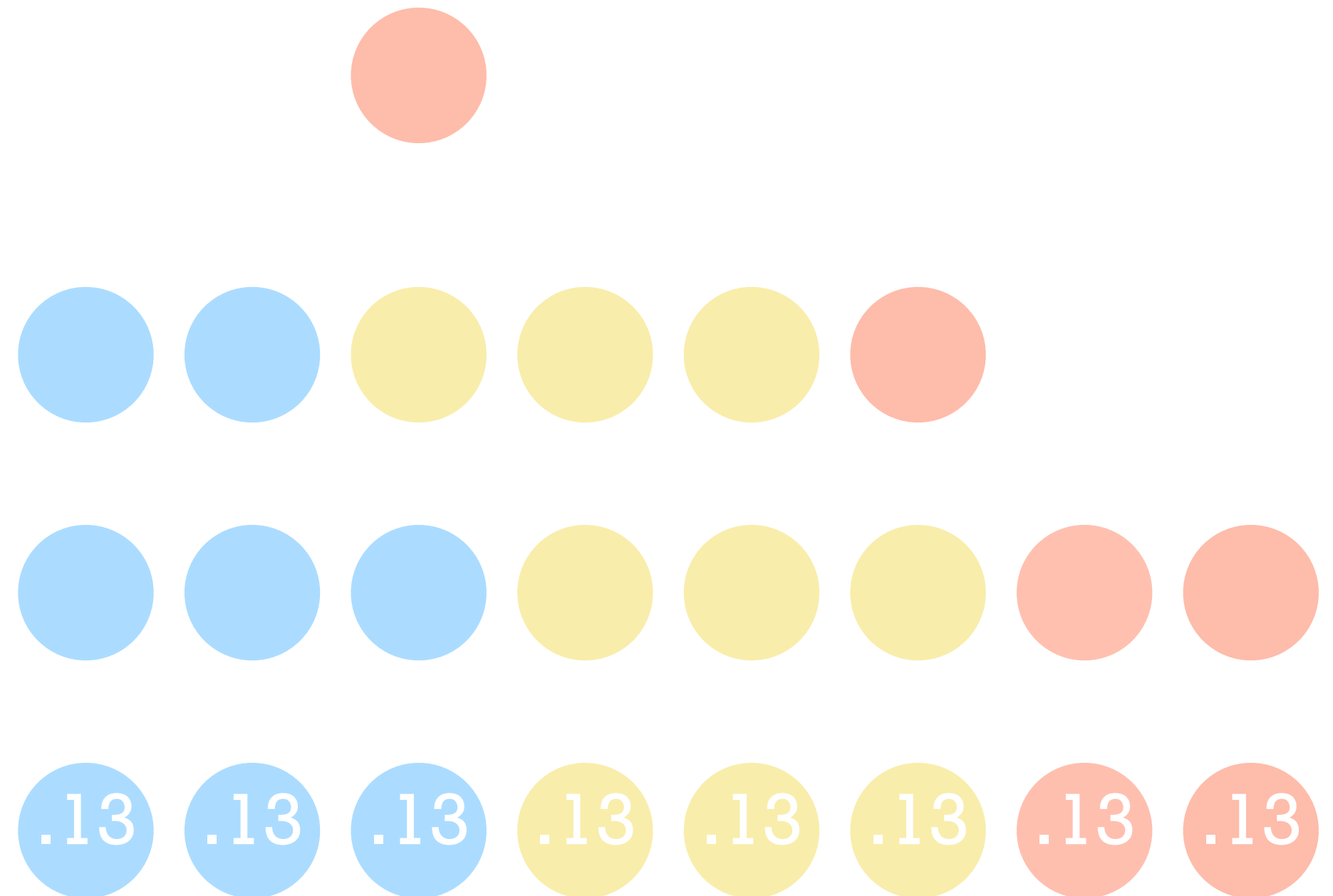
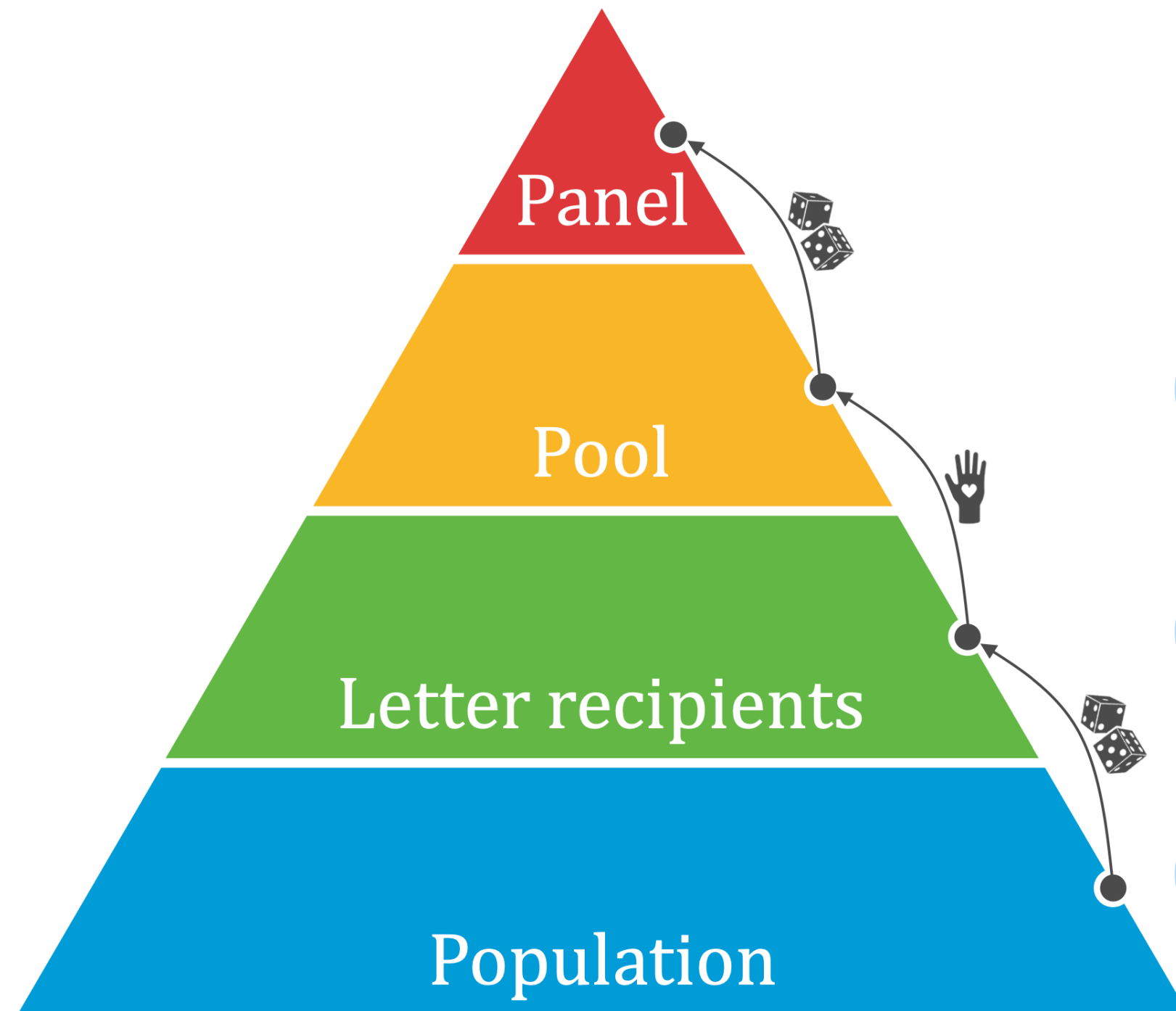
Ariel Procaccia's Class
Optimized Democracy



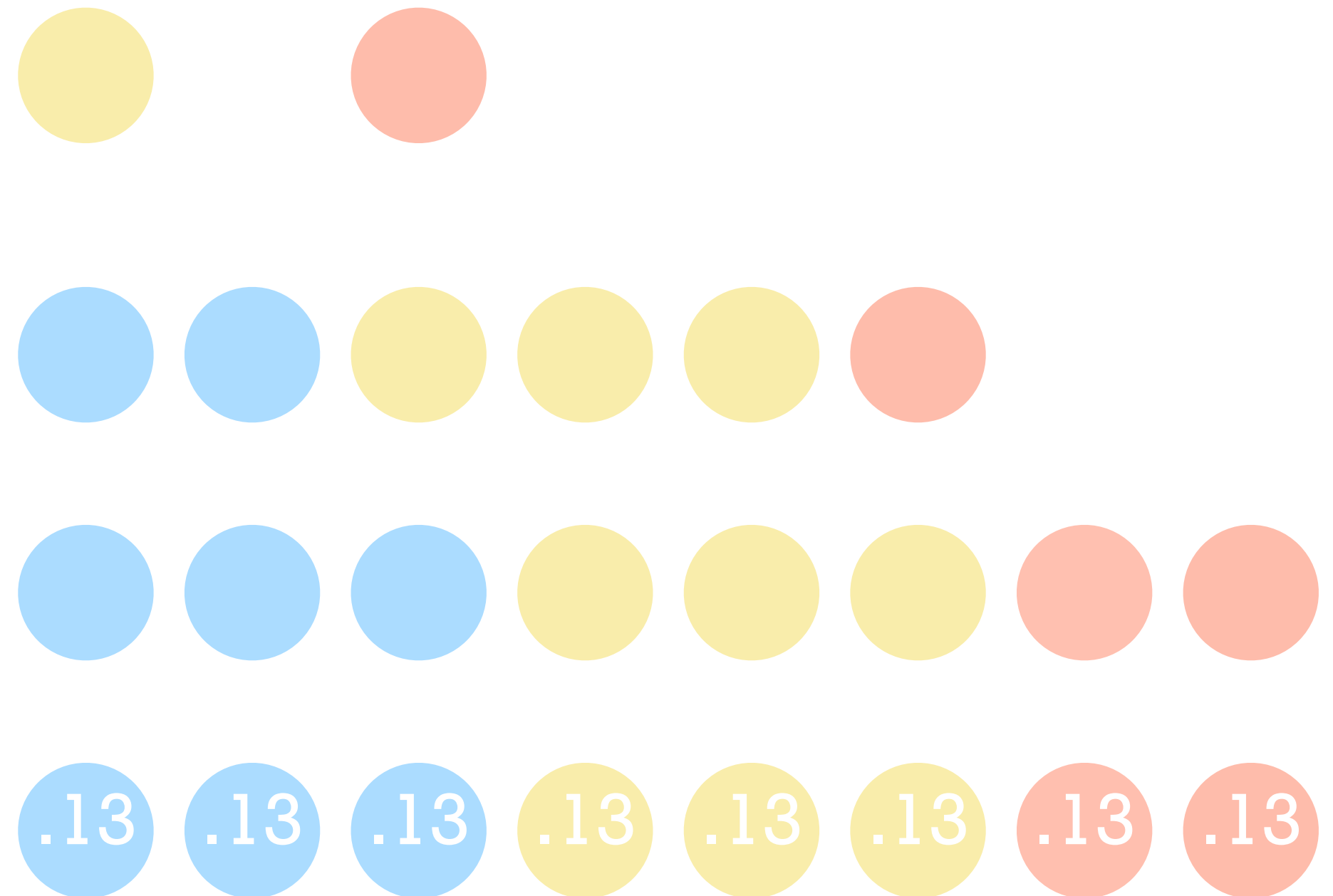
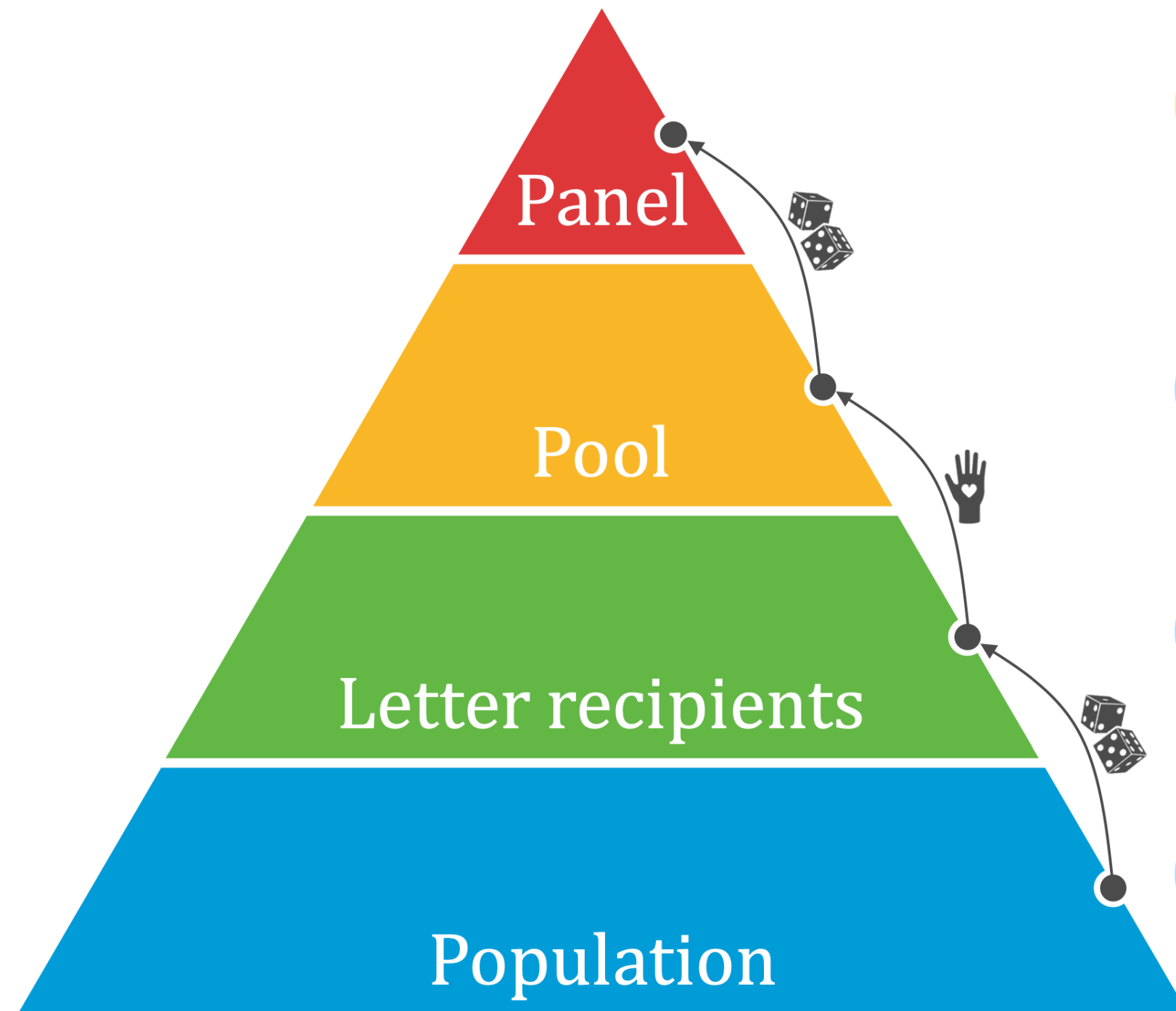
QUOTA-BASED SORTITION



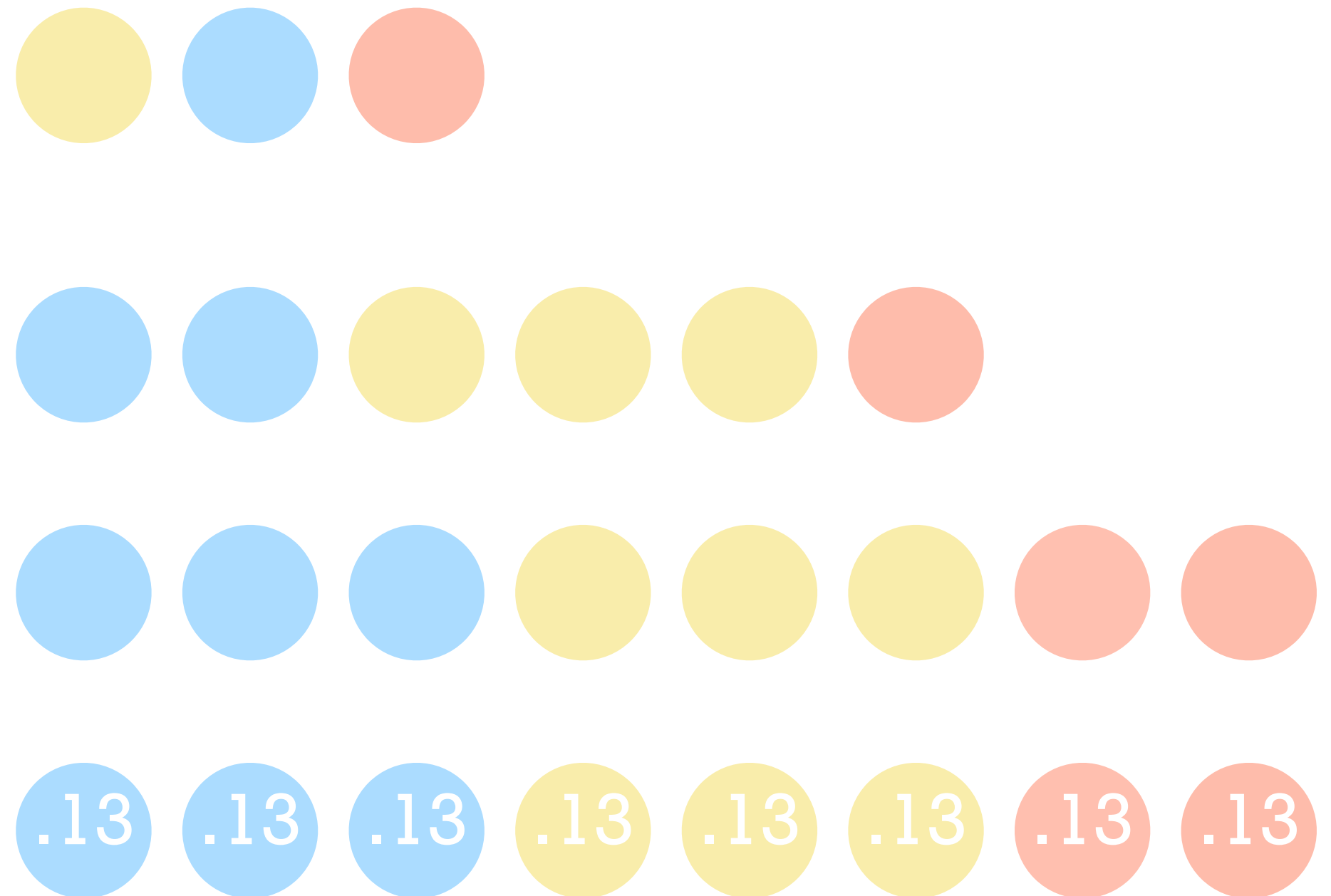
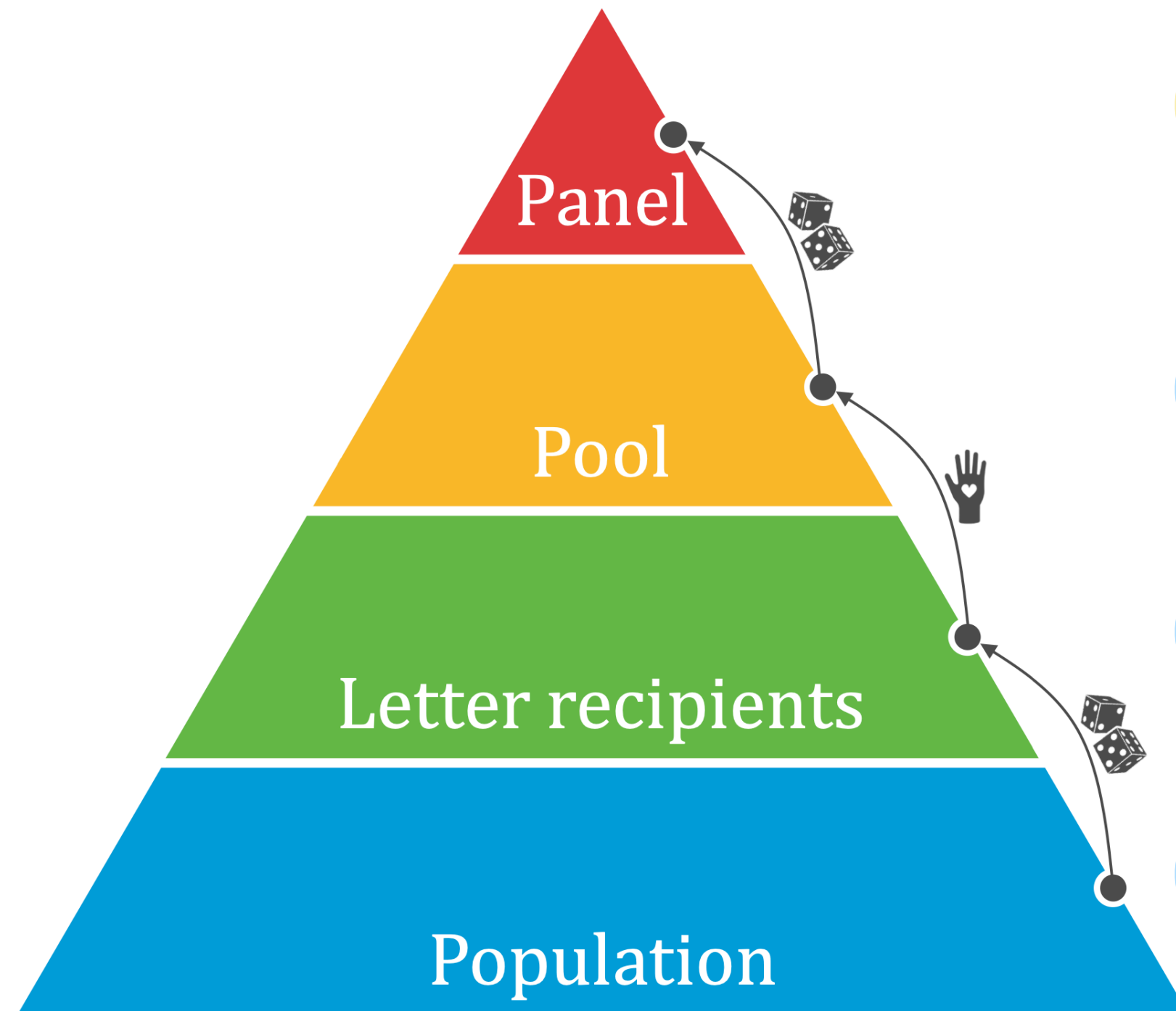
QUOTA-BASED SORTITION



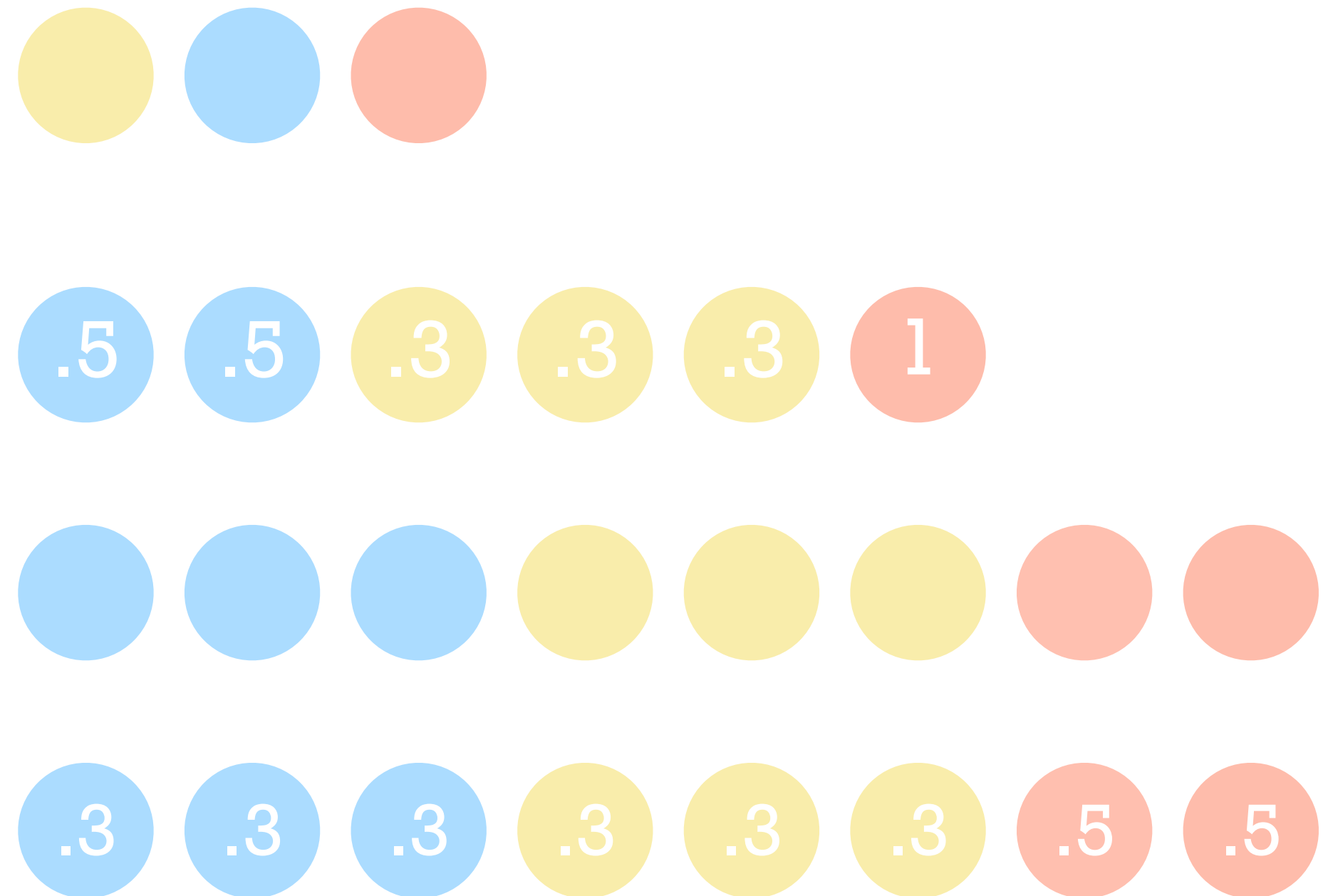
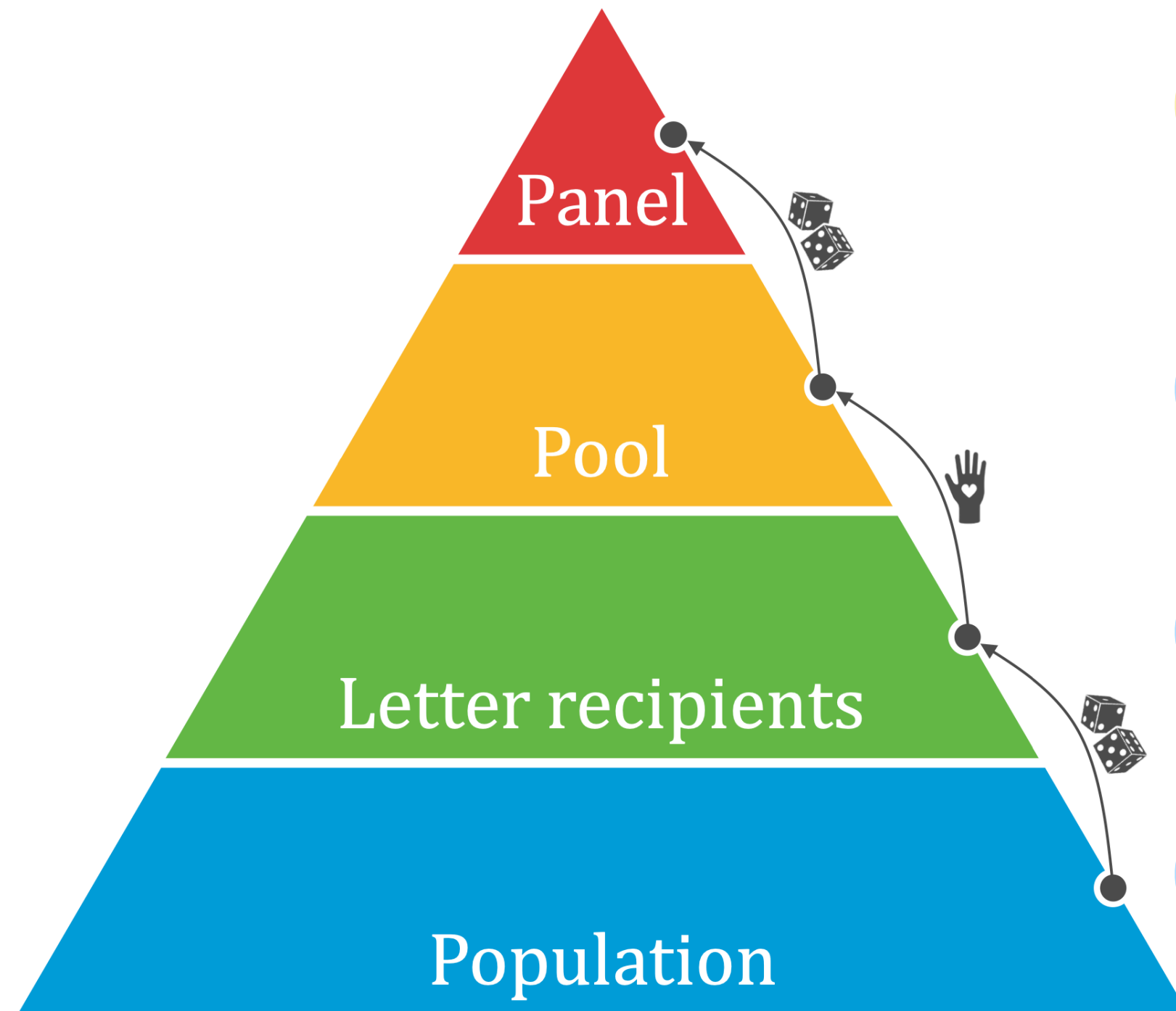
QUOTA-BASED SORTITION



QUOTA-BASED SORTITION




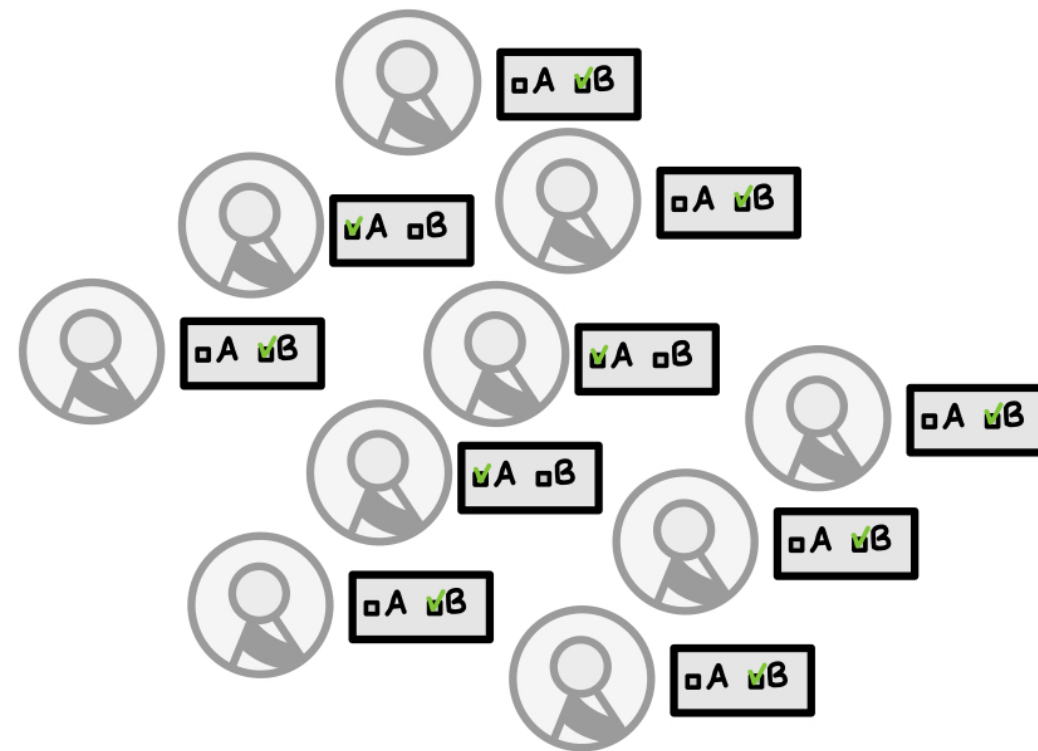
QUOTA-BASED SORTITION



Ariel Procaccia's Class
Optimized Democracy



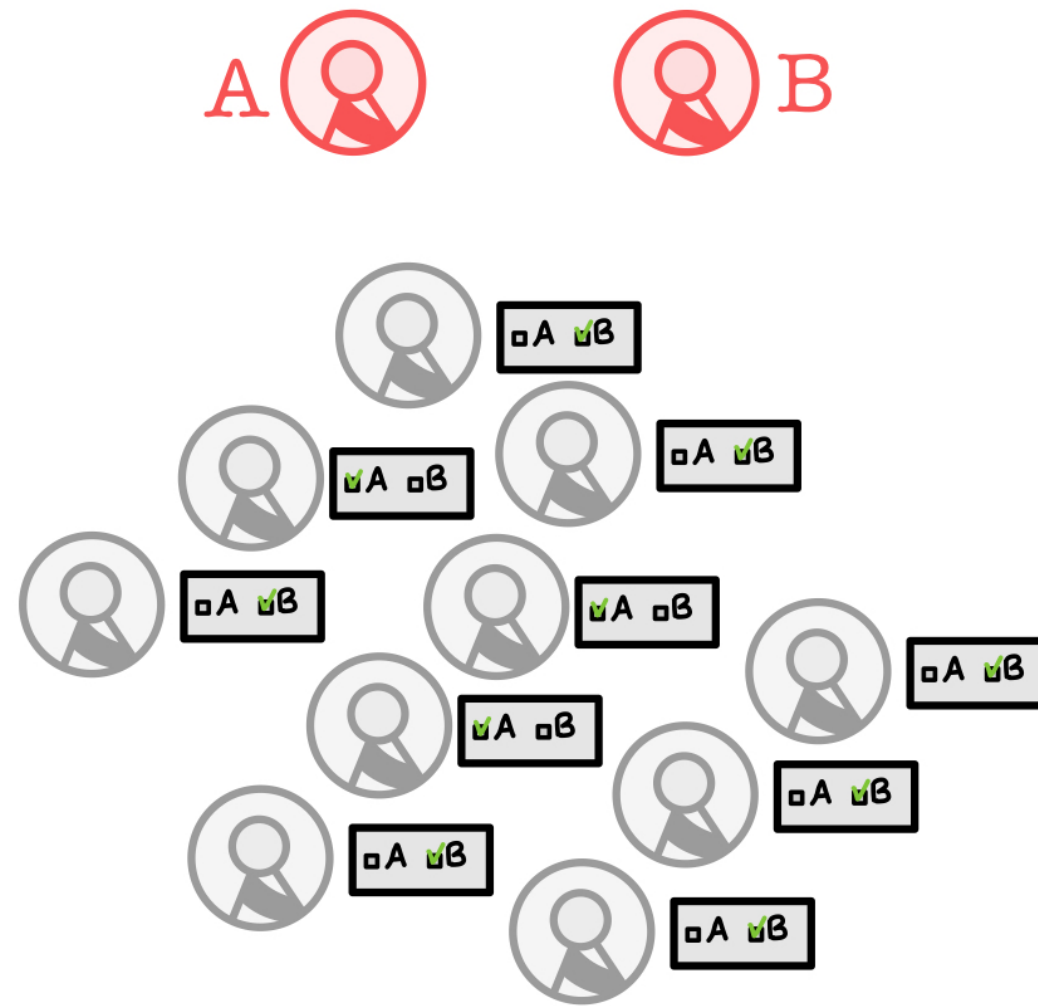
A  B 



Elections  



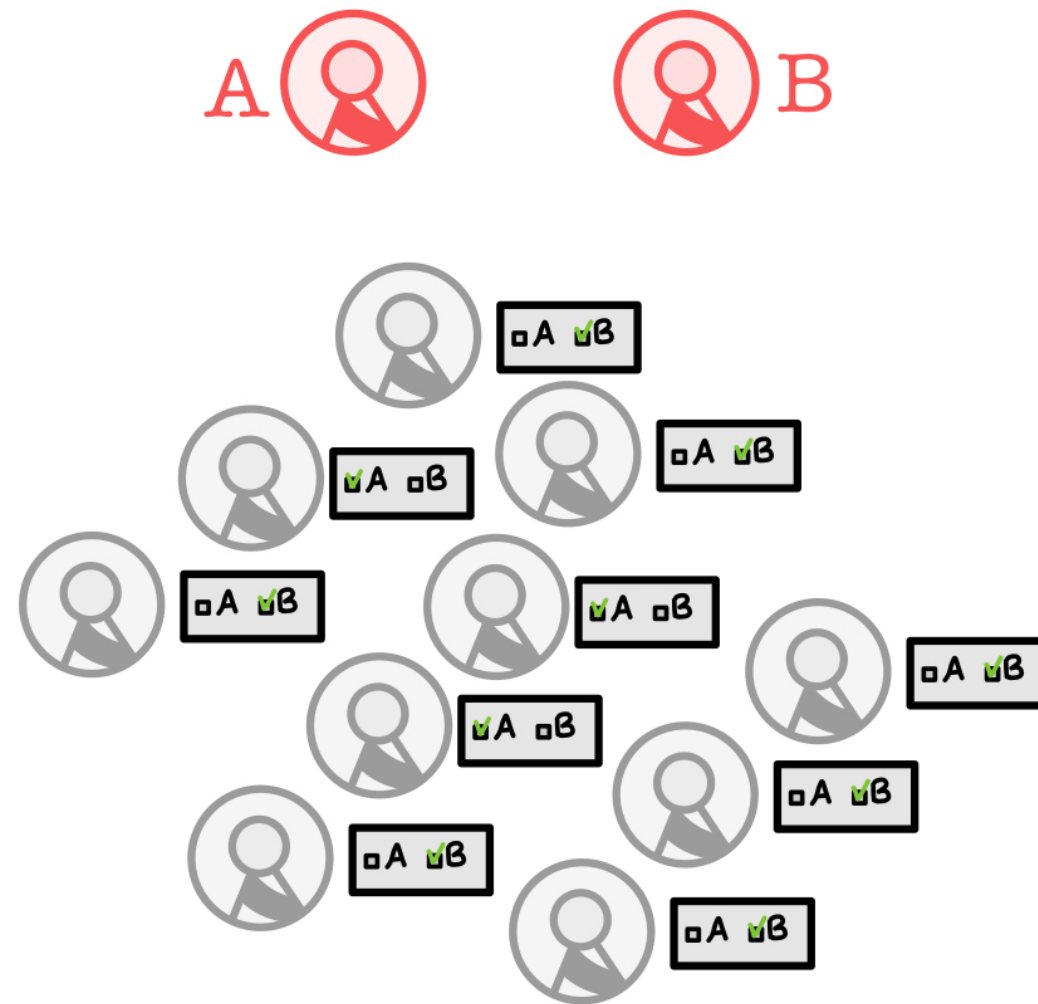
Sortition 🎲🎲



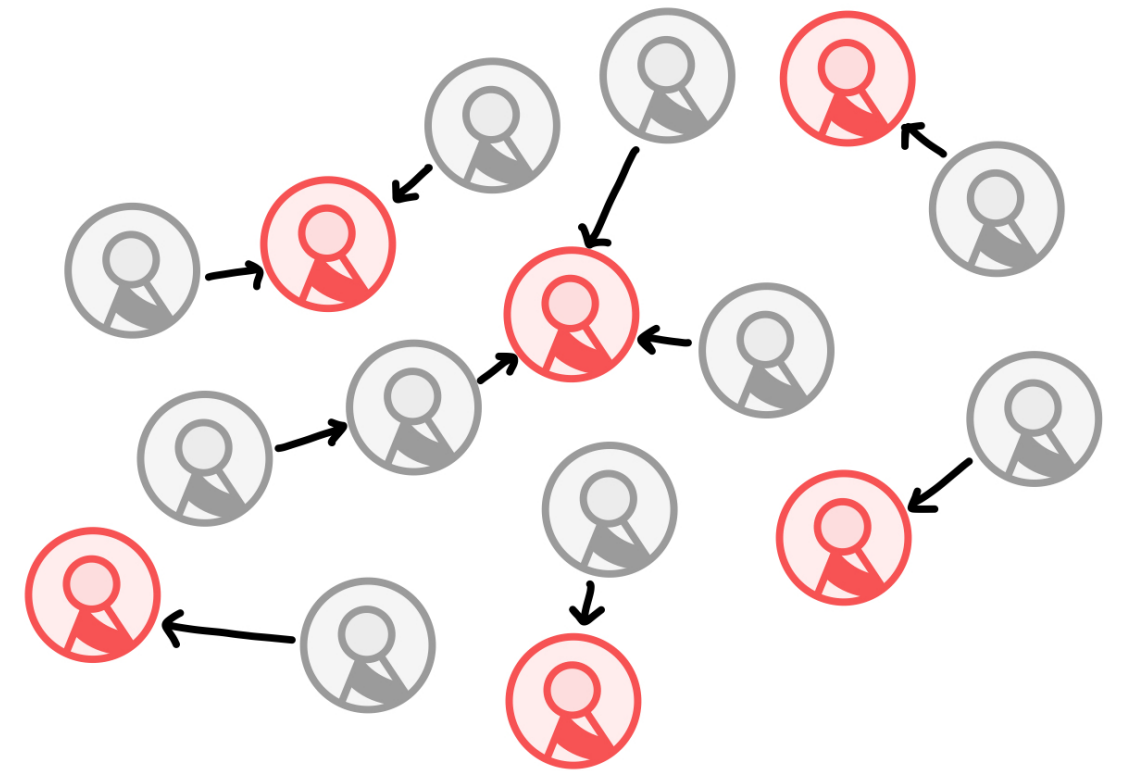
Elections 🗳️🗳️



Sortition 🎲🎲



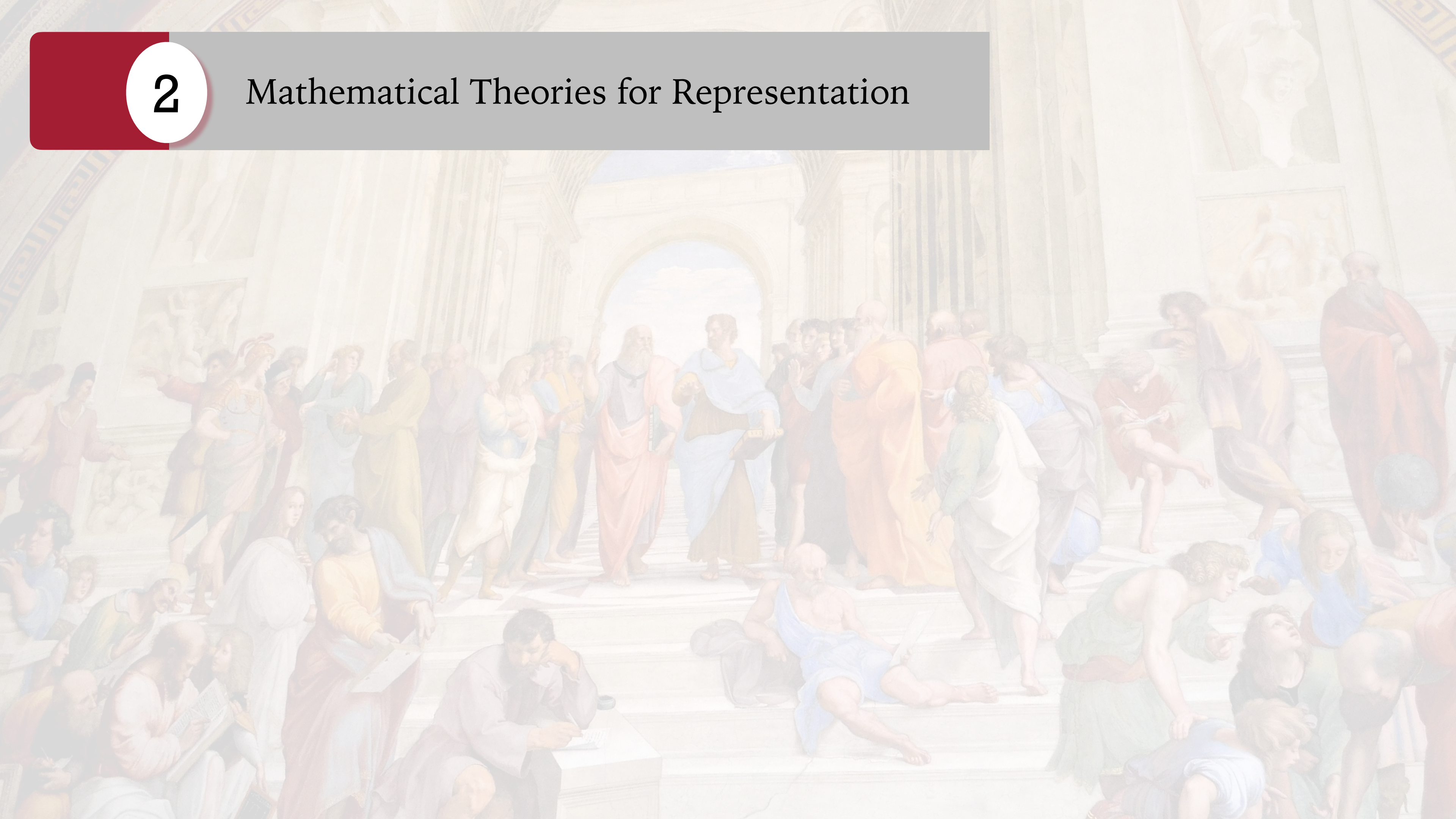
Elections 🗳️🗳️



Delegation ▶️▶️

2

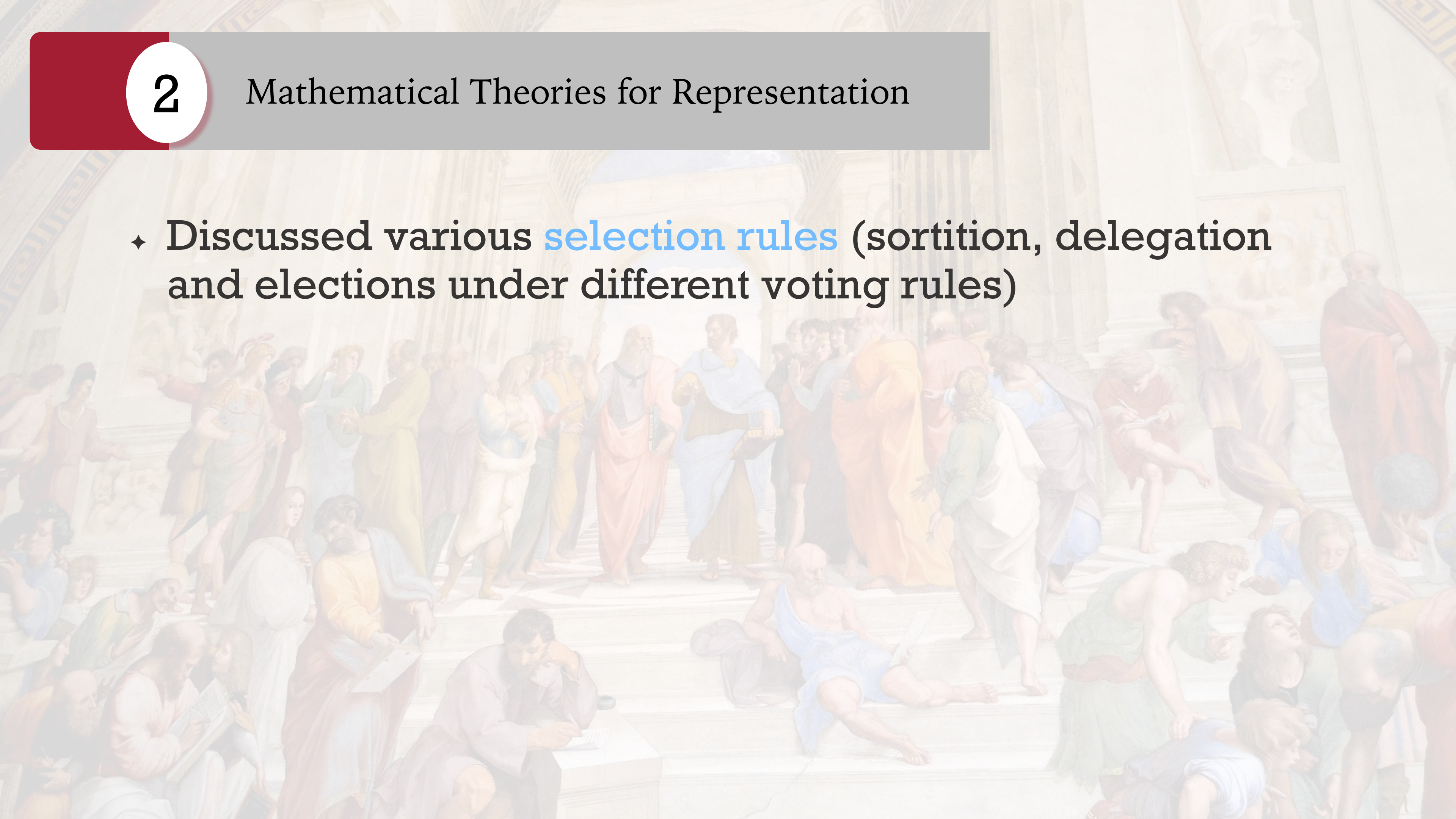
Mathematical Theories for Representation



2

Mathematical Theories for Representation

- ✦ Discussed various **selection rules** (sortition, delegation and elections under different voting rules)



2

Mathematical Theories for Representation

- ✦ Discussed various **selection rules** (sortition, delegation and elections under different voting rules)
- ✦ Discussed the **epistemic foundations** for the wisdom of crowds:  **substantive** representation in Pitkin

2

Mathematical Theories for Representation

- ✦ Discussed various **selection rules** (sortition, delegation and elections under different voting rules)
- ✦ Discussed the **epistemic foundations** for the wisdom of crowds:  **substantive** representation in Pitkin
- ✦ Discussed two **fairness definition** in social choice theory for multi-winner voting and sortition:  **formalistic** and **descriptive** representation in Pitkin, **capability equality** is Sen

MATHEMATICAL THEORIES FOR REPRESENTATION

Question for all:

Pick a building block and describe how what we've discussed so far informs your design choices. Pick an element below and discuss how you would design it.

Set-Up

- Filtering
- Selection
- Group Building

Deliberation

- Learning
- Sense-Making
- Consensus-Building

Deliverable

- Making Decisions
- Drafting Recommendations

Course Outline

1

Political Philosophy and Democratic Representation

2

Mathematical Theories for Representation

3

Algorithms for Bridging (by Luke Thorburn)

4

Algorithms for Deliberation

Course Outline

1

Political Philosophy and Democratic Representation

2

Mathematical Theories for Representation

3

Algorithms for Bridging (by Luke Thorburn)

4

Algorithms for Deliberation

Chapter Outline

4

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

Chapter Outline

4

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

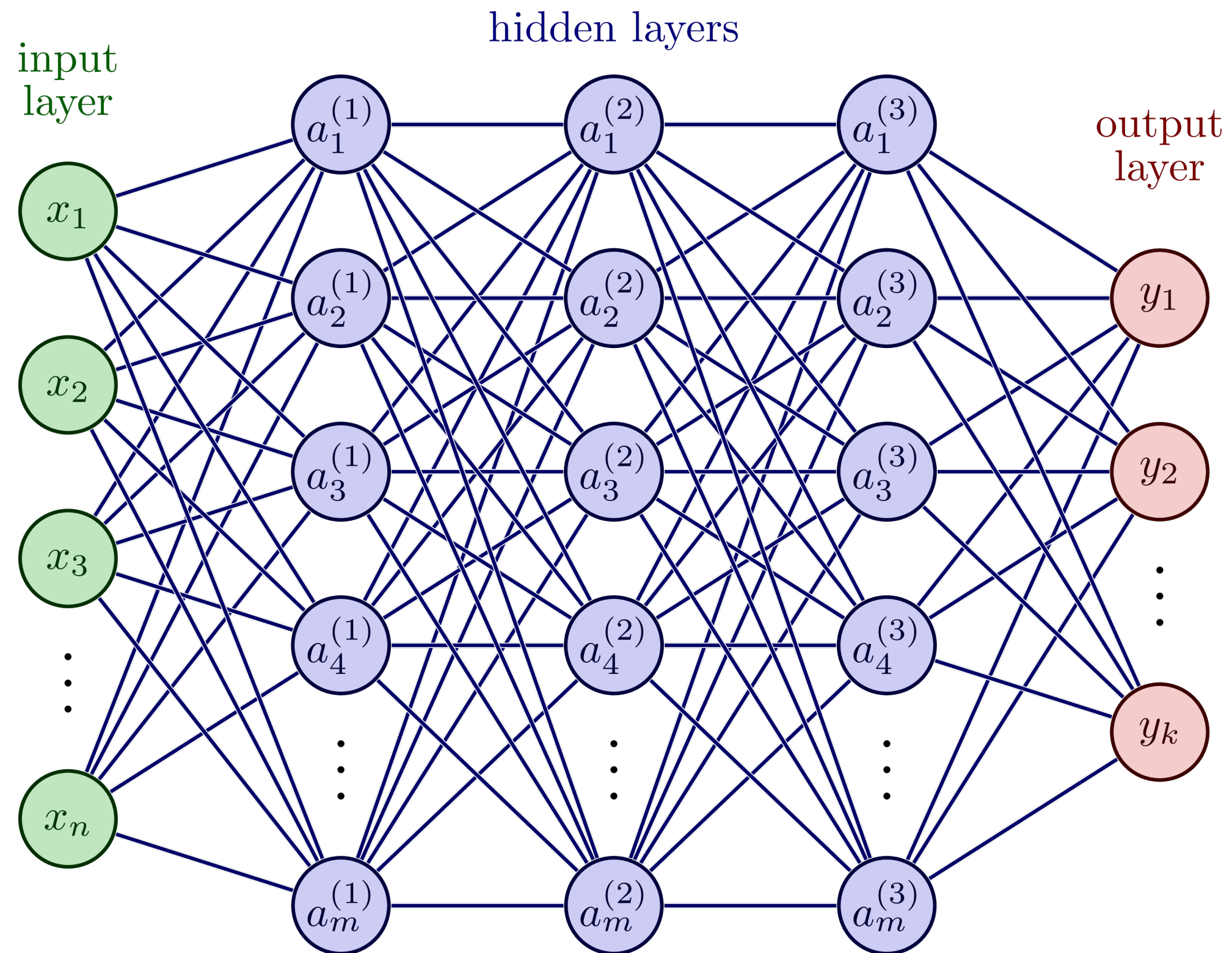
Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

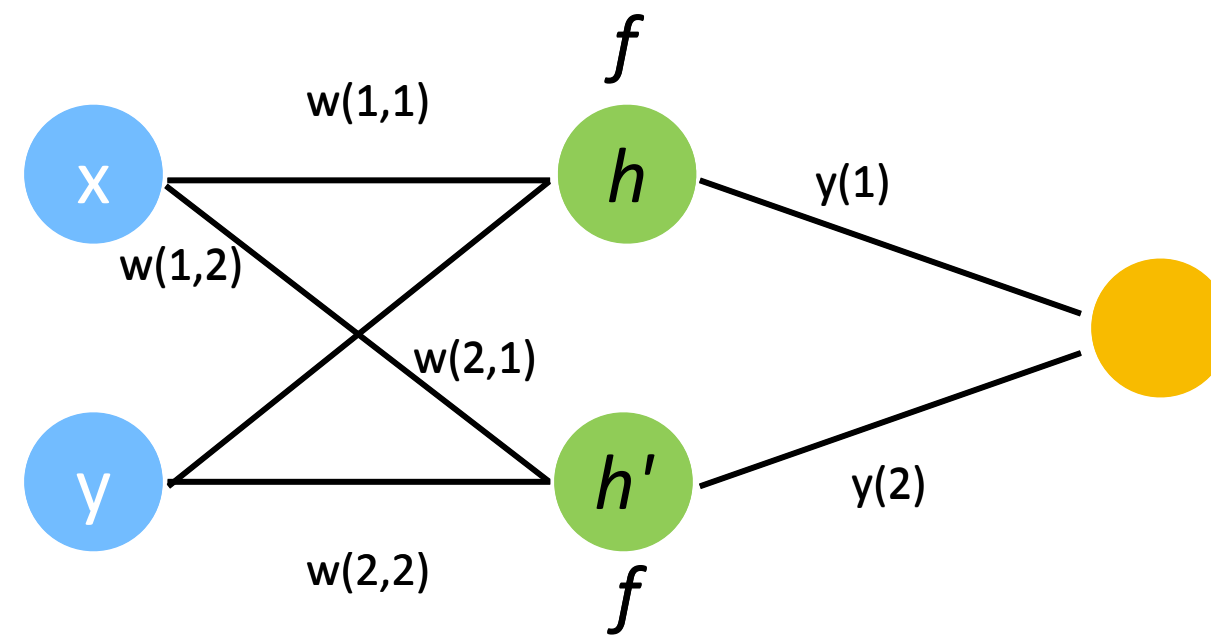
Building Representative Statements

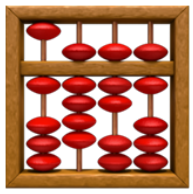
A NEURAL NETWORK



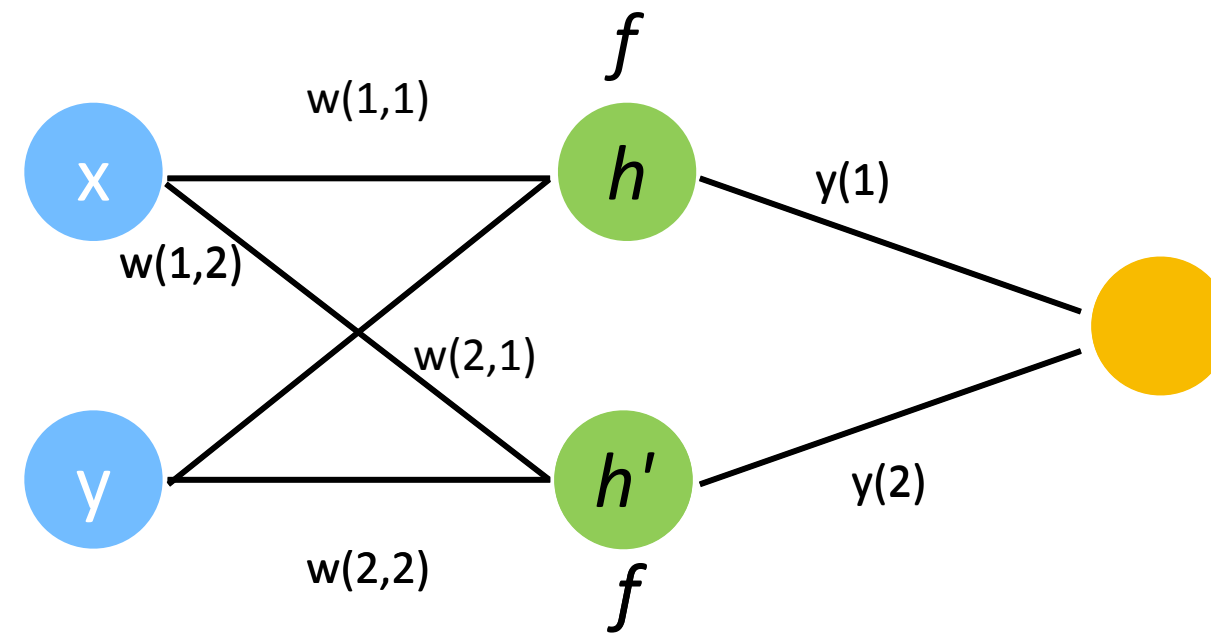


A NEURAL NETWORK

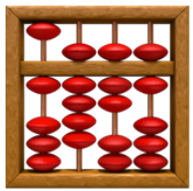




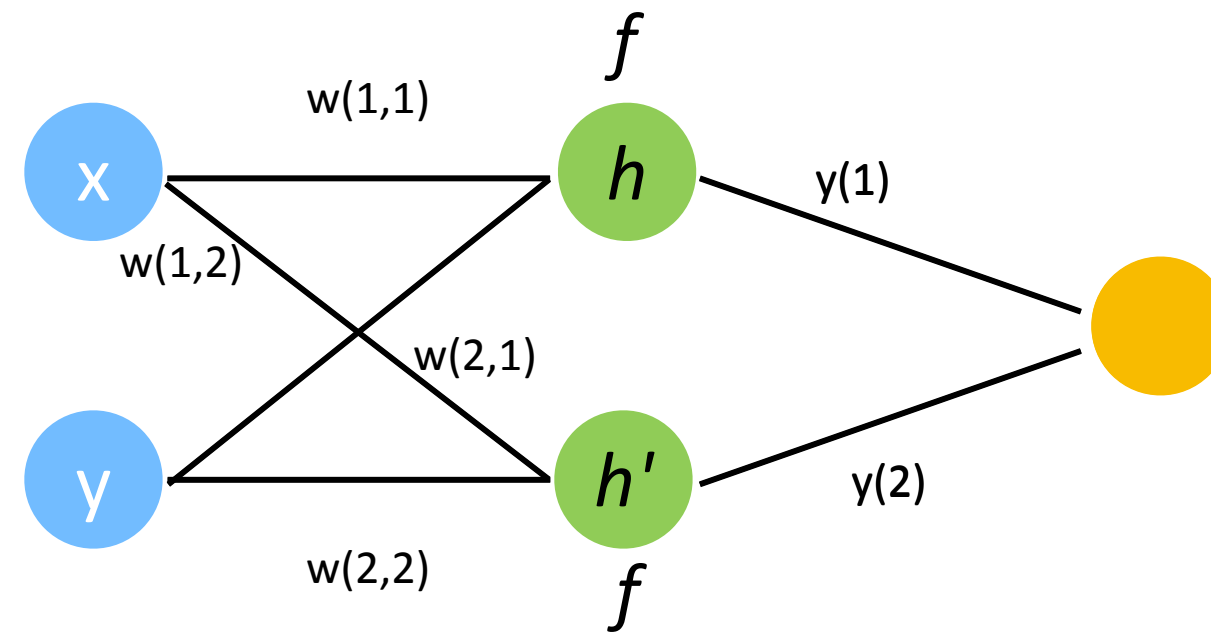
A NEURAL NETWORK



$$h = f \left(w(1,1) x + w(2,1) y \right)$$

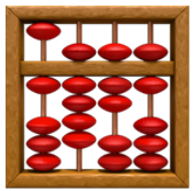


A NEURAL NETWORK

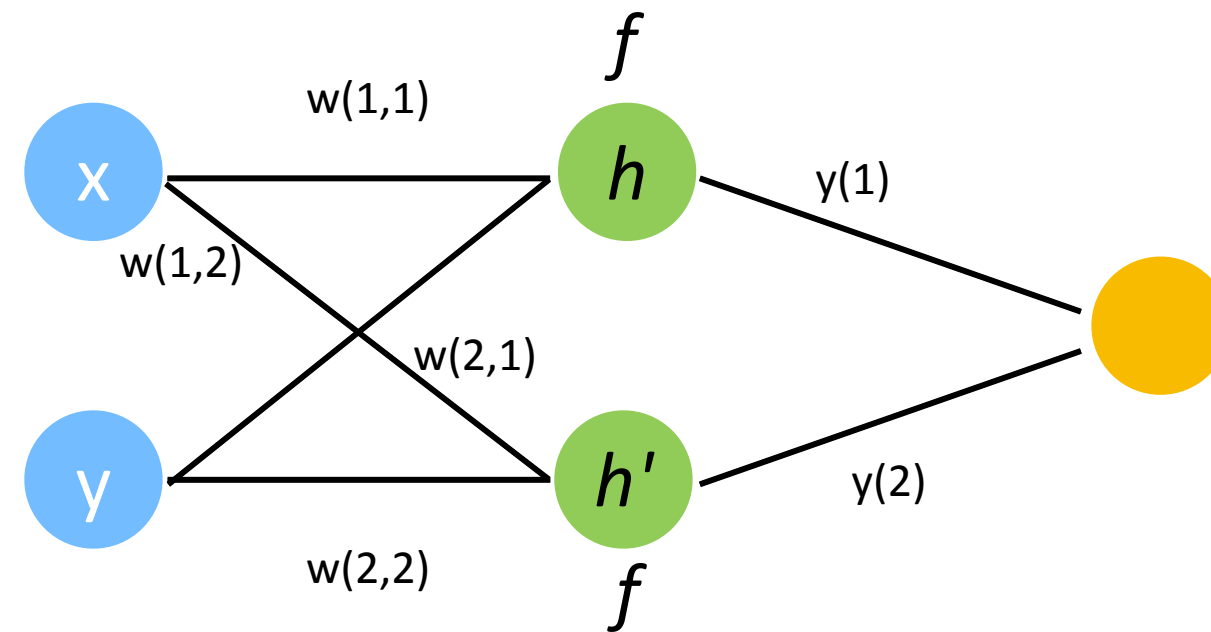


$$h = f (w(1,1) x + w(2,1) y)$$

$$h' = f (w(1,2) x + w(2,2) y)$$



A NEURAL NETWORK

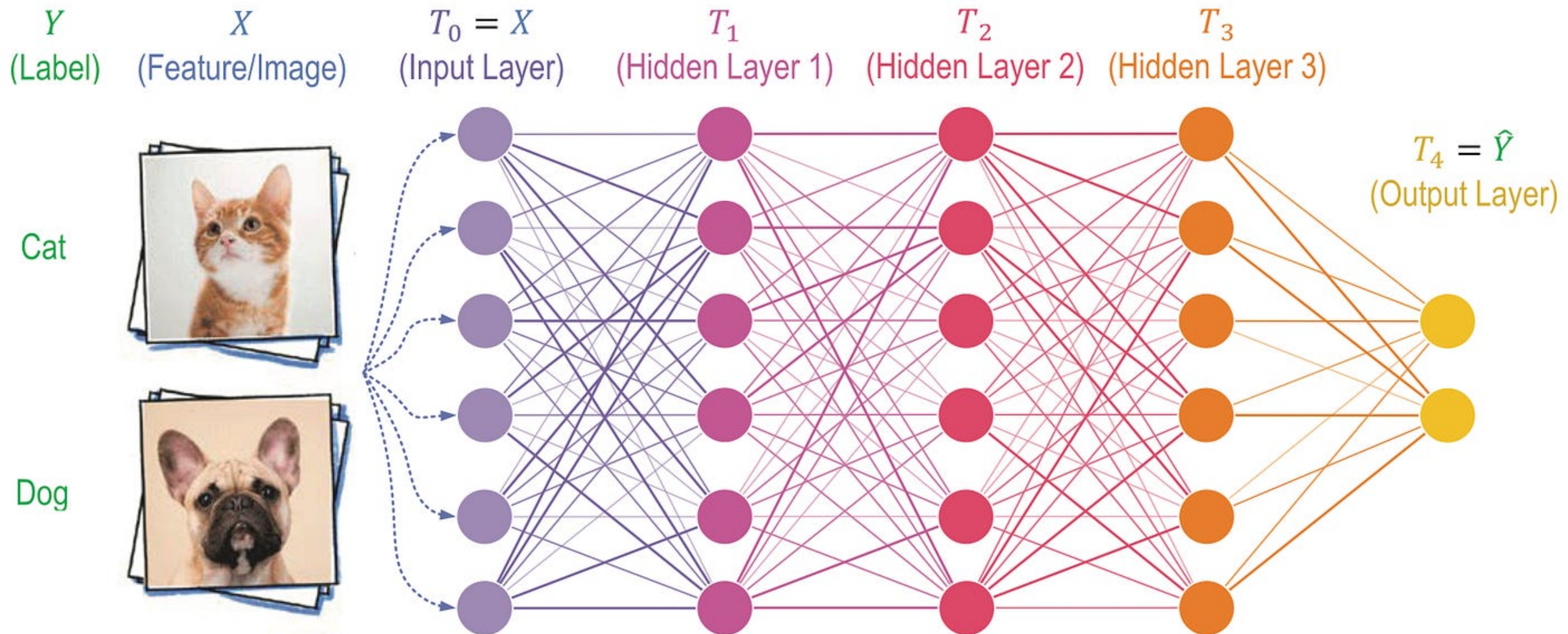


$$h = f (w(1,1) x + w(2,1) y)$$

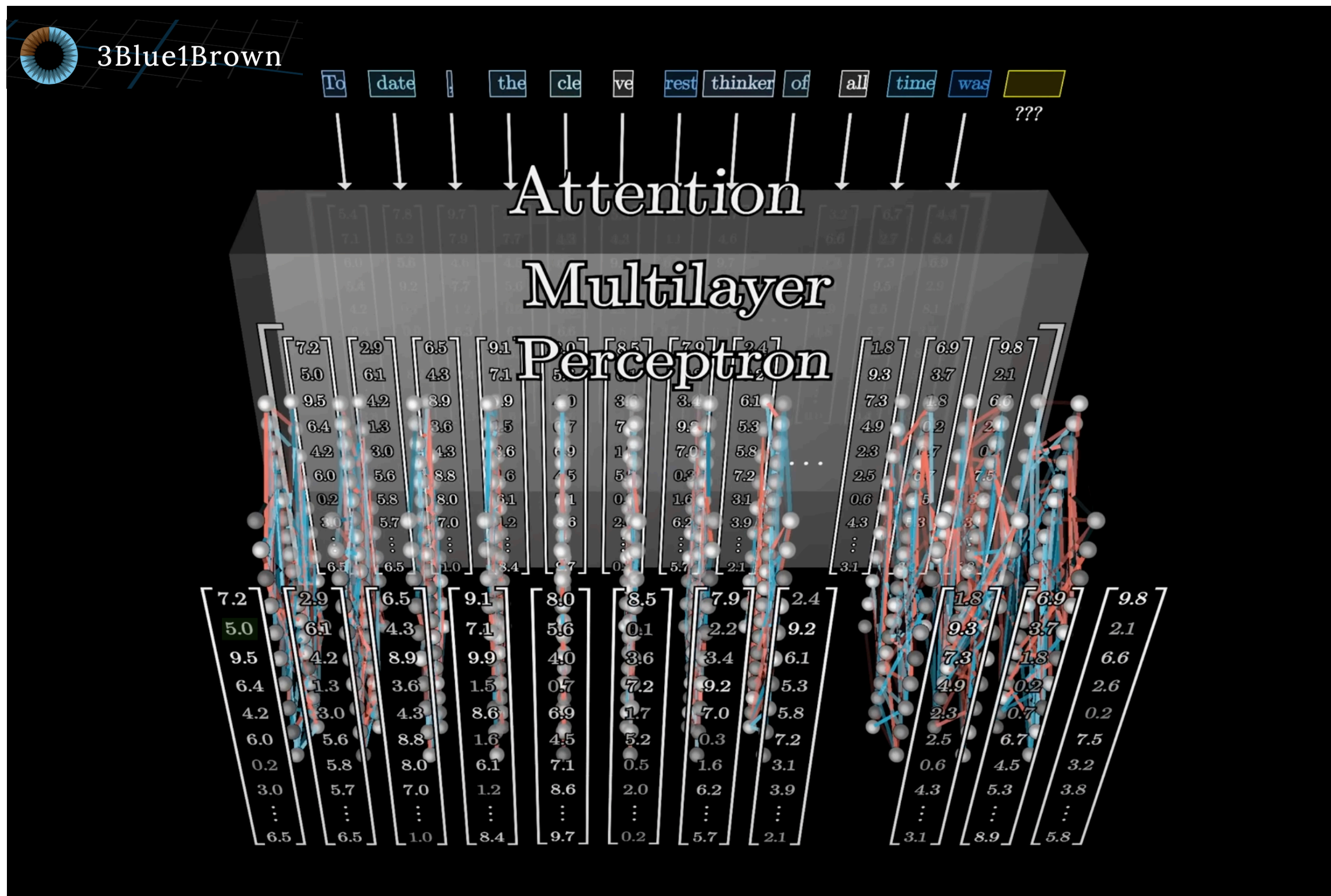
$$h' = f (w(1,2) x + w(2,2) y)$$

$$\text{Output} = y(1) h + y(2) h'$$

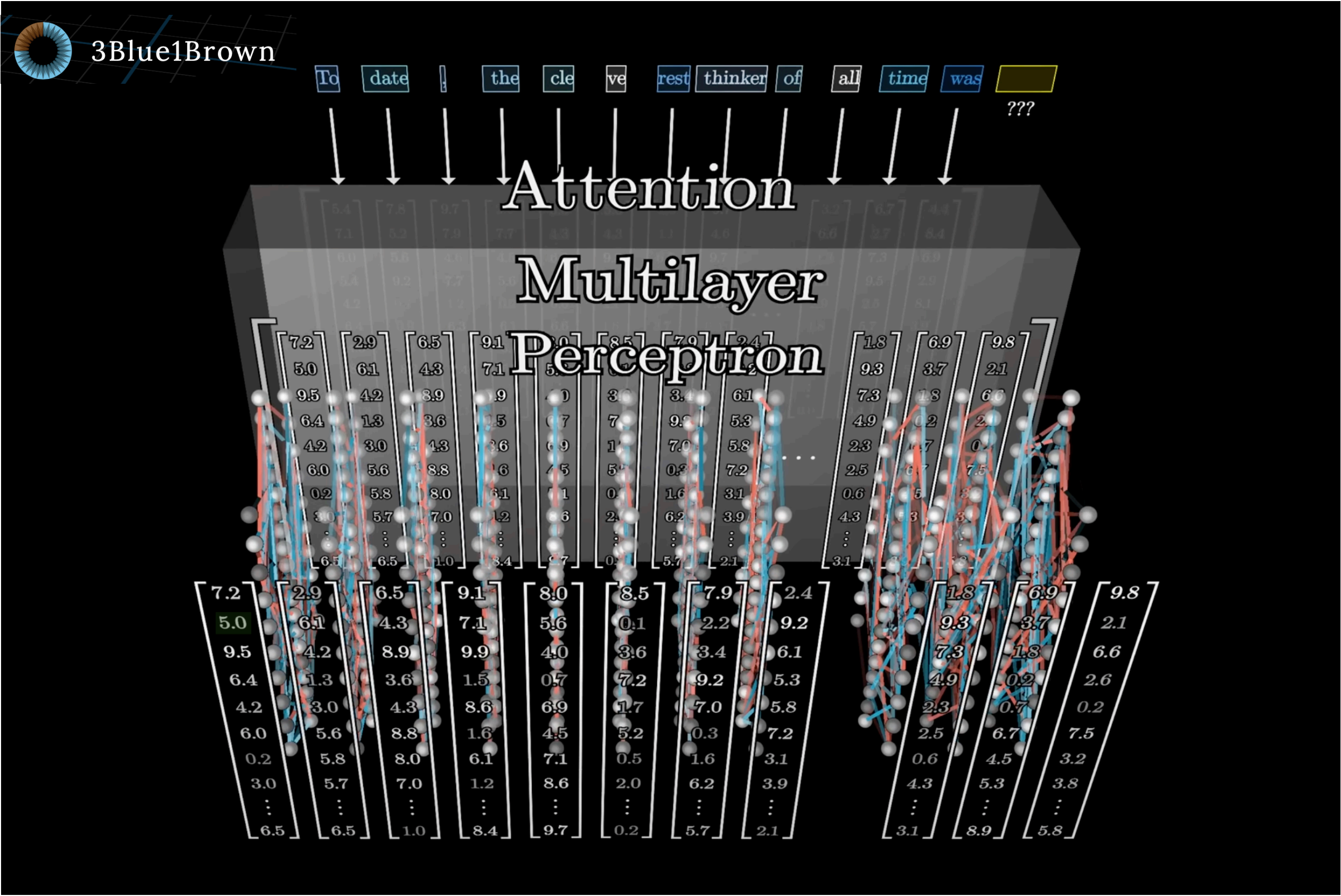
A NEURAL NETWORK



TRANSFORMERS



TRANSFORMERS



Albert Einstein 0.4

Judit Polgar 0.2

Confucius 0.1

Philip Emeagwa 0.2

Leonardo DaVinci 0.1

Chapter Outline

3

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

Chapter Outline

3

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

PROMPTING

What is peace building (answer in less than 100 words).

< 2/2 >



Peace building is the process of creating lasting peace by addressing the root causes and effects of conflict. It involves various efforts such as reconciliation, institution building, and socioeconomic development to prevent the recurrence of violence. Peace building aims to strengthen political, economic, and social structures to support sustainable peace, often involving community engagement, justice, human rights promotion, and restoring governance and rule of law.



What is peace building (answer in less than 100 words à la Lisa Schirch).



Peacebuilding, as described by Lisa Schirch, is a comprehensive approach to creating a sustainable, just peace. It involves efforts to transform relationships, structures, and systems that fuel violence and injustice. Peacebuilding integrates conflict resolution, development, and human rights work, aiming to build social cohesion and address root causes of conflict. It encompasses activities like dialogue, reconciliation, and institution-building to foster resilient communities and prevent future conflicts.



PROMPTING: ZERO-SHOT LEARNING

PROMPTING: ZERO-SHOT LEARNING

- ✦ **Description:** Zero-shot learning refers to the capability of an AI model to perform a task without any prior training on examples of that specific task. Instead, it relies on its general understanding and knowledge learned from related tasks.

PROMPTING: ZERO-SHOT LEARNING

- ✦ **Description:** Zero-shot learning refers to the capability of an AI model to perform a task without any prior training on examples of that specific task. Instead, it relies on its general understanding and knowledge learned from related tasks.

PROMPTING: ZERO-SHOT LEARNING

- ✦ **Description:** Zero-shot learning refers to the capability of an AI model to perform a task without any prior training on examples of that specific task. Instead, it relies on its general understanding and knowledge learned from related tasks.
- ✦ **Prompt Example:** "Translate the following sentence into French: 'Hello, how are you?'"

PROMPTING: FEW-SHOT LEARNING

PROMPTING: FEW-SHOT LEARNING

- ✦ **Description:** Few-shot learning involves training an AI model with a very limited number of examples (a few shots) for a specific task. The model learns to adapt quickly based on these examples.

PROMPTING: FEW-SHOT LEARNING

- ✦ **Description:** Few-shot learning involves training an AI model with a very limited number of examples (a few shots) for a specific task. The model learns to adapt quickly based on these examples.

PROMPTING: FEW-SHOT LEARNING

- ✦ **Description:** Few-shot learning involves training an AI model with a very limited number of examples (a few shots) for a specific task. The model learns to adapt quickly based on these examples.
- ✦ **Prompt Example:** "Hi, my name is Manon' is translated in French as 'Bonjour, je m'appelle Manon.' Translate the following sentence into French: 'Hello, how are you?'"

PROMPTING: CHAIN-OF-THOUGHTS

PROMPTING: CHAIN-OF-THOUGHTS

- ✦ **Description:** Chaining thoughts refers to guiding an AI model through a series of prompts or questions to build upon a previous response or to explore a connected sequence of ideas.

PROMPTING: CHAIN-OF-THOUGHTS

- ✦ **Description:** Chaining thoughts refers to guiding an AI model through a series of prompts or questions to build upon a previous response or to explore a connected sequence of ideas.

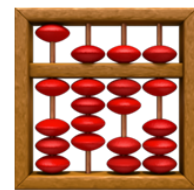
PROMPTING: CHAIN-OF-THOUGHTS

- ✦ **Description:** Chaining thoughts refers to guiding an AI model through a series of prompts or questions to build upon a previous response or to explore a connected sequence of ideas.
- ✦ **Prompt Example:** "If John has 5 pears, then eats 2, and buys 5 more, then gives 3 to his friend, how many pears does he have? Let's think step by step."

FINE-TUNING

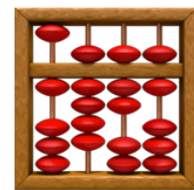
FINE-TUNING

- ✦ Prompting does not change the internal models' parameters. Sometimes, a more systematic intervention is necessary — and is performed by means of fine-tuning.

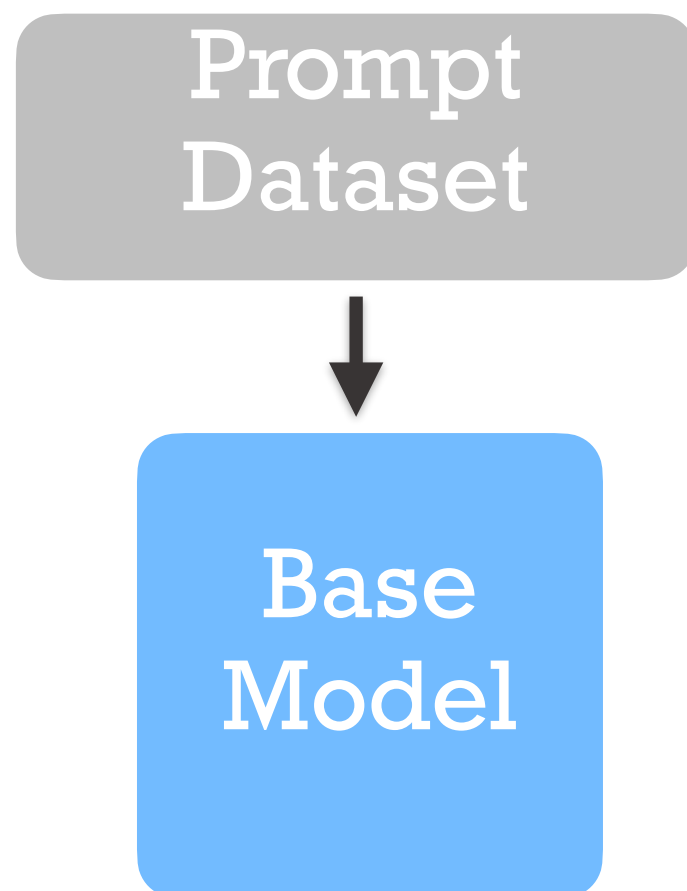


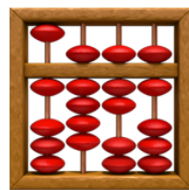
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Base
Model



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK





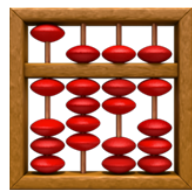
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

- What does Meta mean in Greek?
- Which LLM underlies MEDITRON?

Prompt
Dataset



Base
Model



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Prompt
Dataset



Base
Model

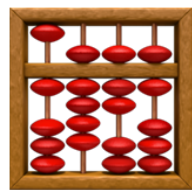


Output

Output

Q: What does Meta mean in Greek?
A: Iron

Q: What does Meta mean in Greek?
A: Transcending



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Prompt
Dataset



Base
Model

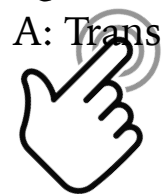


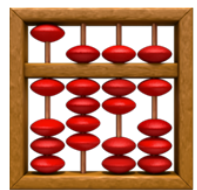
Output

Output

Q: What does Meta mean in Greek?
A: Iron

Q: What does Meta mean in Greek?
A: Transcending





REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Prompt
Dataset



Base
Model



Output

Output

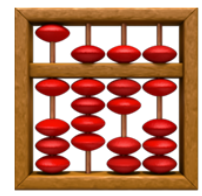


Q: What does Meta mean in Greek?

A: Iron [rejected]

Q: What does Meta mean in Greek?

A: Transcending [chosen]



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Prompt
Dataset



Base
Model



Output

Output

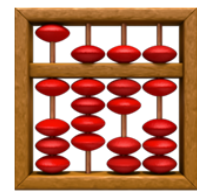


Q: What does Meta mean in Greek?
A: Iron [rejected]

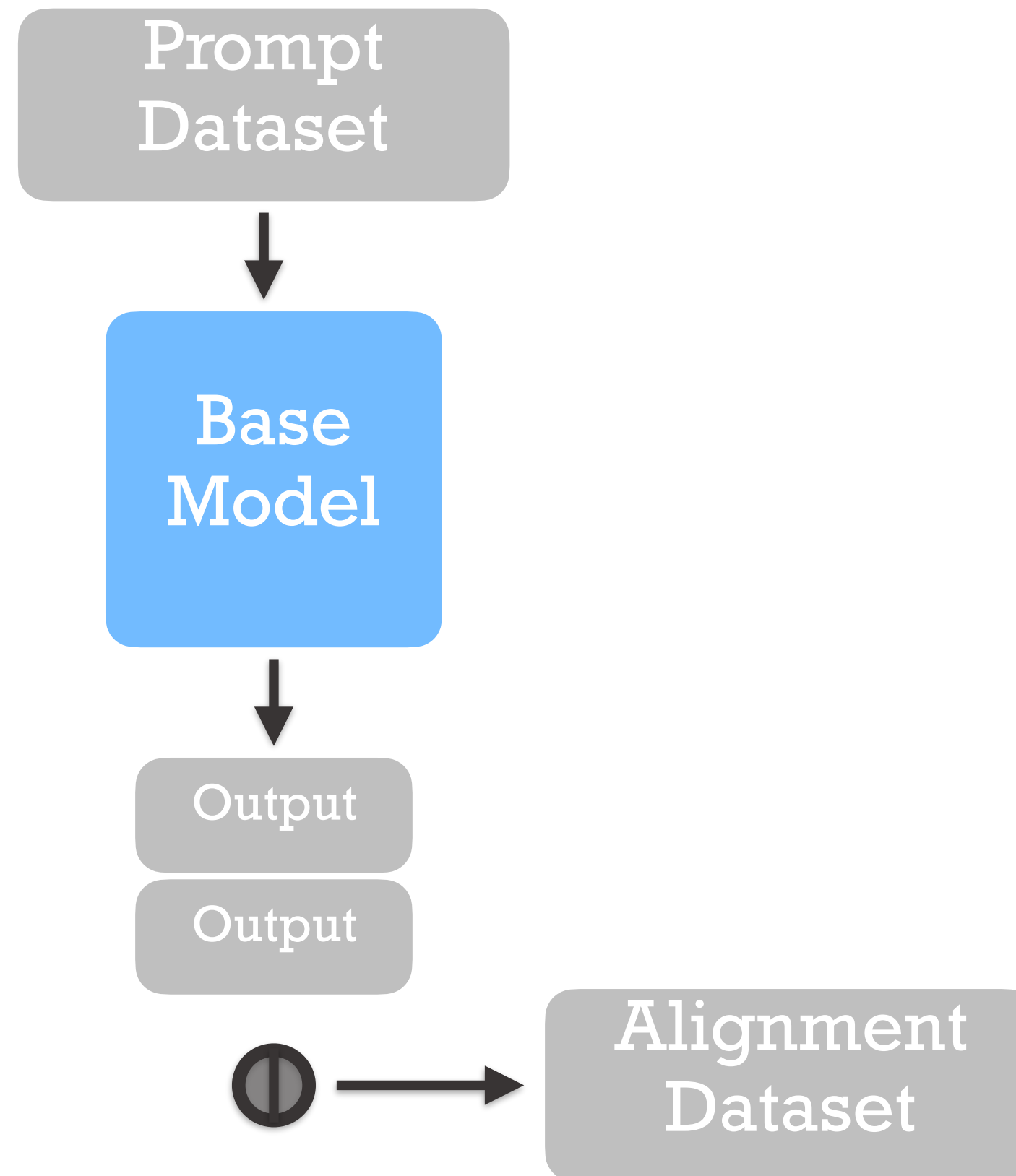
Q: What does Meta mean in Greek?
A: Transcending [chosen]

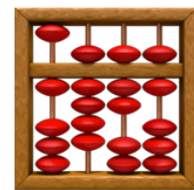
Q: Which LLM underlies MEDITRON?
A: Llama 2 [chosen]

Q: Which LLM underlies MEDITRON?
A: Mistral 7B [rejected]

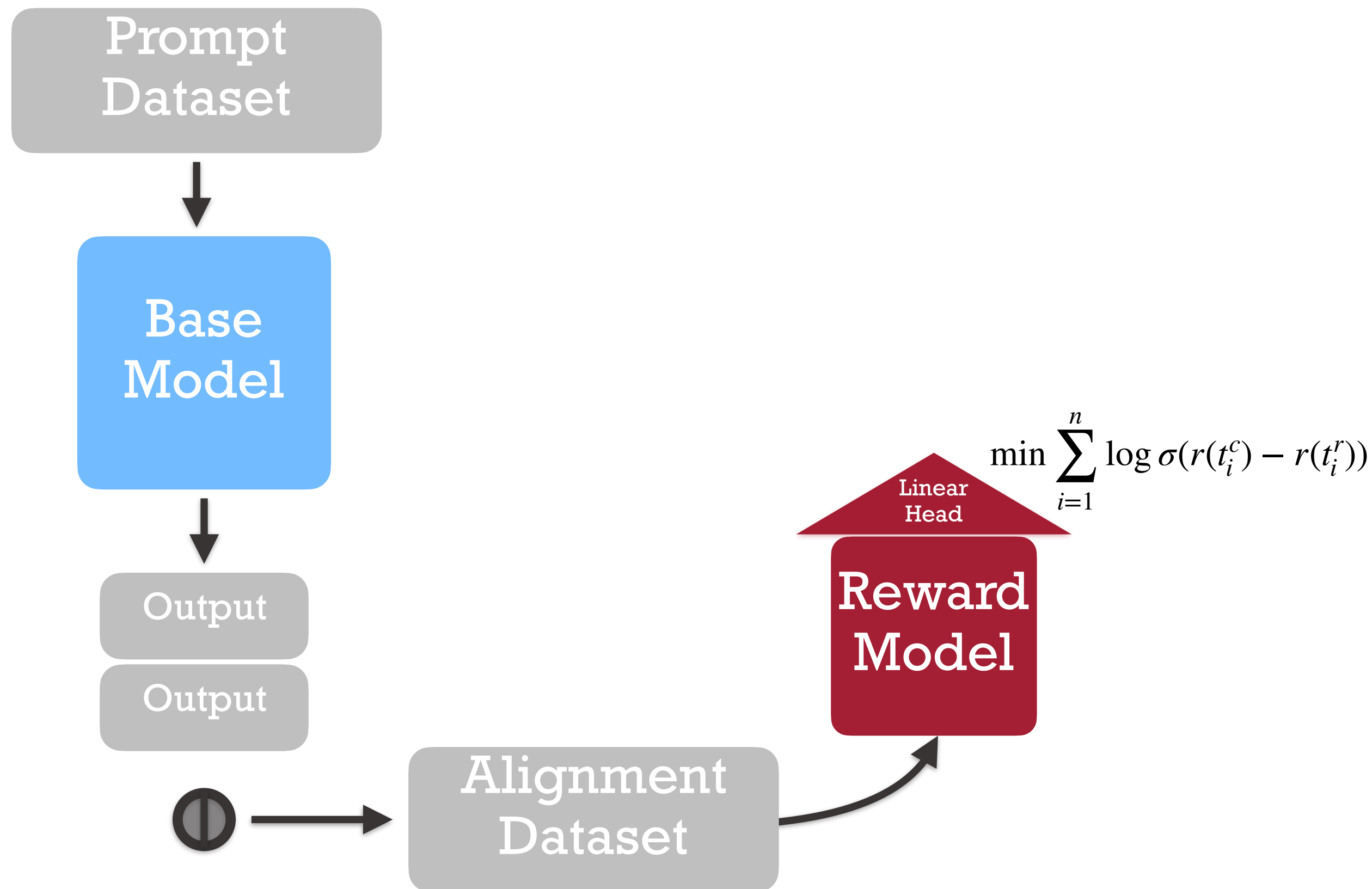


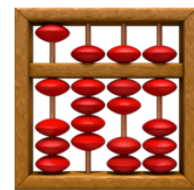
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



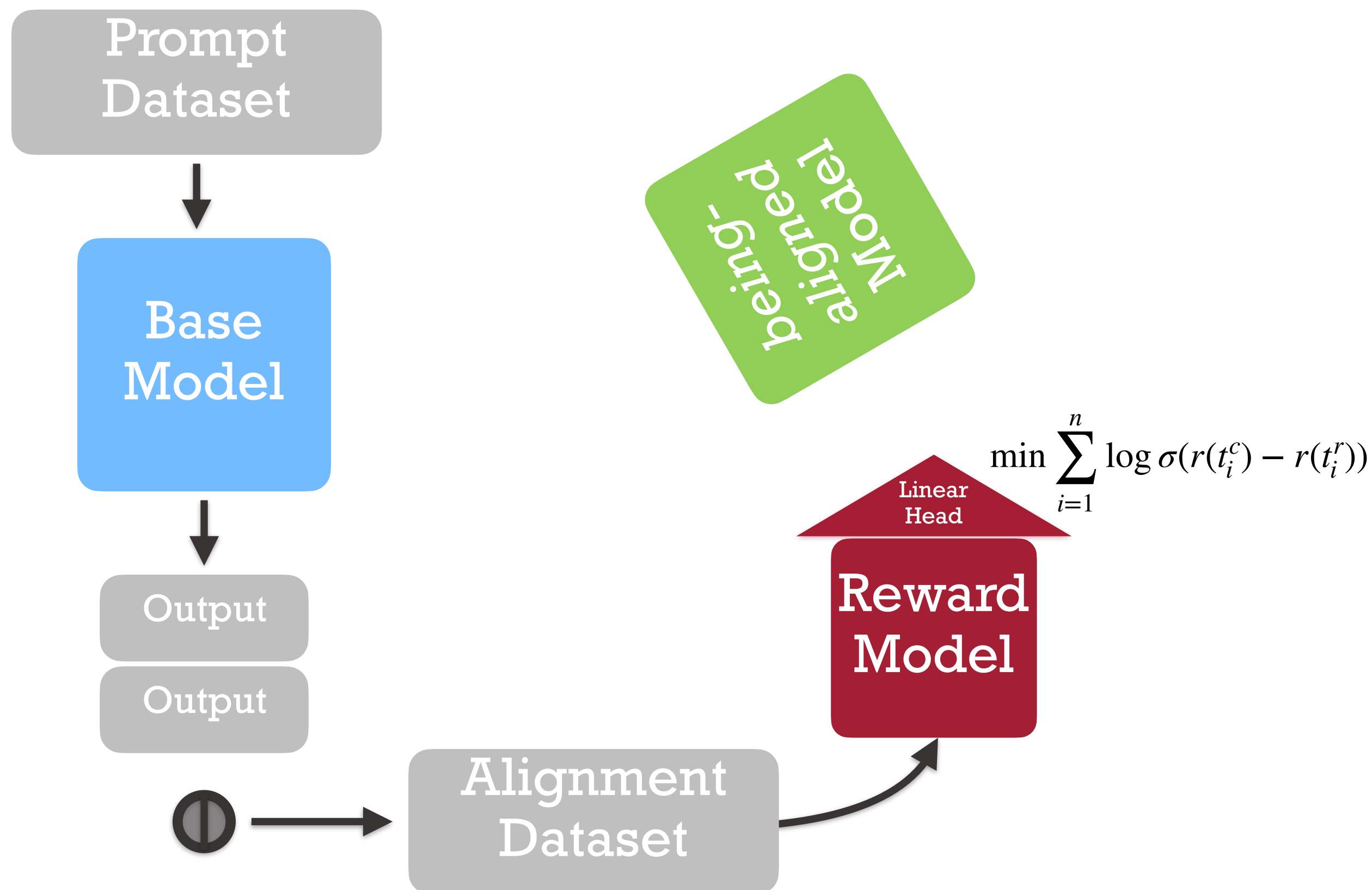


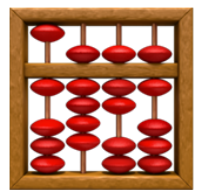
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



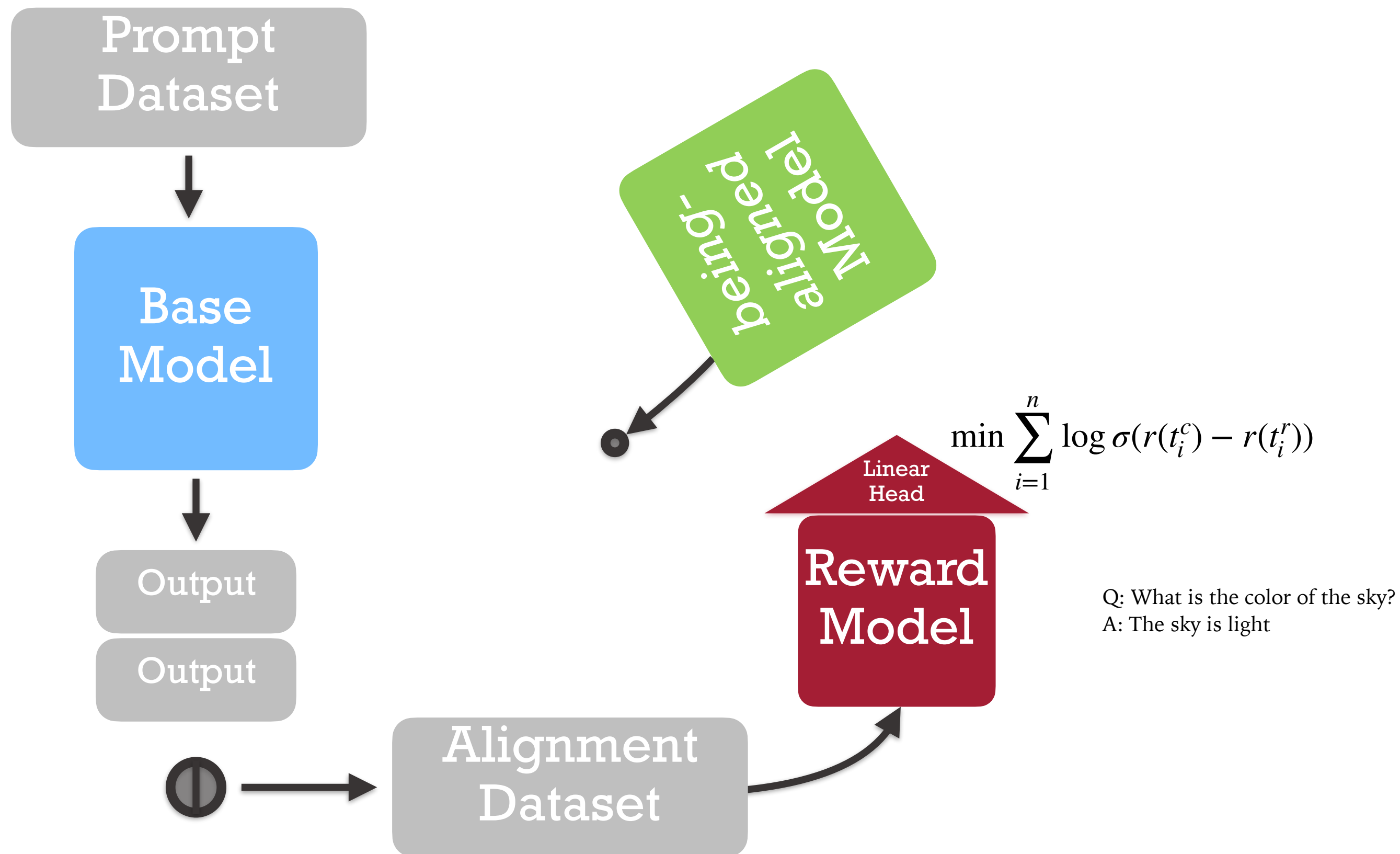


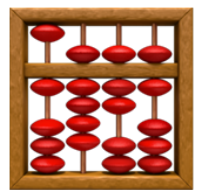
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



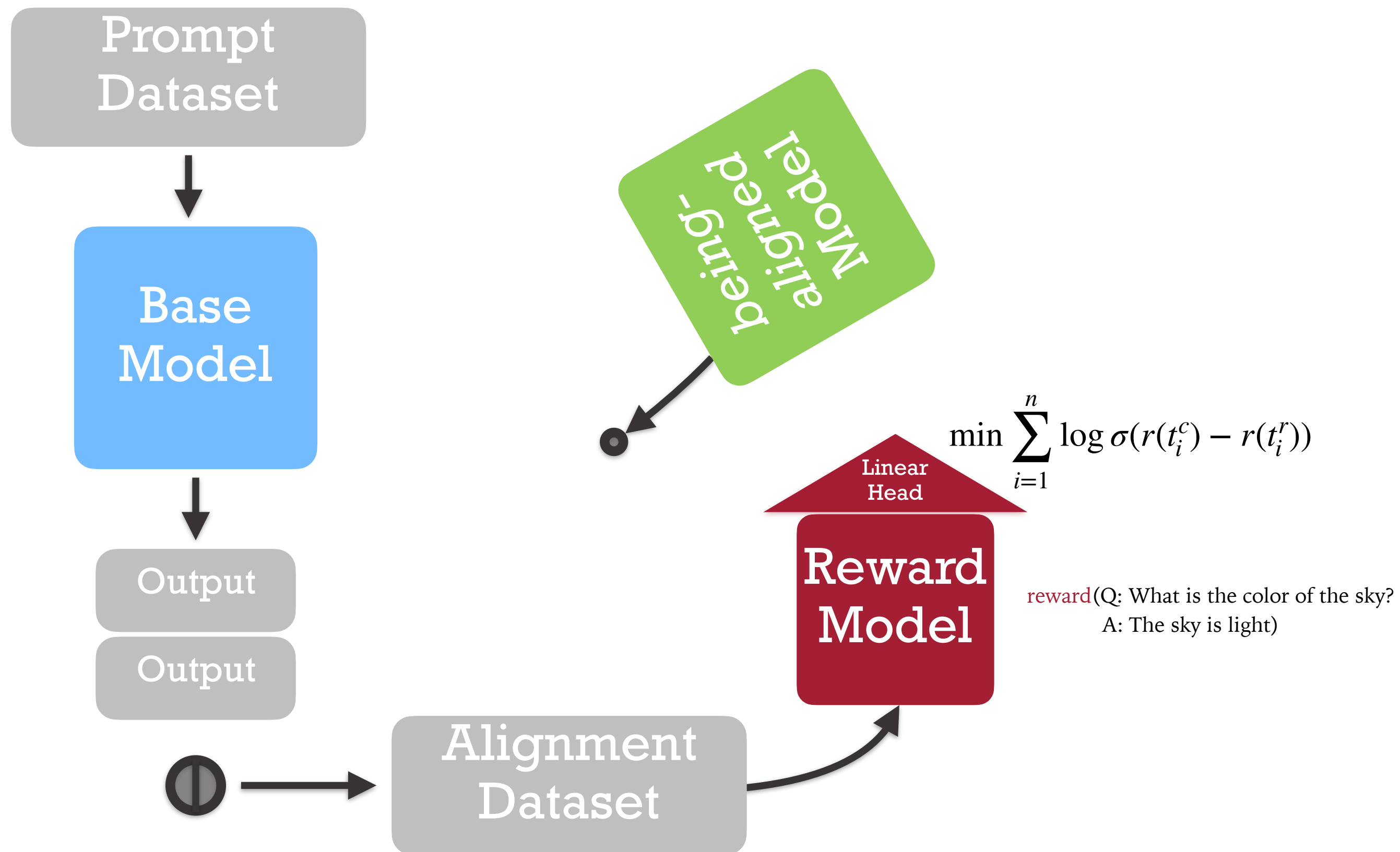


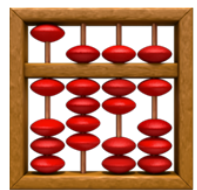
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



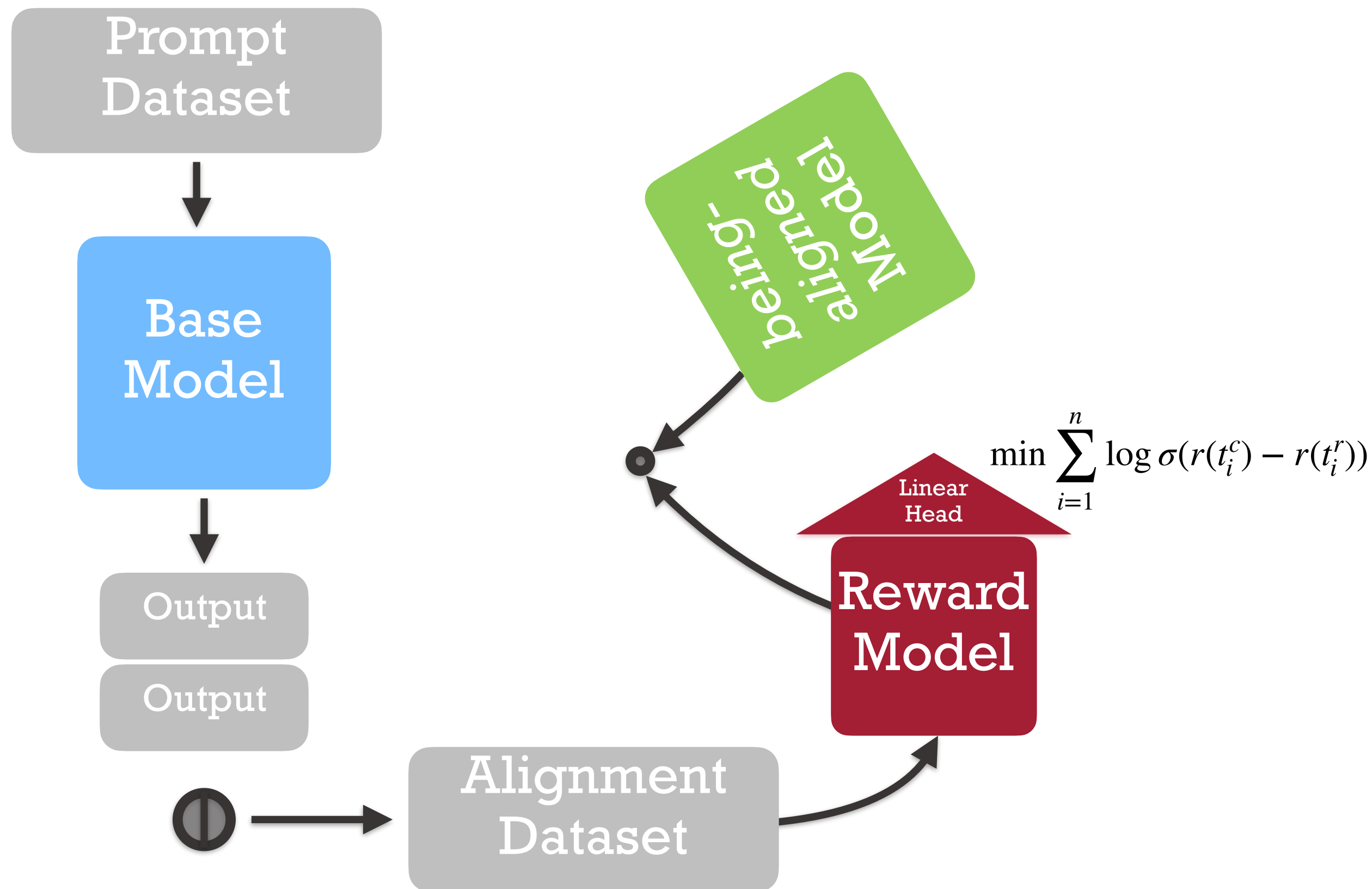


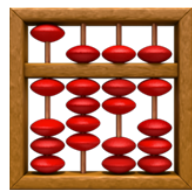
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



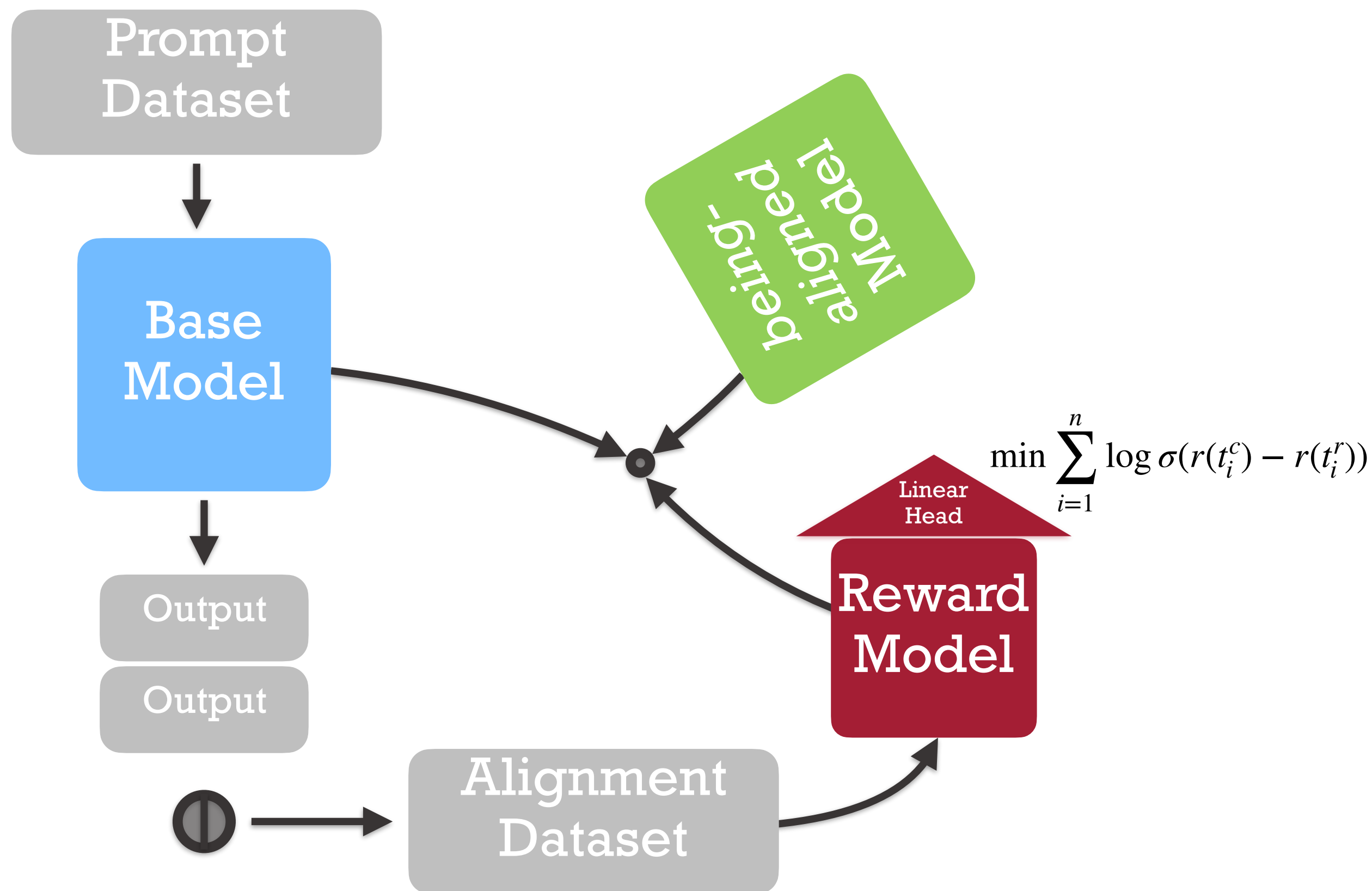


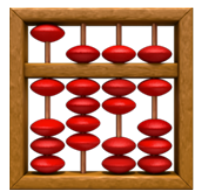
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



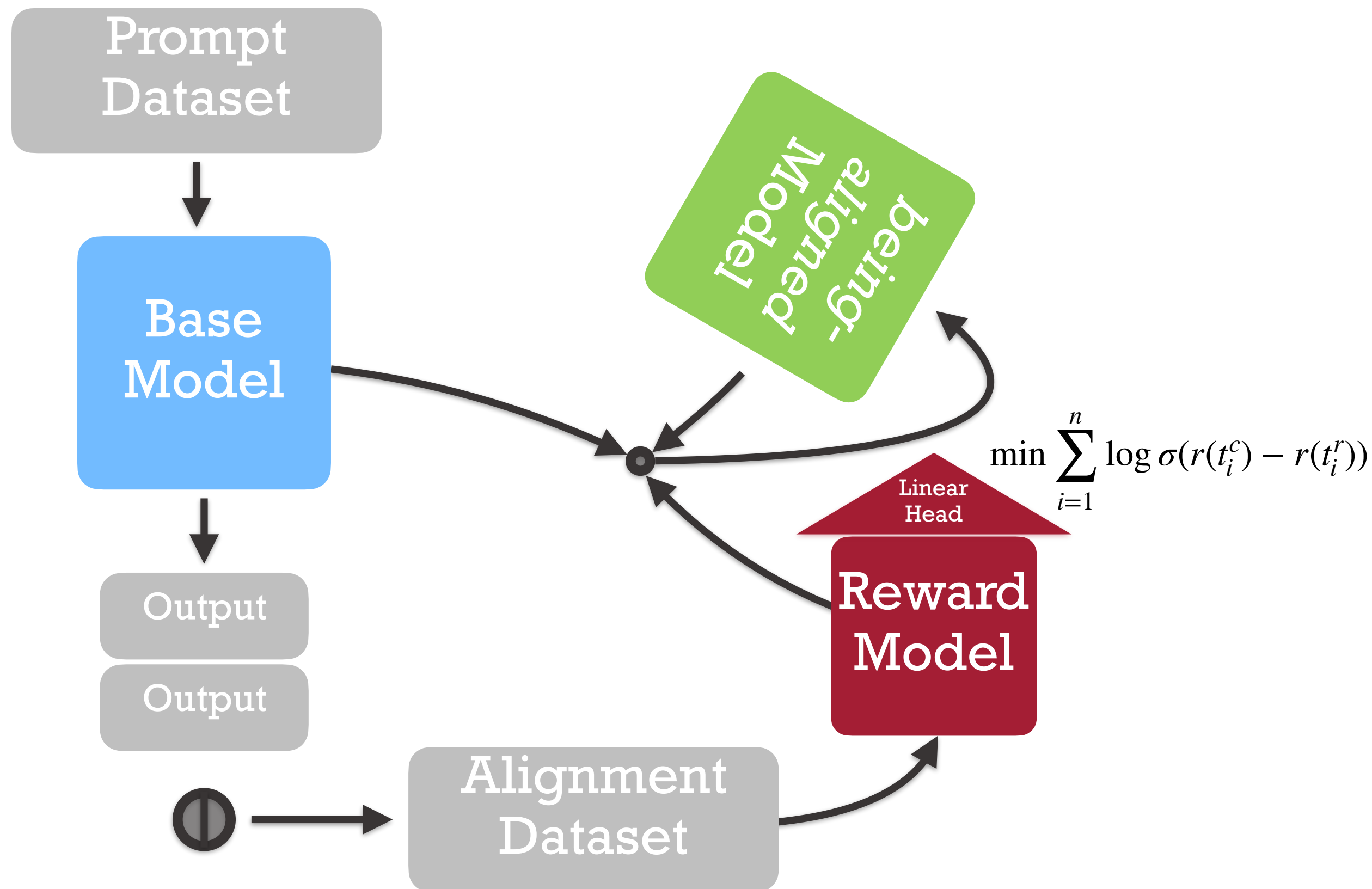


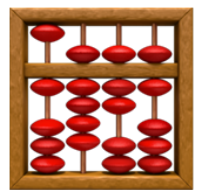
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



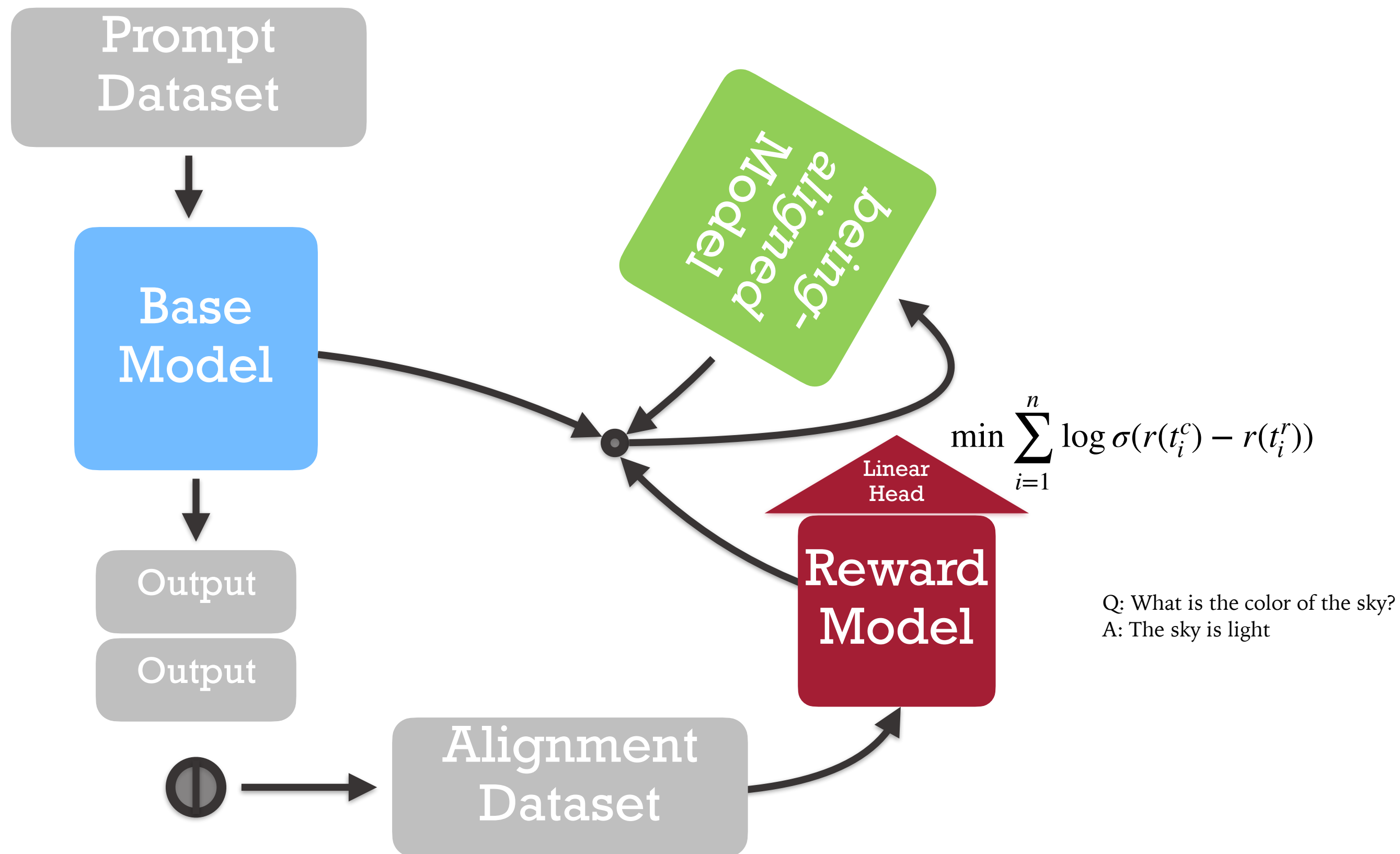


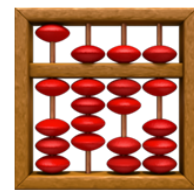
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



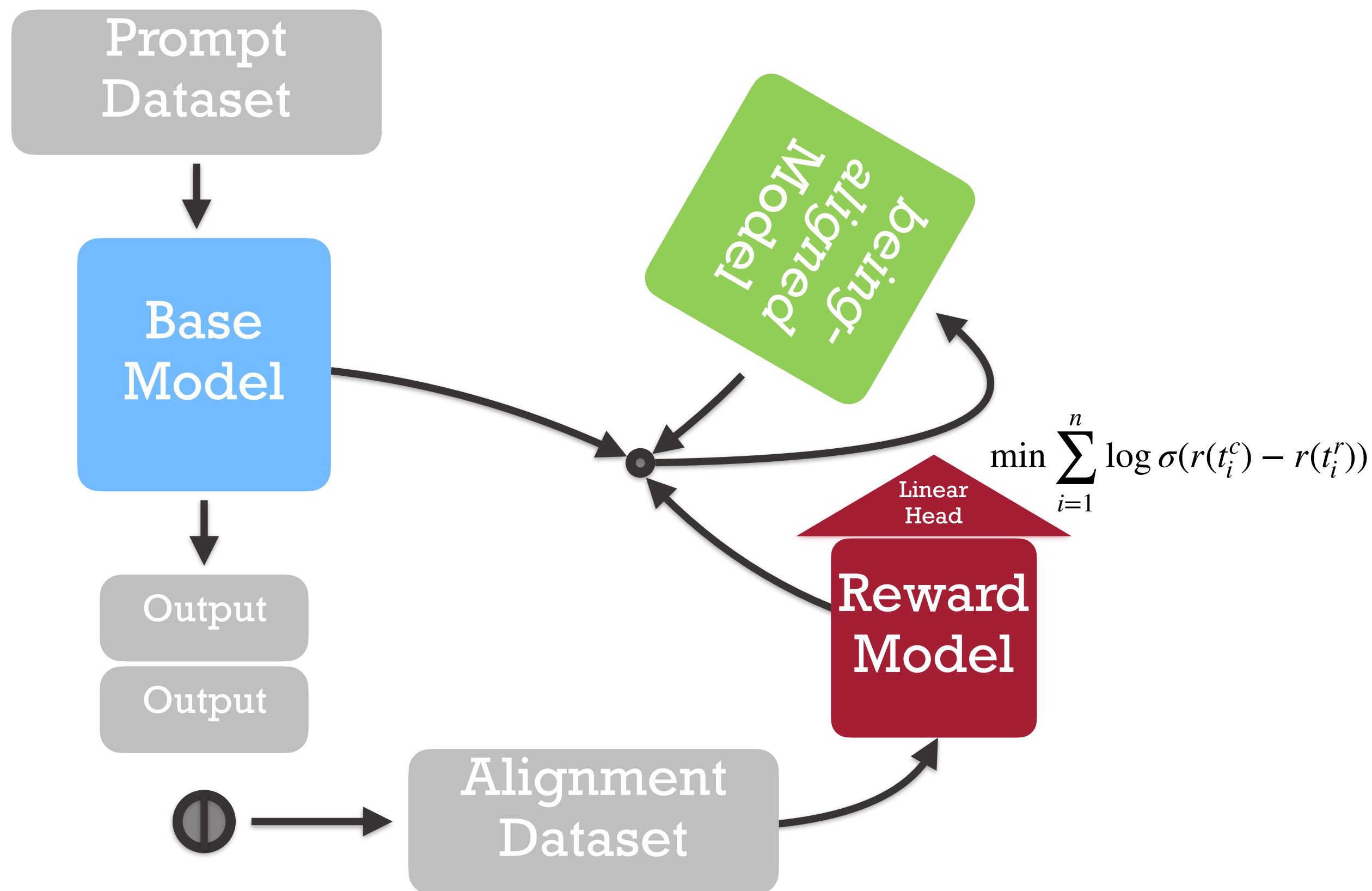


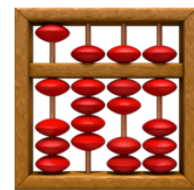
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



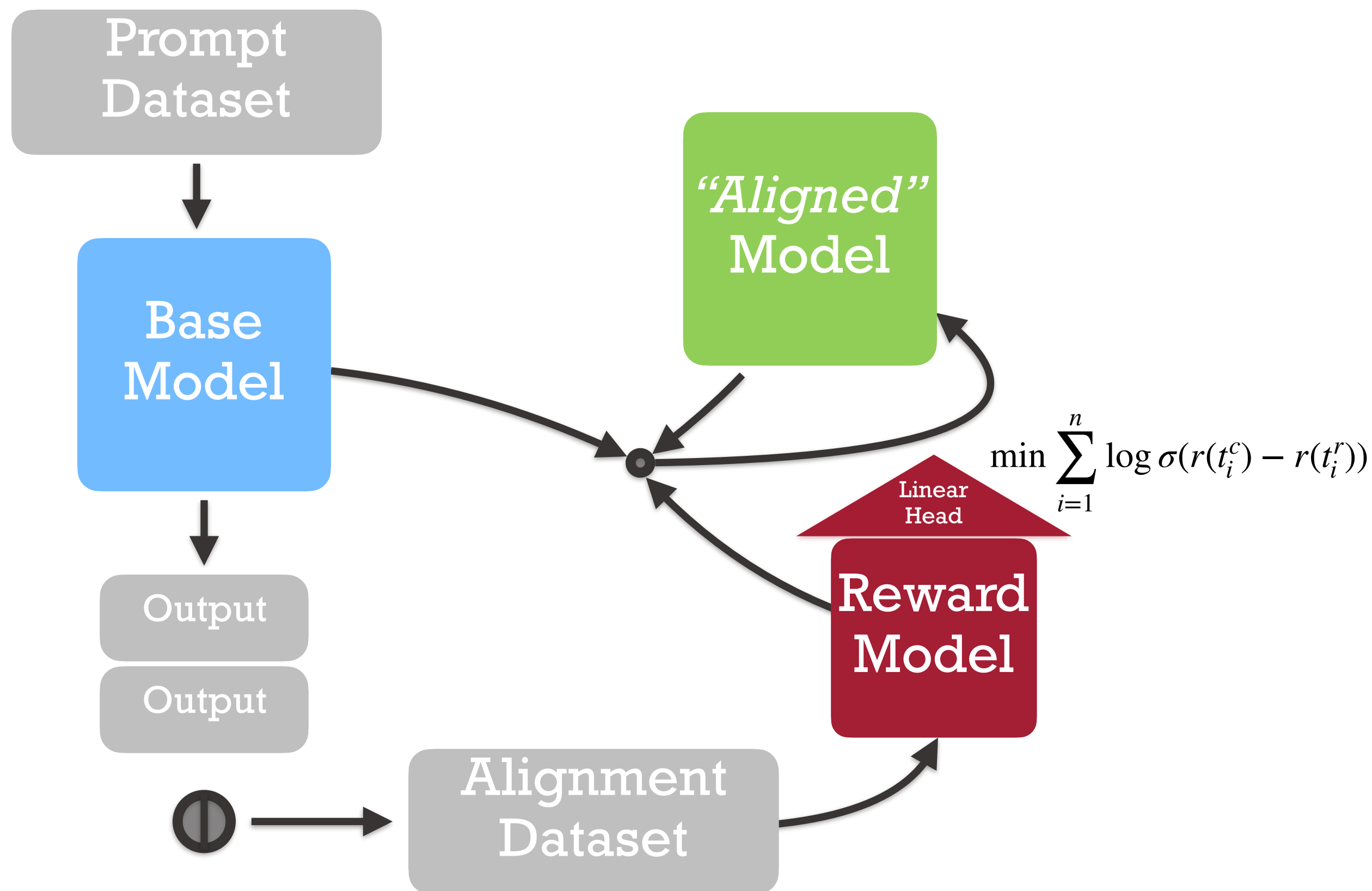


REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

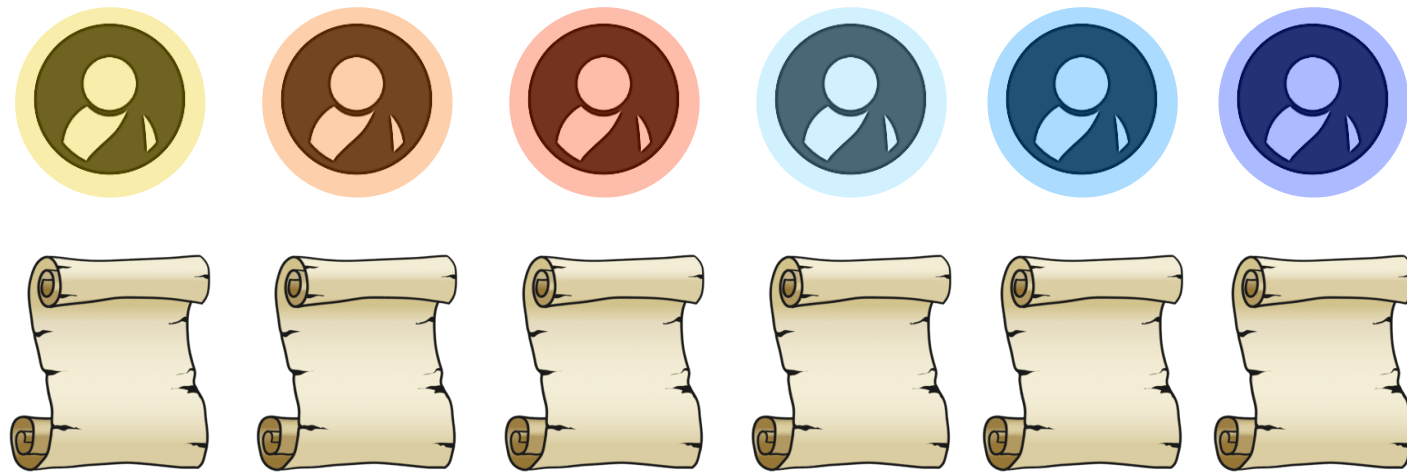




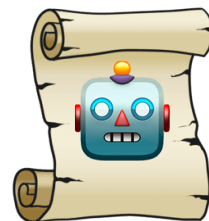
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



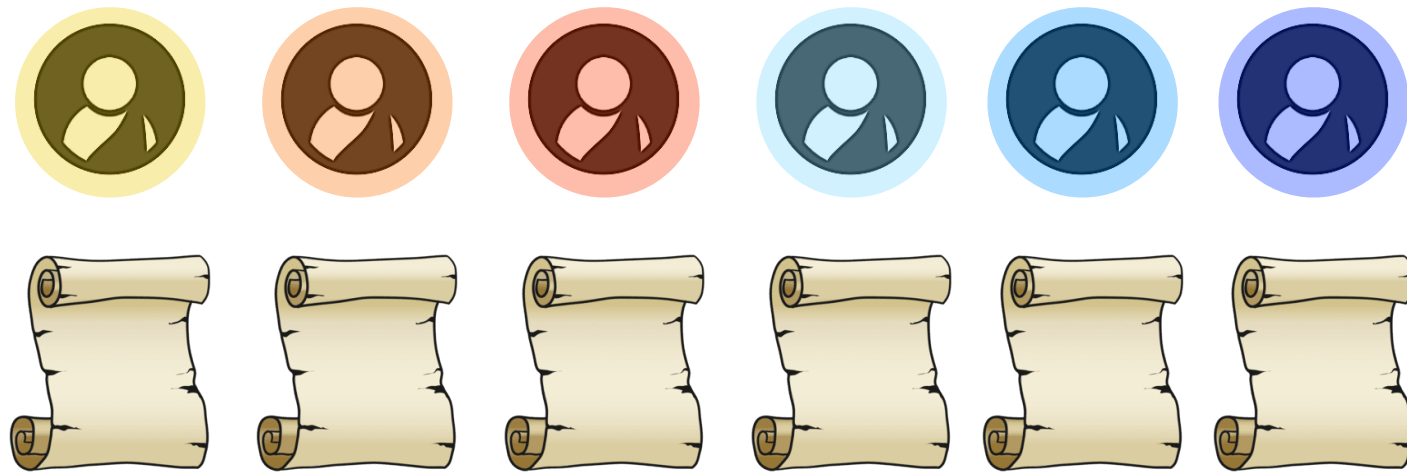
CONSENSUS STATEMENTS



Consensus
Statement

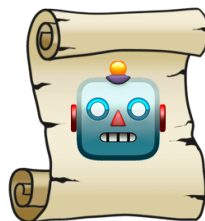


CONSENSUS STATEMENTS

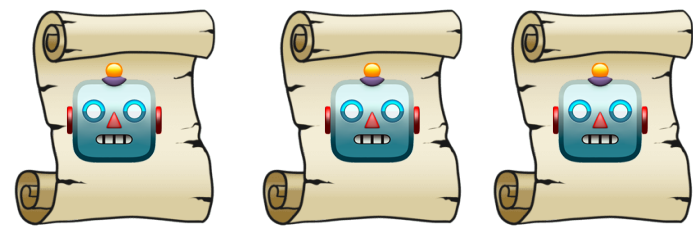
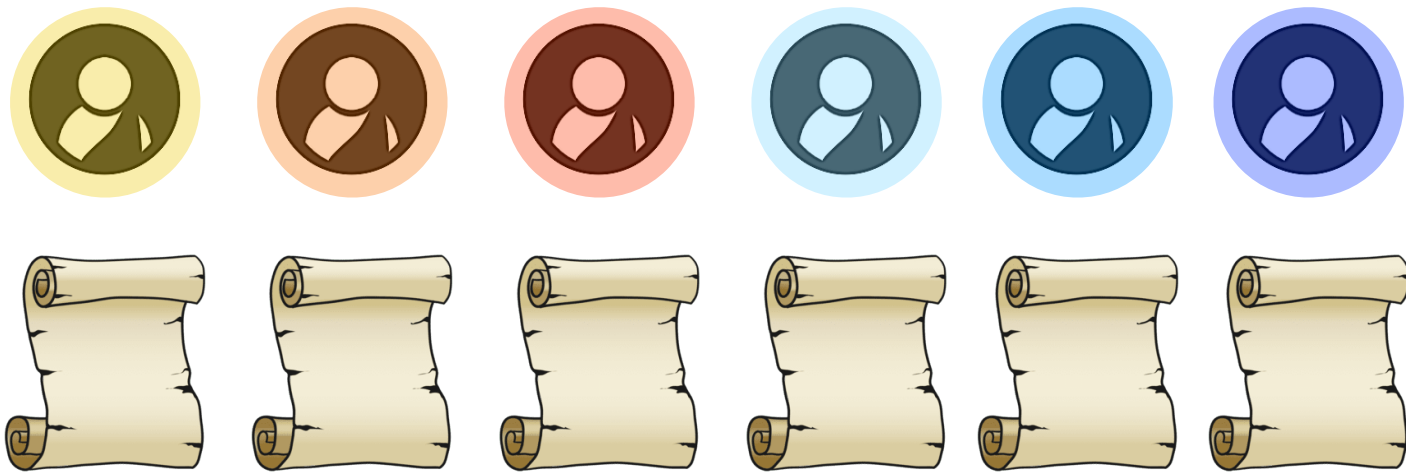


- ✦ Preference for model candidates over human opinions

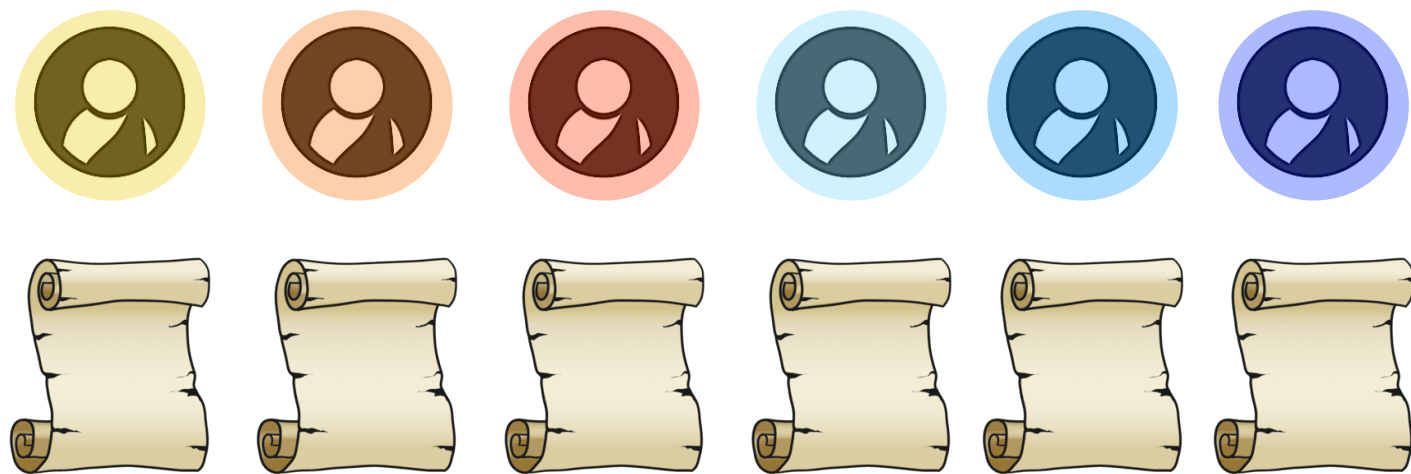
Consensus
Statement



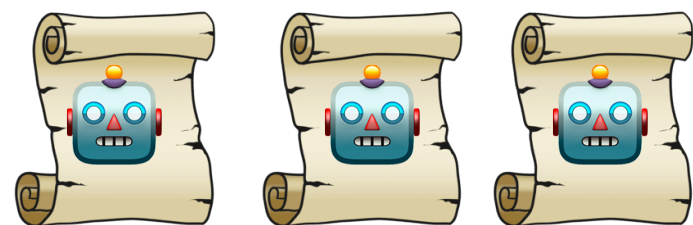
REPRESENTATIVE STATEMENTS

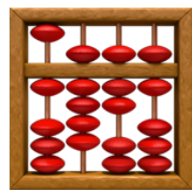


REPRESENTATIVE STATEMENTS



Policy
Recommendations

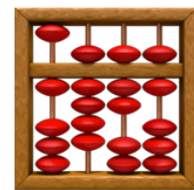




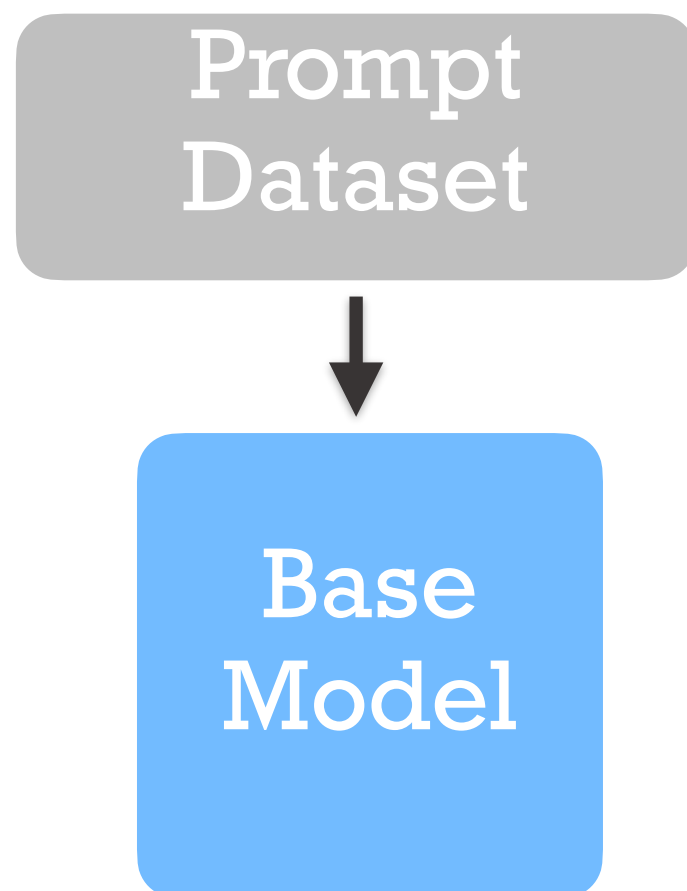
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Base
Model

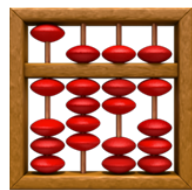
$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

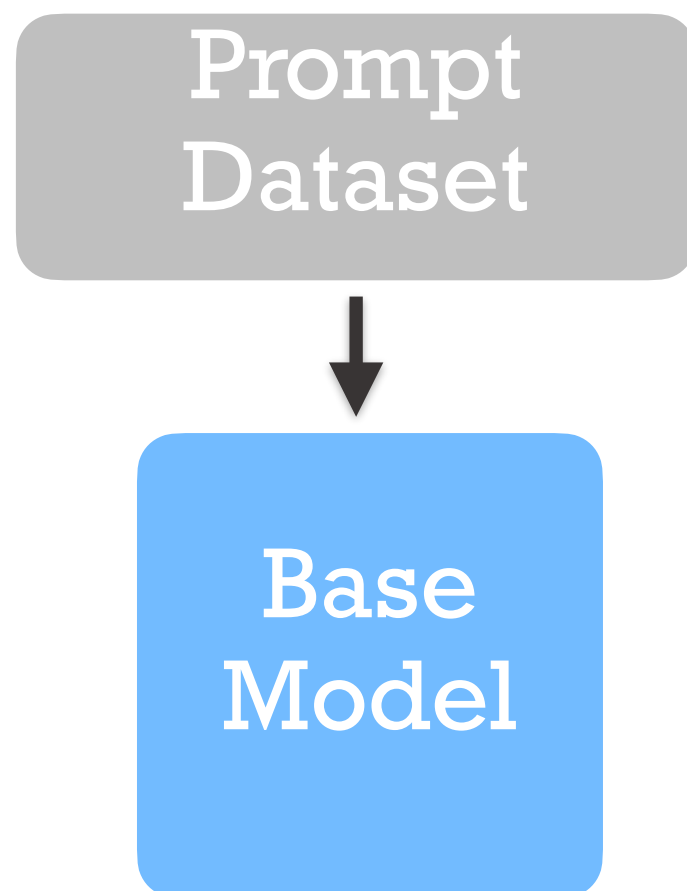


$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$

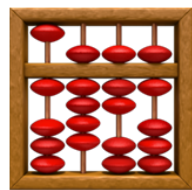


REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

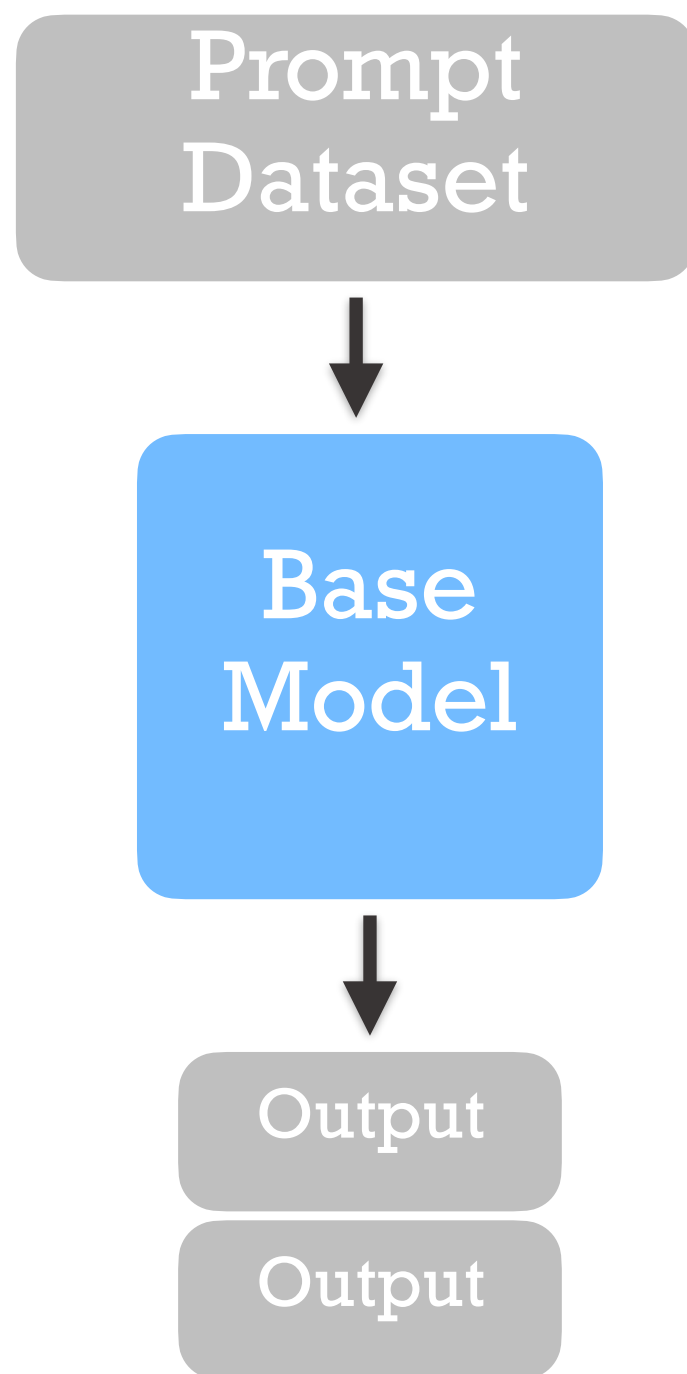
- What does Meta mean in Greek?
- Which LLM underlies MEDITRON?



$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$



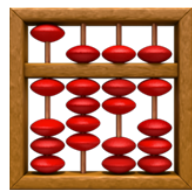
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



Q: What does Meta mean in Greek?
A: Iron

Q: What does Meta mean in Greek?
A: Transcending

$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Prompt
Dataset



Base
Model

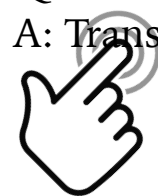


Output

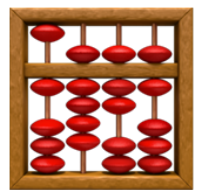
Output

Q: What does Meta mean in Greek?
A: Iron

Q: What does Meta mean in Greek?
A: Transcending



$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

Prompt
Dataset



Base
Model



Output

Output



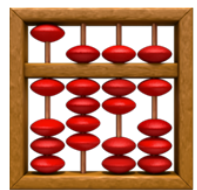
Q: What does Meta mean in Greek?

A: Iron [rejected]

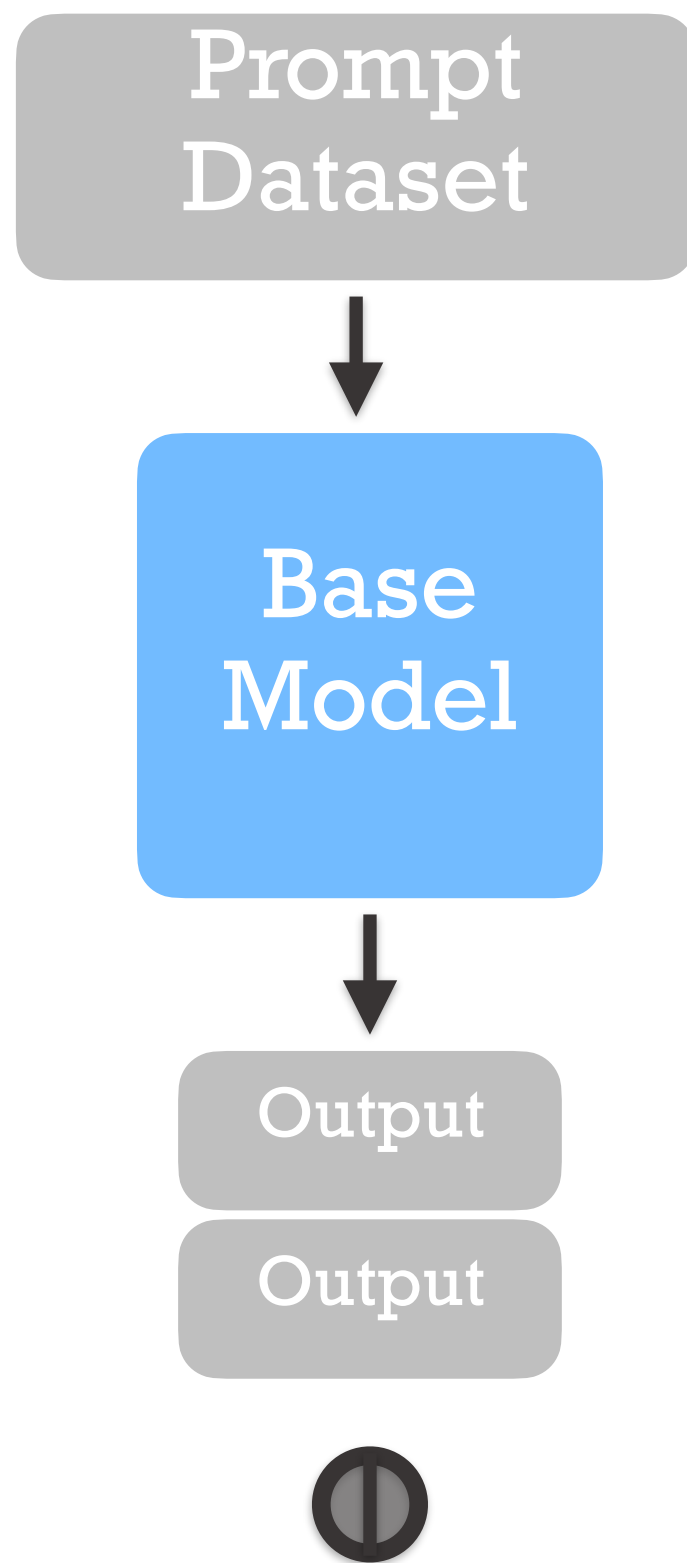
Q: What does Meta mean in Greek?

A: Transcending [chosen]

$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$



REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



Q: What does Meta mean in Greek?

A: Iron [rejected]

Q: What does Meta mean in Greek?

A: Transcending [chosen]

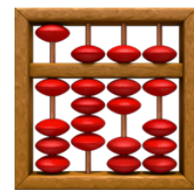
Q: Which LLM underlies MEDITRON?

A: Llama 2 [chosen]

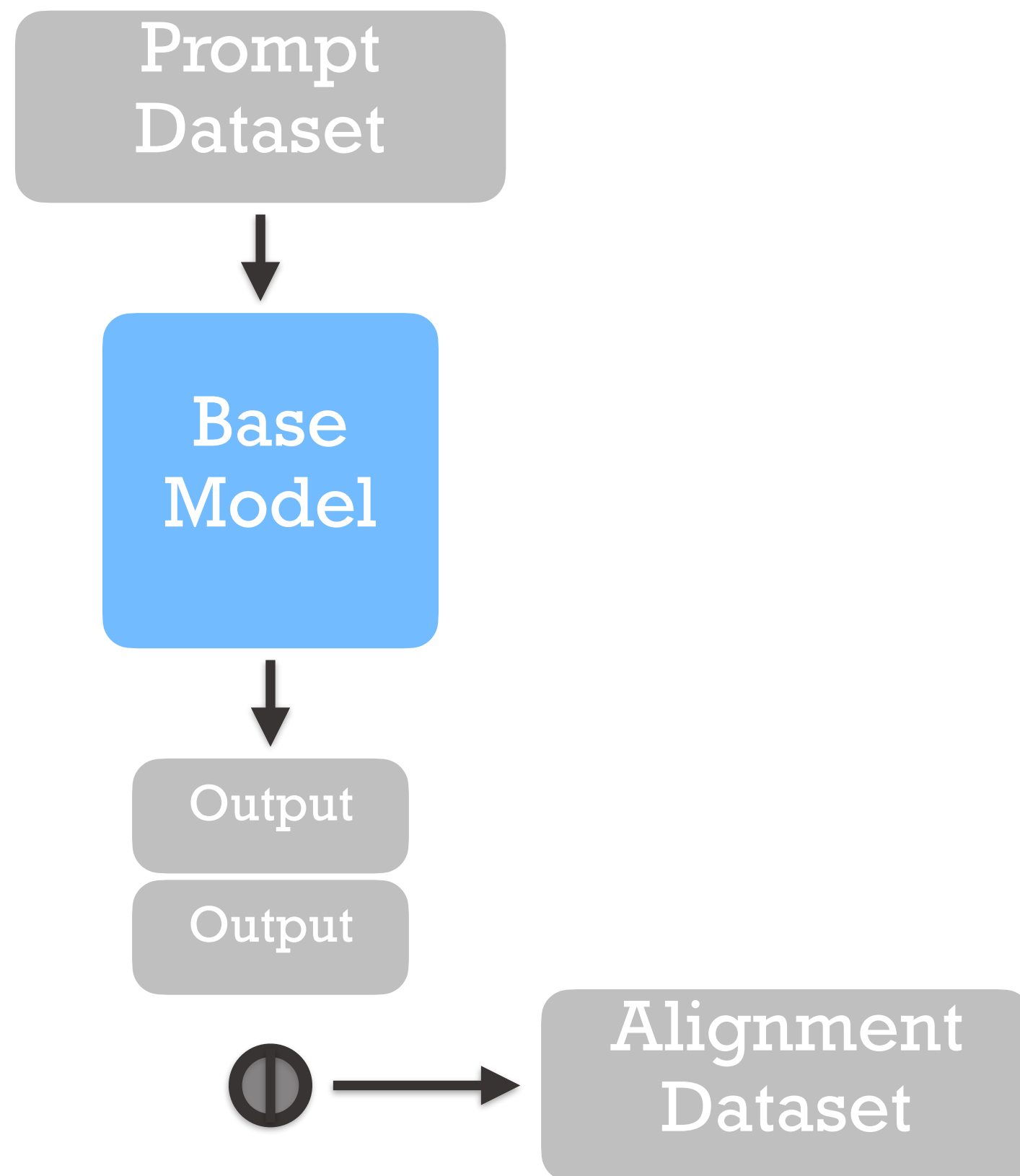
Q: Which LLM underlies MEDITRON?

A: Mistral 7B [rejected]

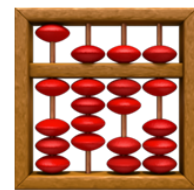
$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$



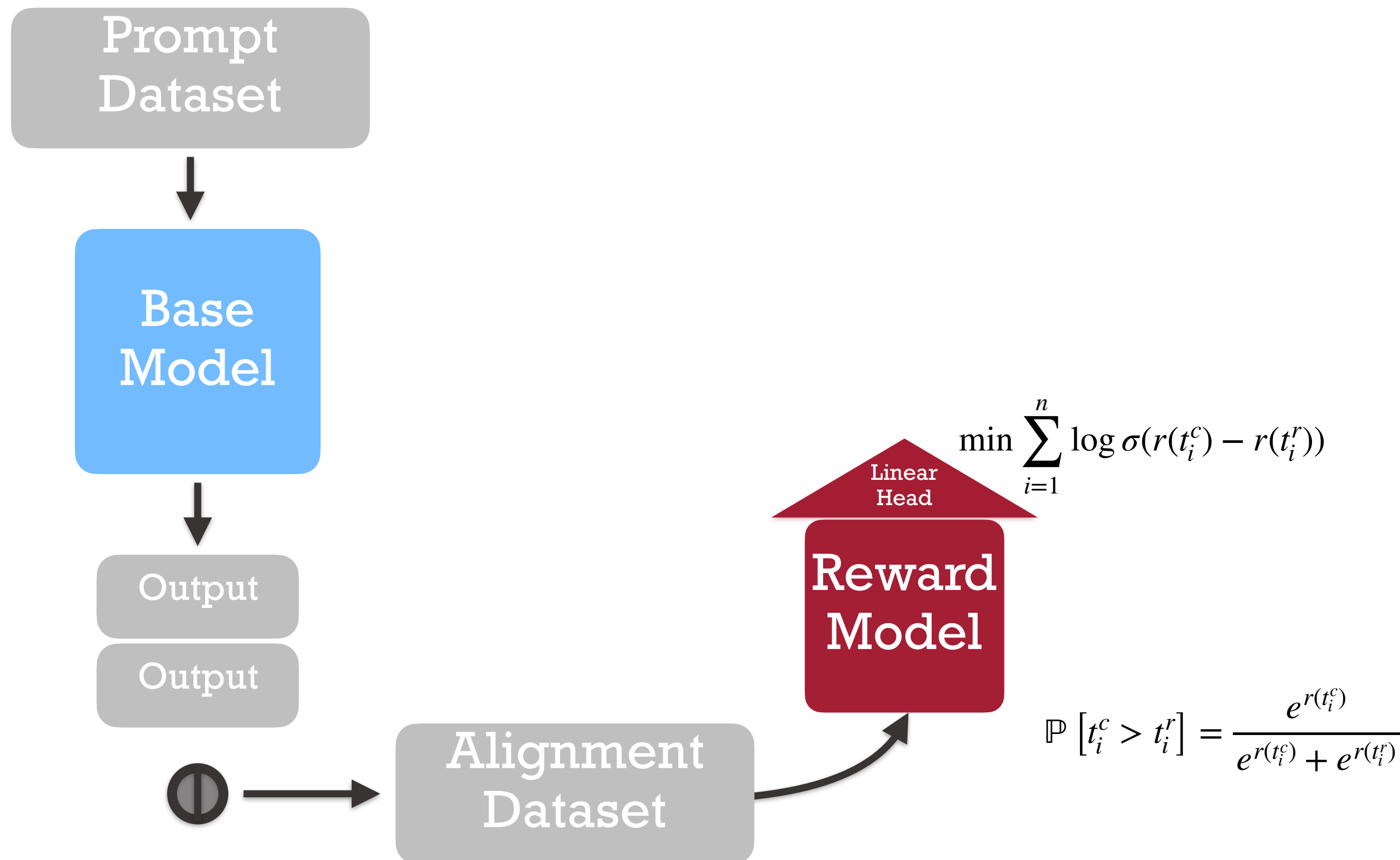
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK

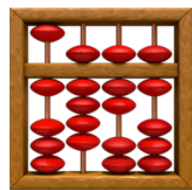


$$\mathbb{P} \left[t_i^c > t_i^r \right] = \frac{e^{r(t_i^c)}}{e^{r(t_i^c)} + e^{r(t_i^r)}}$$

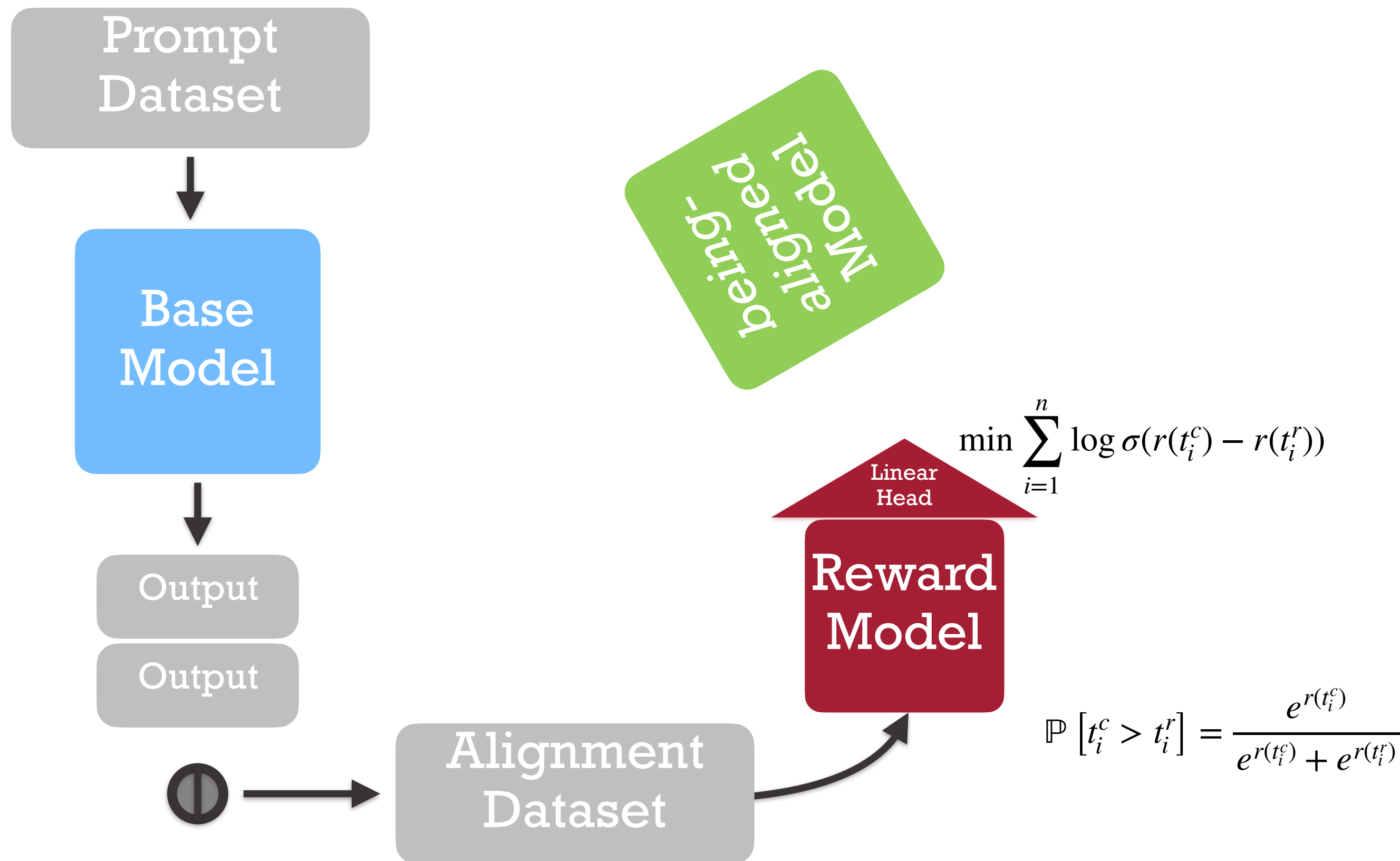


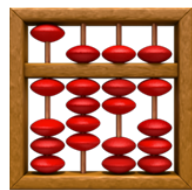
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



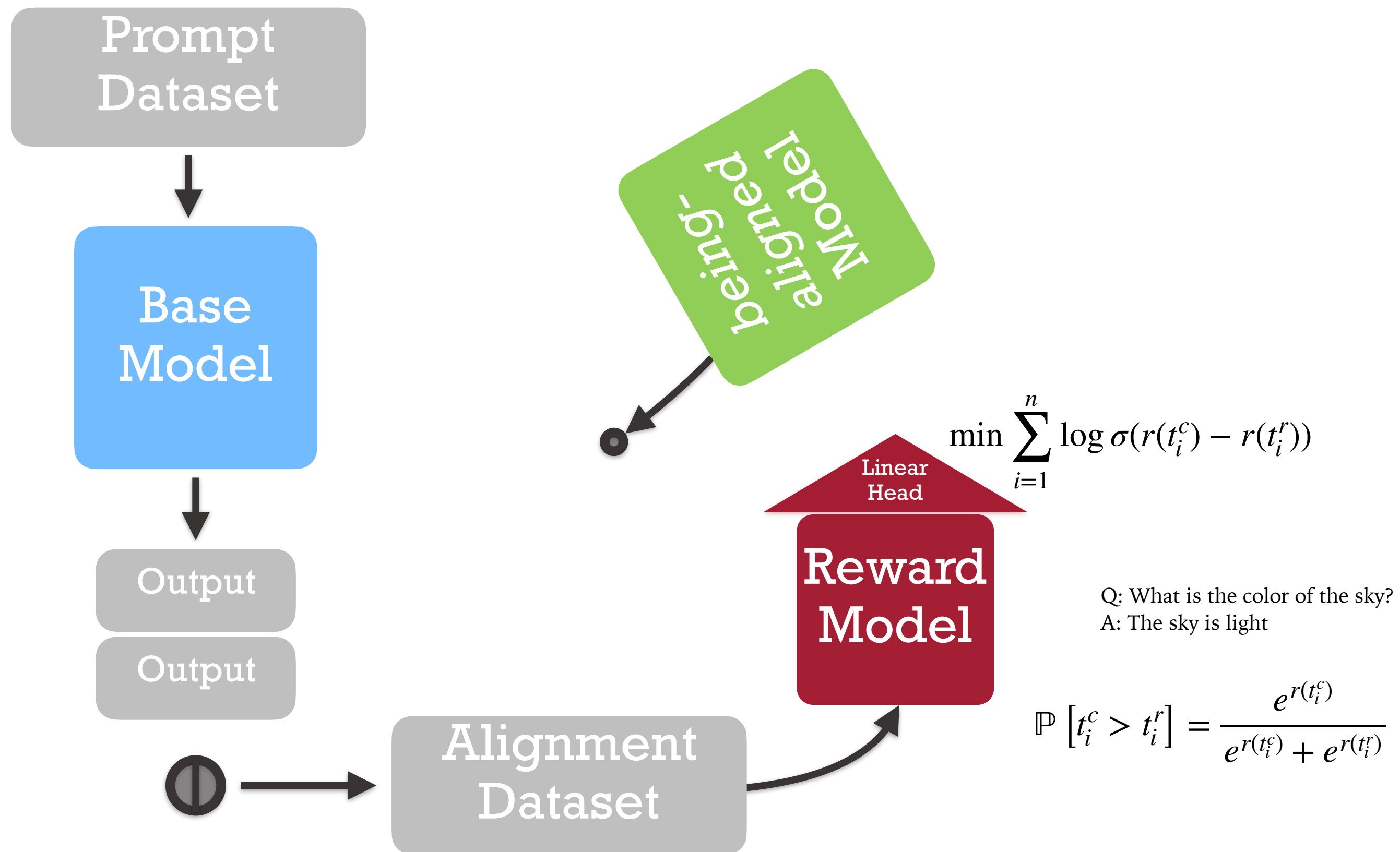


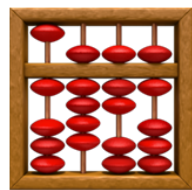
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



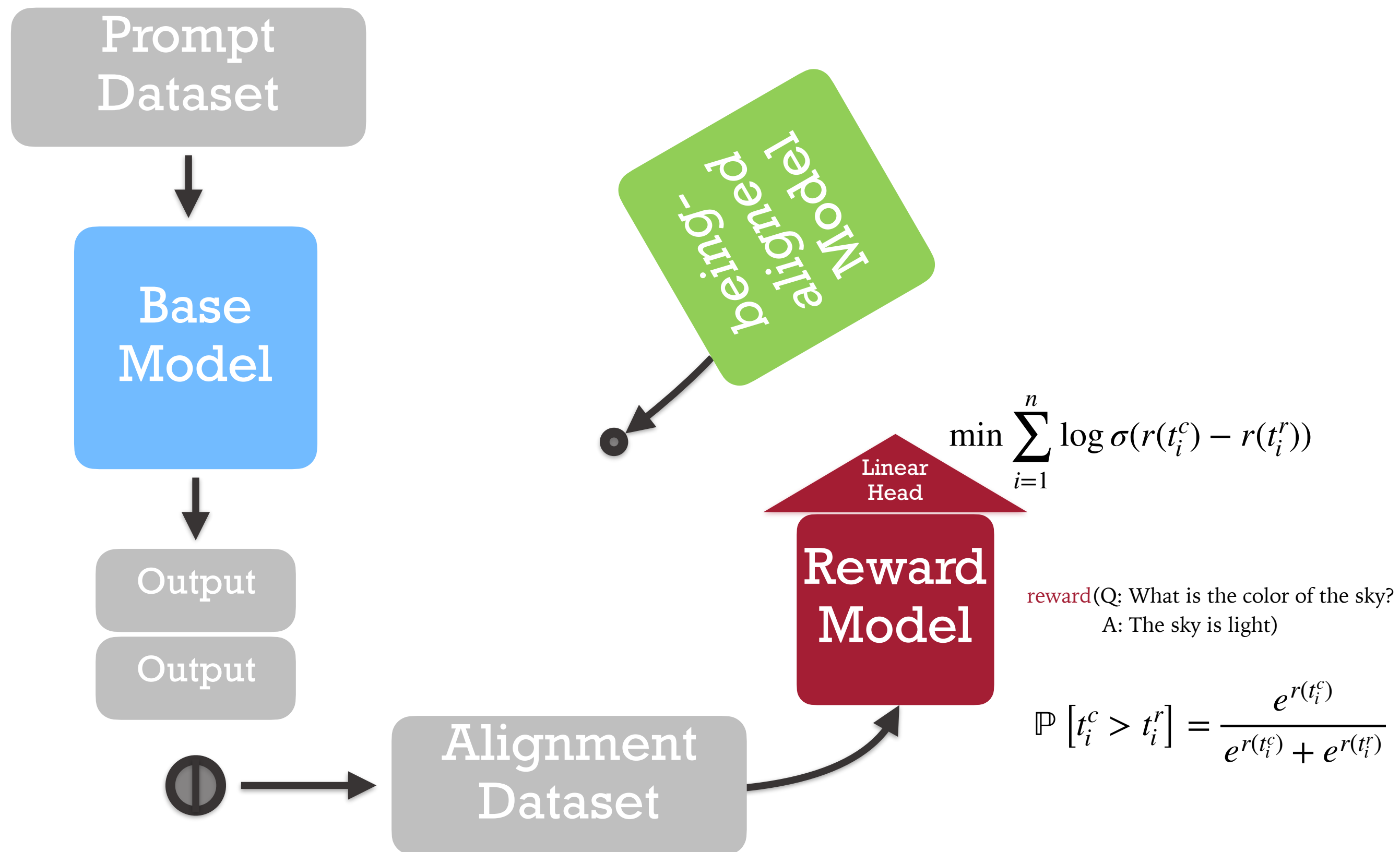


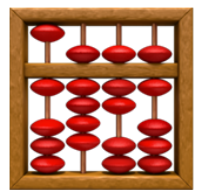
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



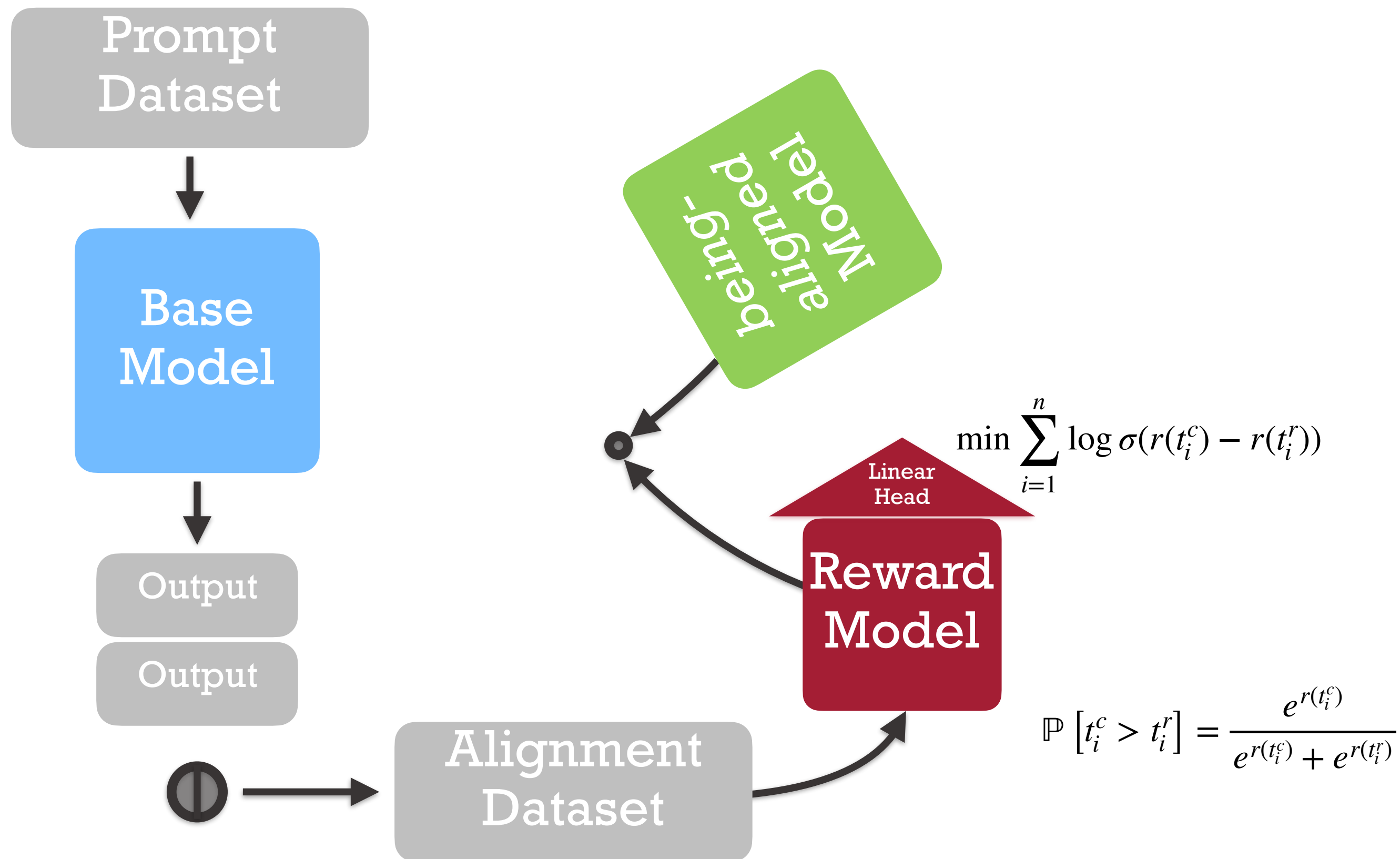


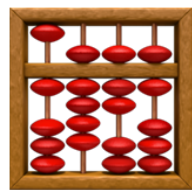
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



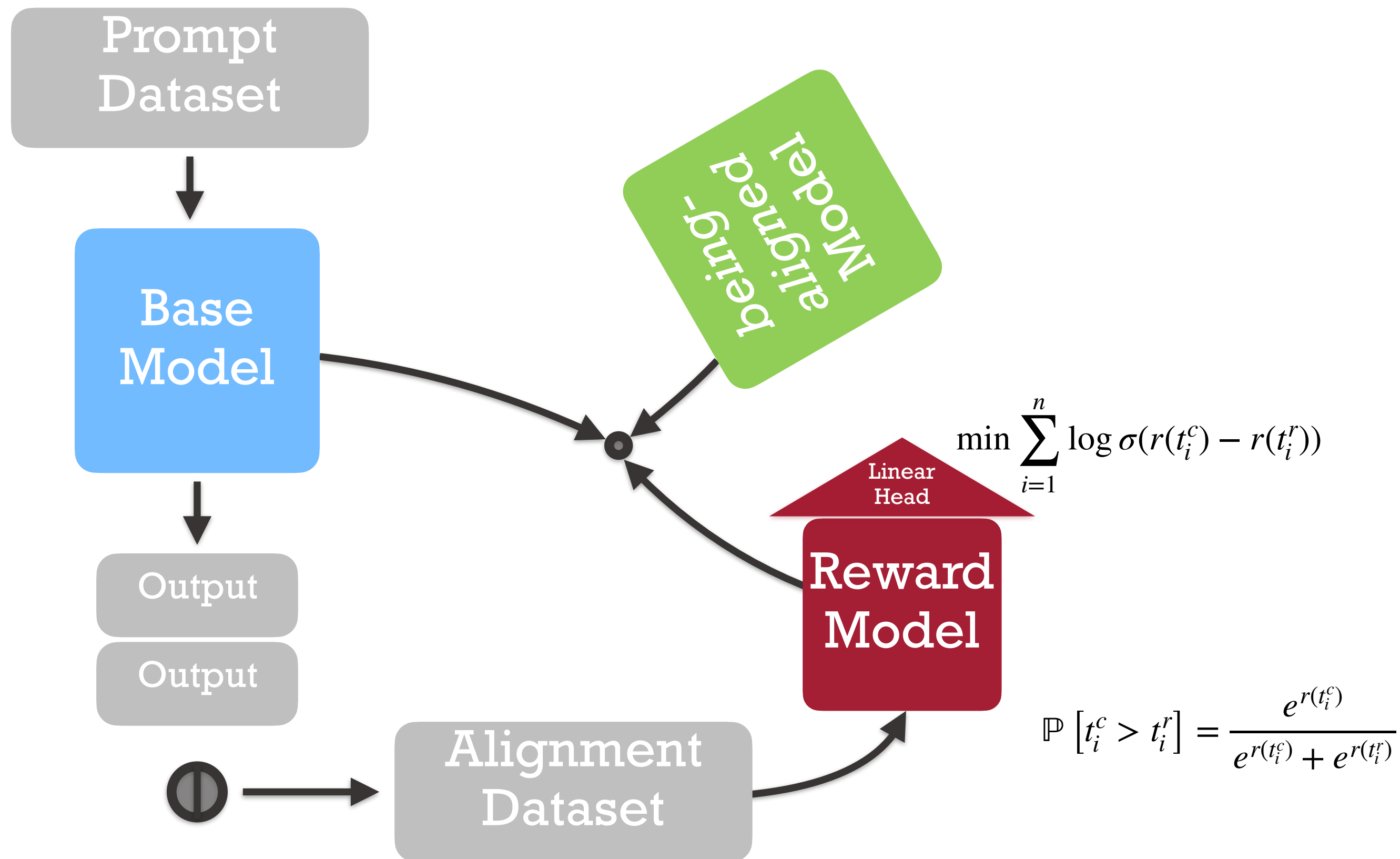


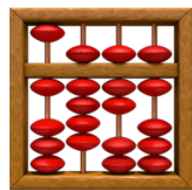
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



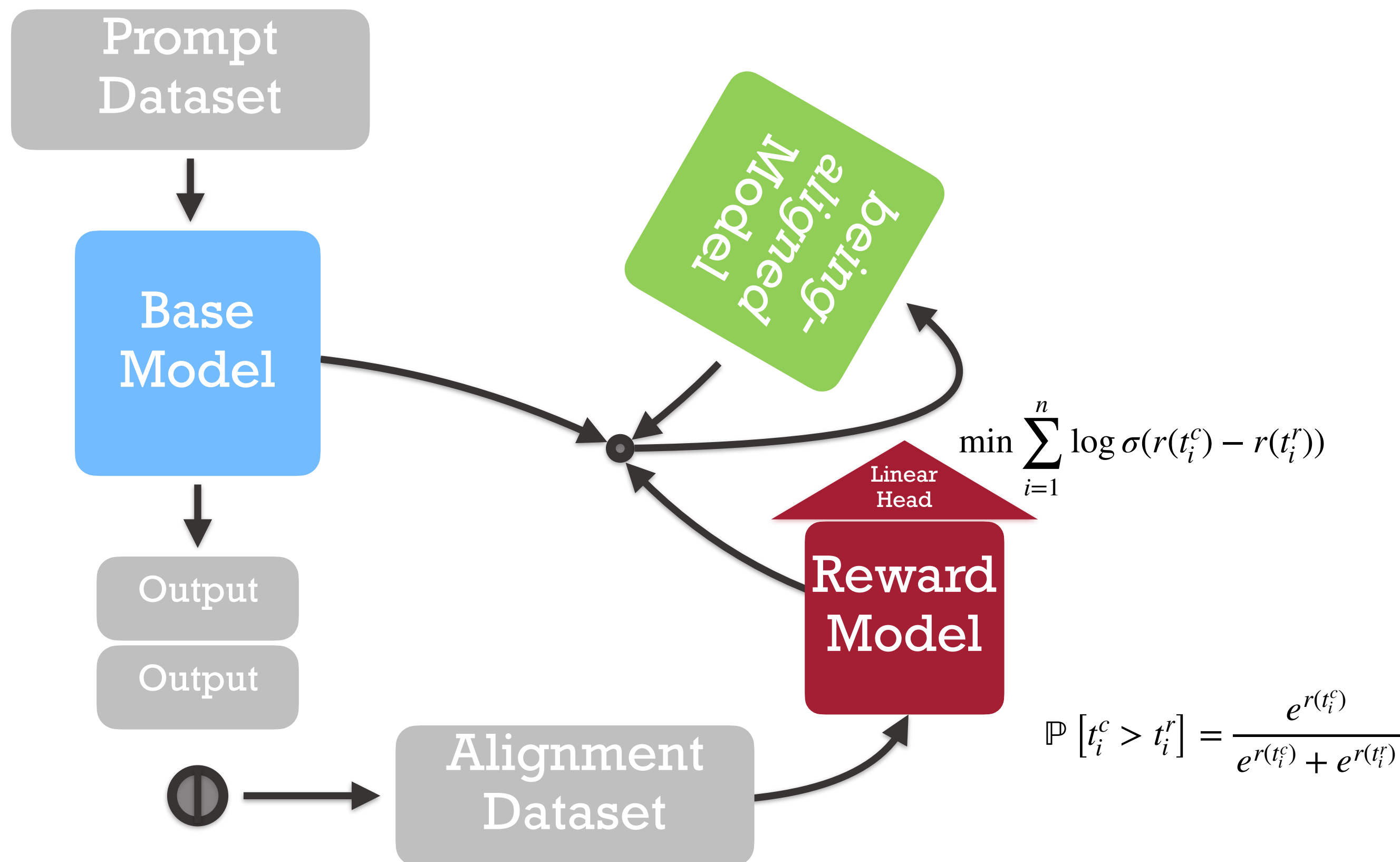


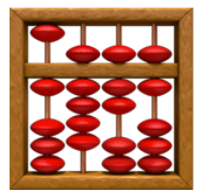
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



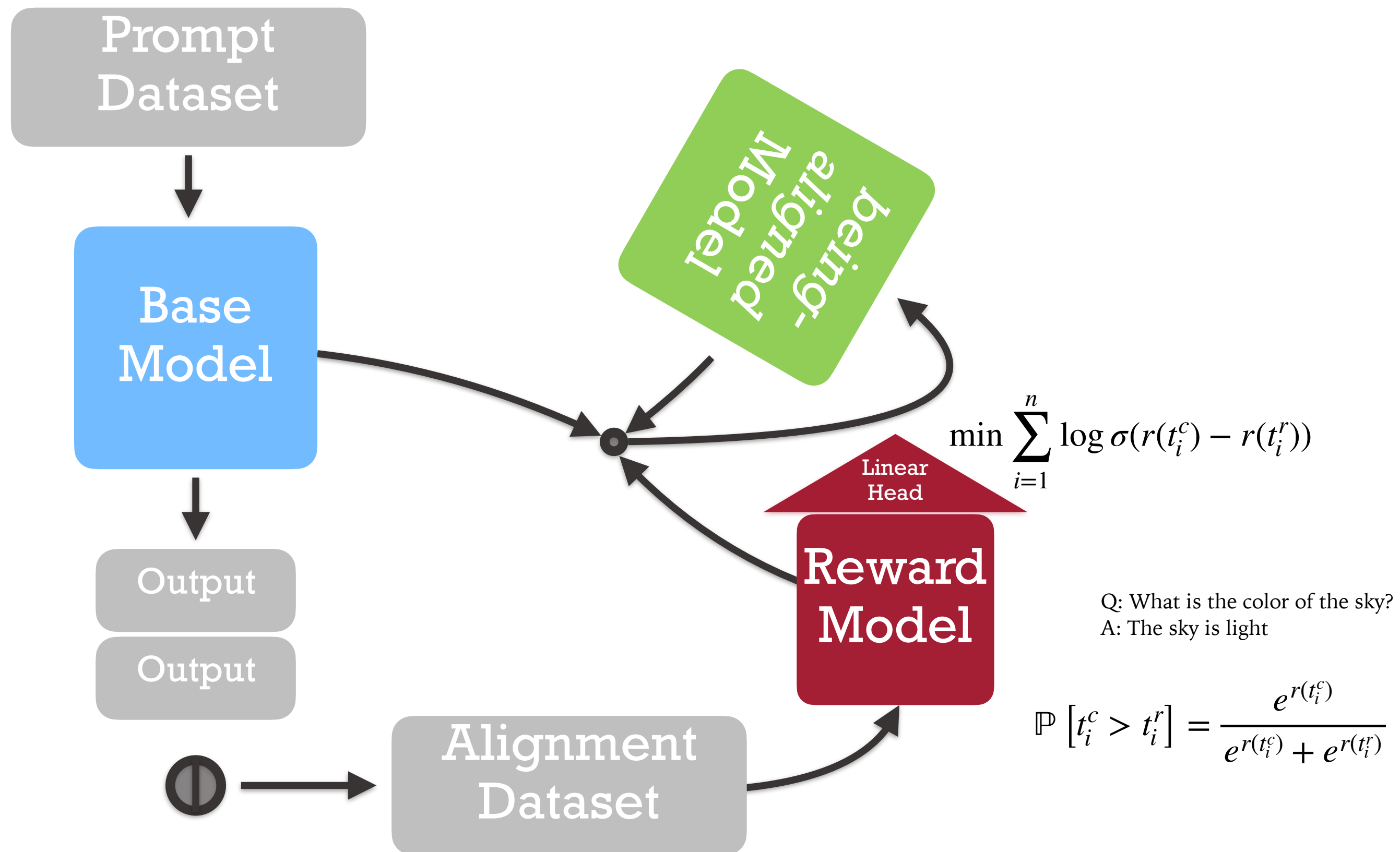


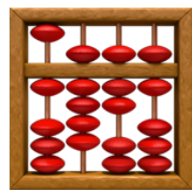
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



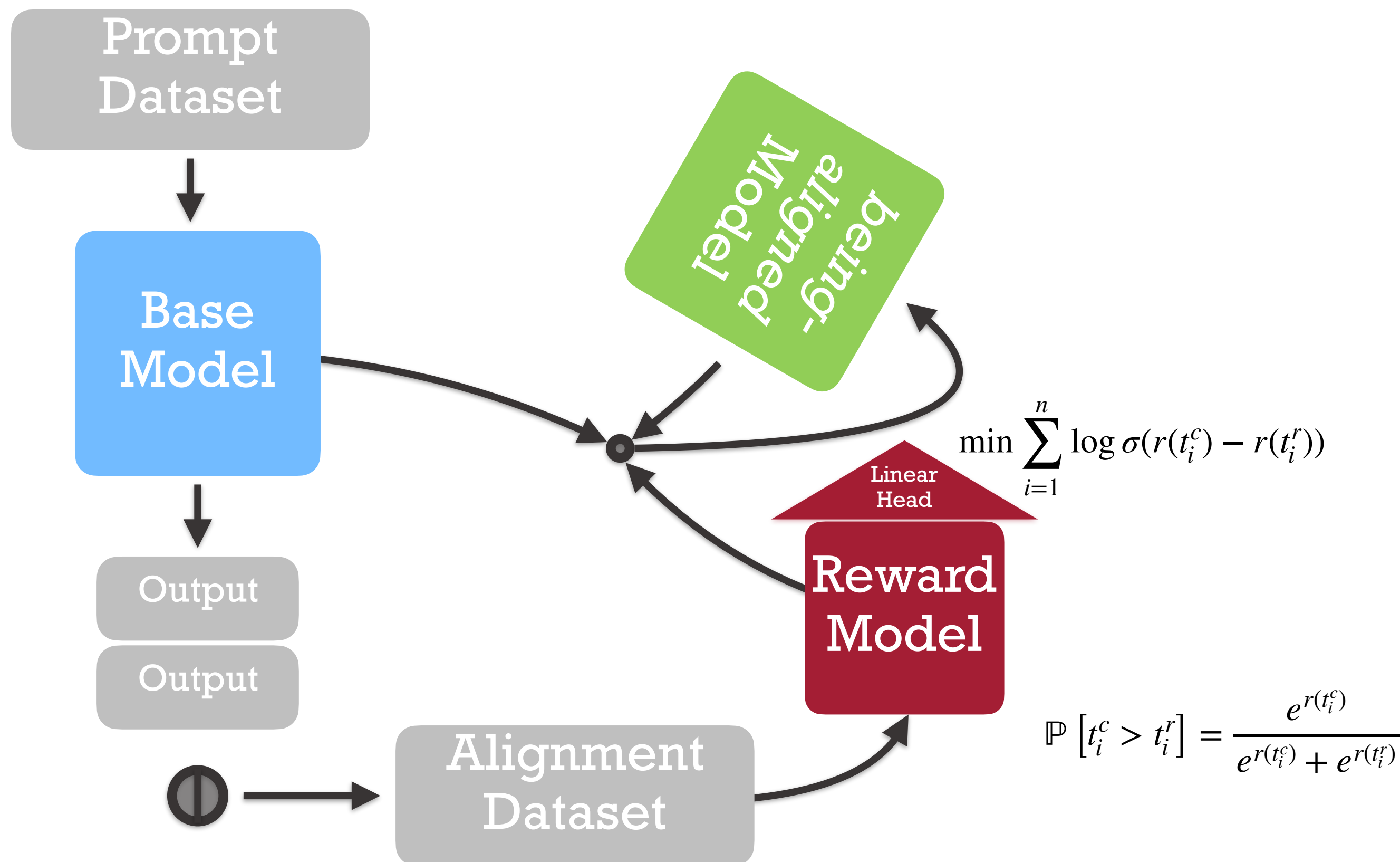


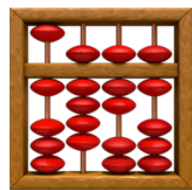
REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



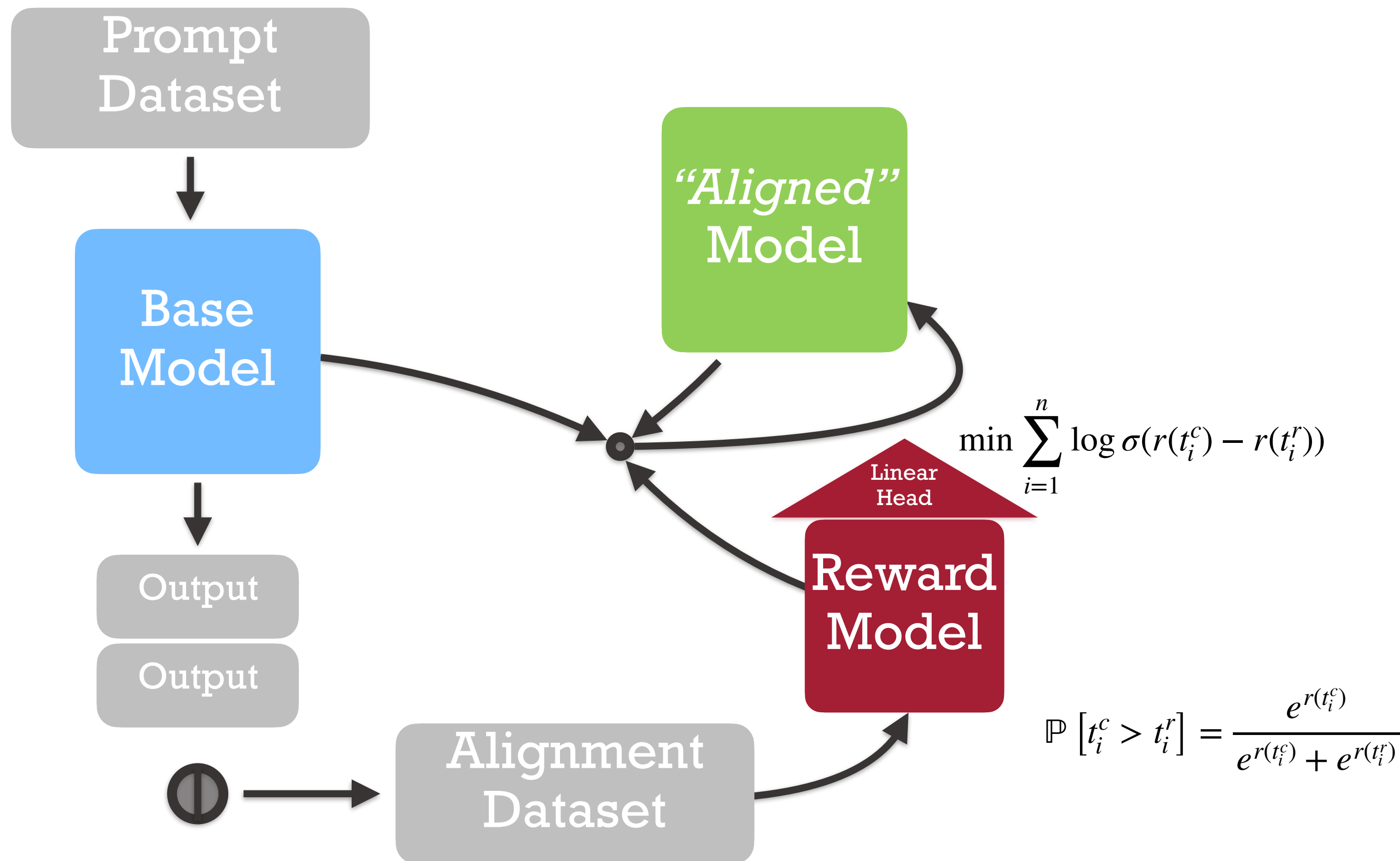


REINFORCEMENT LEARNING FROM HUMAN FEEDBACK





REINFORCEMENT LEARNING FROM HUMAN FEEDBACK



Chapter Outline

3

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

NATURAL LANGUAGE PROCESSING

NATURAL LANGUAGE PROCESSING

- ✦ Natural Language Processing (NLP) has been used for tasks such as topic modeling, summarisation, moderation...

NATURAL LANGUAGE PROCESSING

- ✦ Natural Language Processing (NLP) has been used for tasks such as topic modeling, summarisation, moderation...
- ✦ Large Language Models (LLMs) offer new possibilities in terms of sense-making of various texts...

NATURAL LANGUAGE PROCESSING

- ✦ Natural Language Processing (NLP) has been used for tasks such as topic modeling, summarisation, moderation...
- ✦ Large Language Models (LLMs) offer new possibilities in terms of sense-making of various texts...
- ✦ Recent research has investigated how consensus statements or representative statements can be built with LLMs...

CONSENSUS STATEMENTS

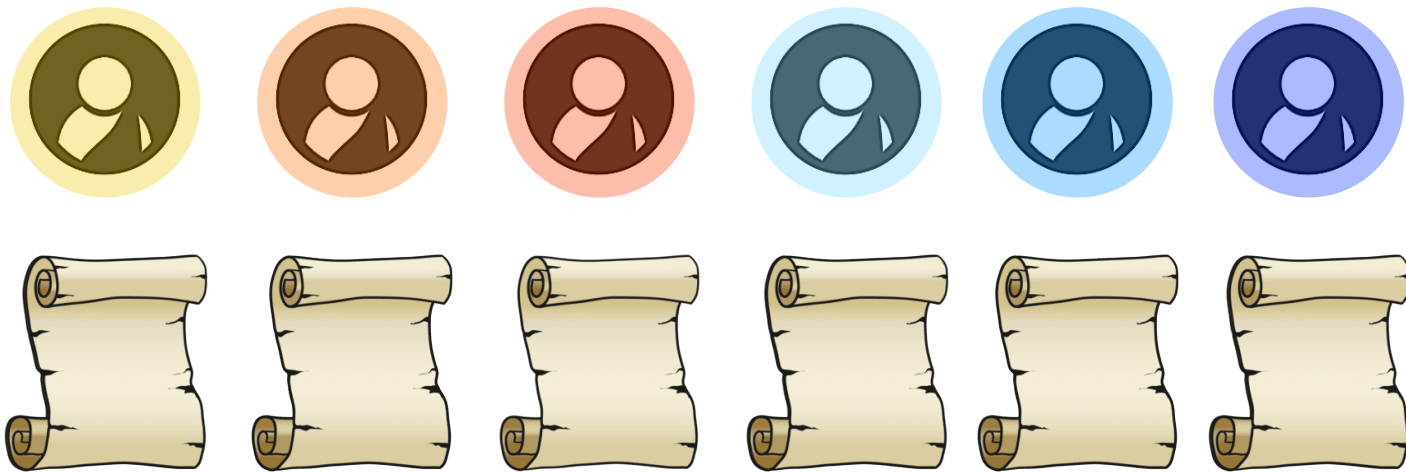
CONSENSUS STATEMENTS

- ✦ **Problem Statement:** How can a machine find agreement in diverse views?

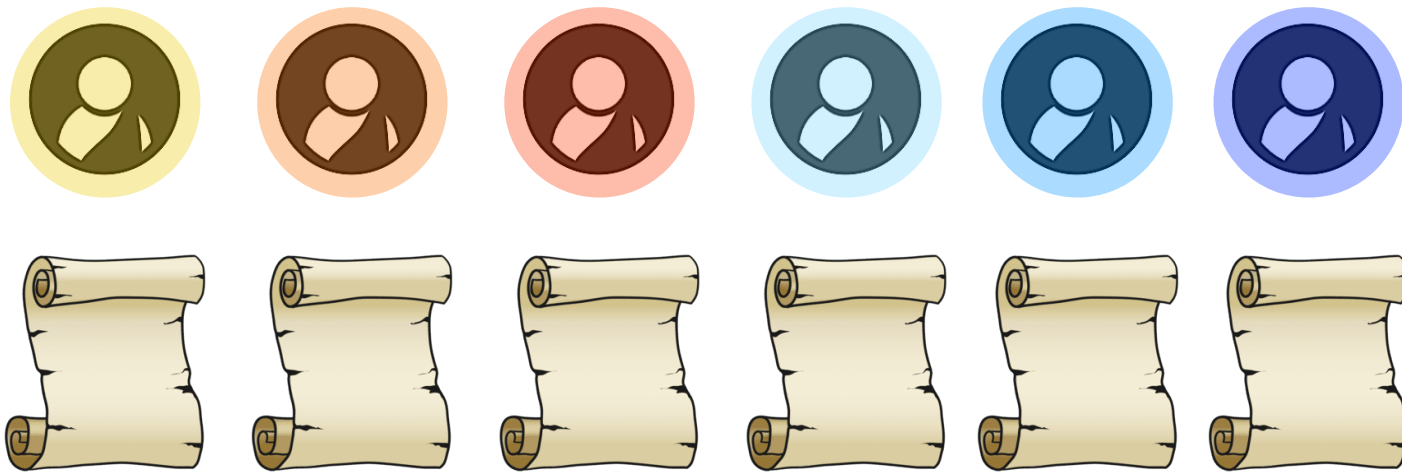
CONSENSUS STATEMENTS

- ✦ **Problem Statement:** How can a machine find agreement in diverse views?
- ✦ **Work by:** Bakker, M., Chadwick, M., Sheahan, H., Tessler, M., Campbell-Gillingham, L., Balaguer, J., ... & Summerfield, C. (2022). Fine-tuning language models to find agreement among humans with diverse preferences. *Advances in Neural Information Processing Systems*, 35, 38176-38189.

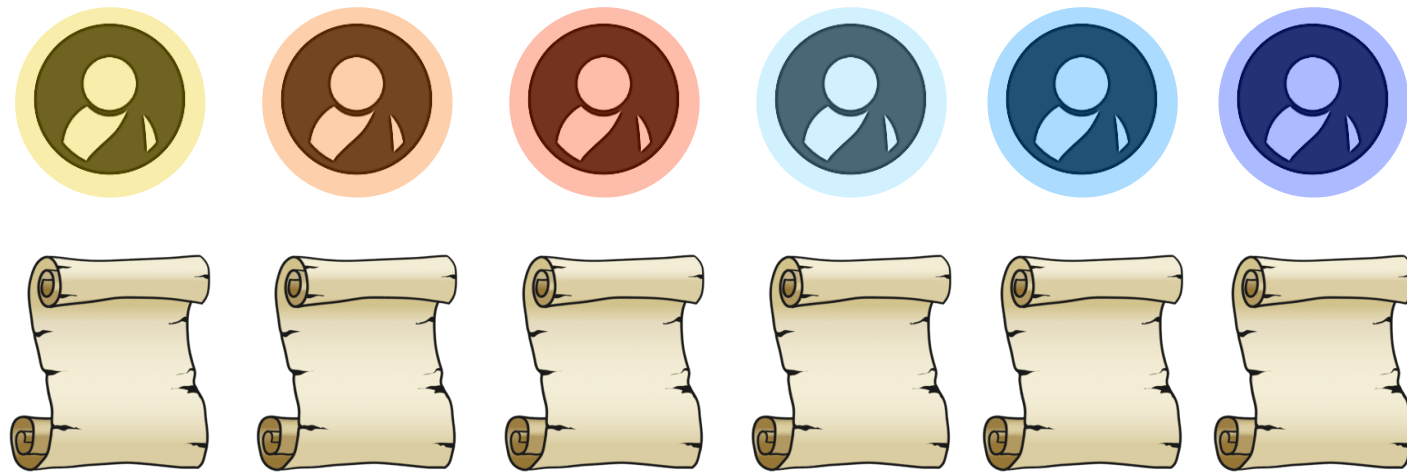
CONSENSUS STATEMENTS



CONSENSUS STATEMENTS

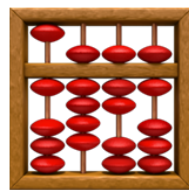


CONSENSUS STATEMENTS



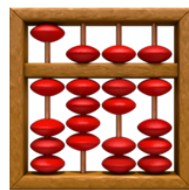
**Consensus
Statement**



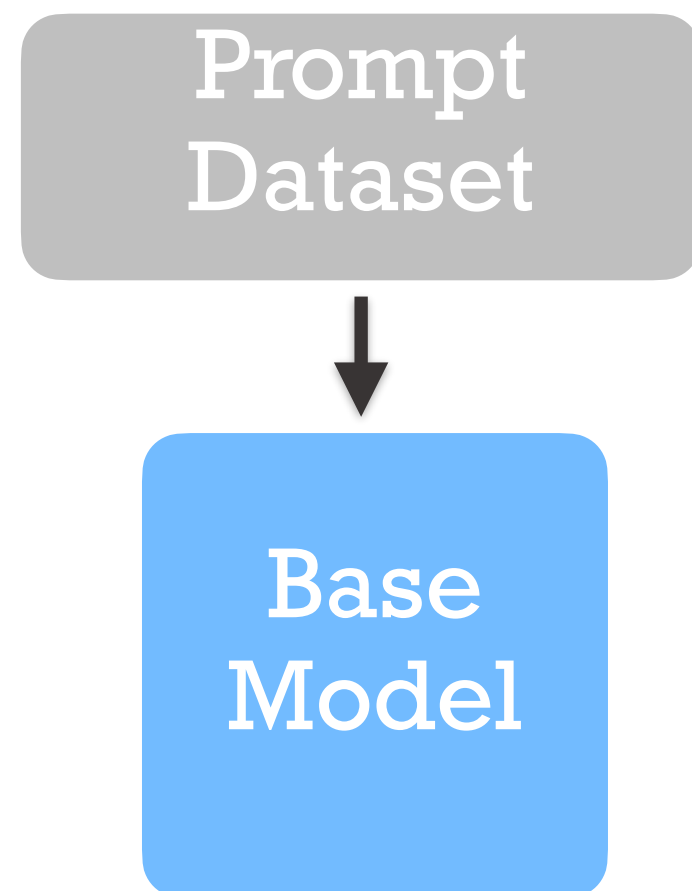


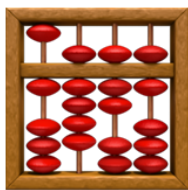
CONSENSUS STATEMENTS

Base
Model









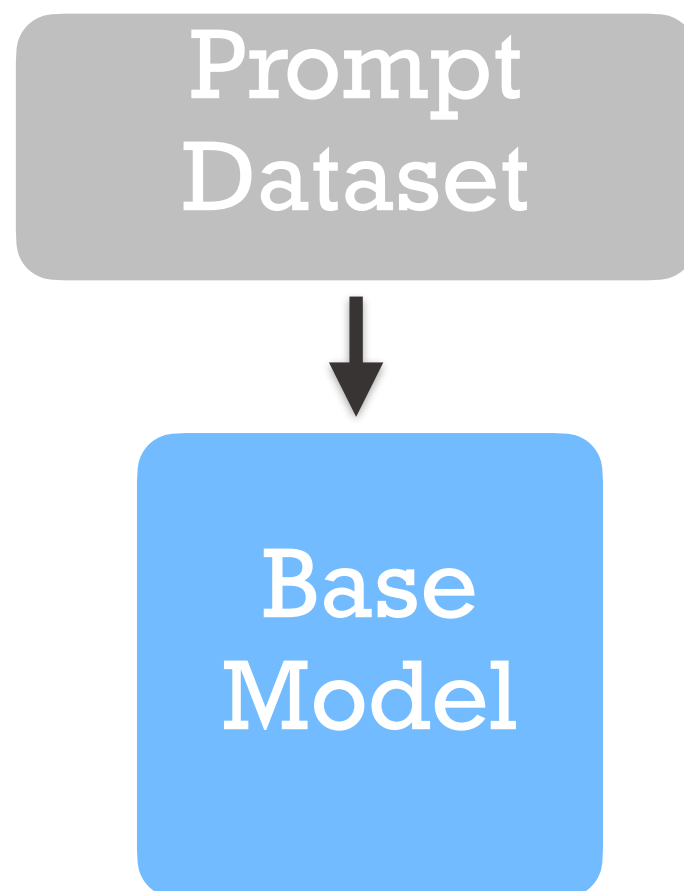
CONSENSUS STATEMENTS

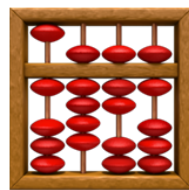




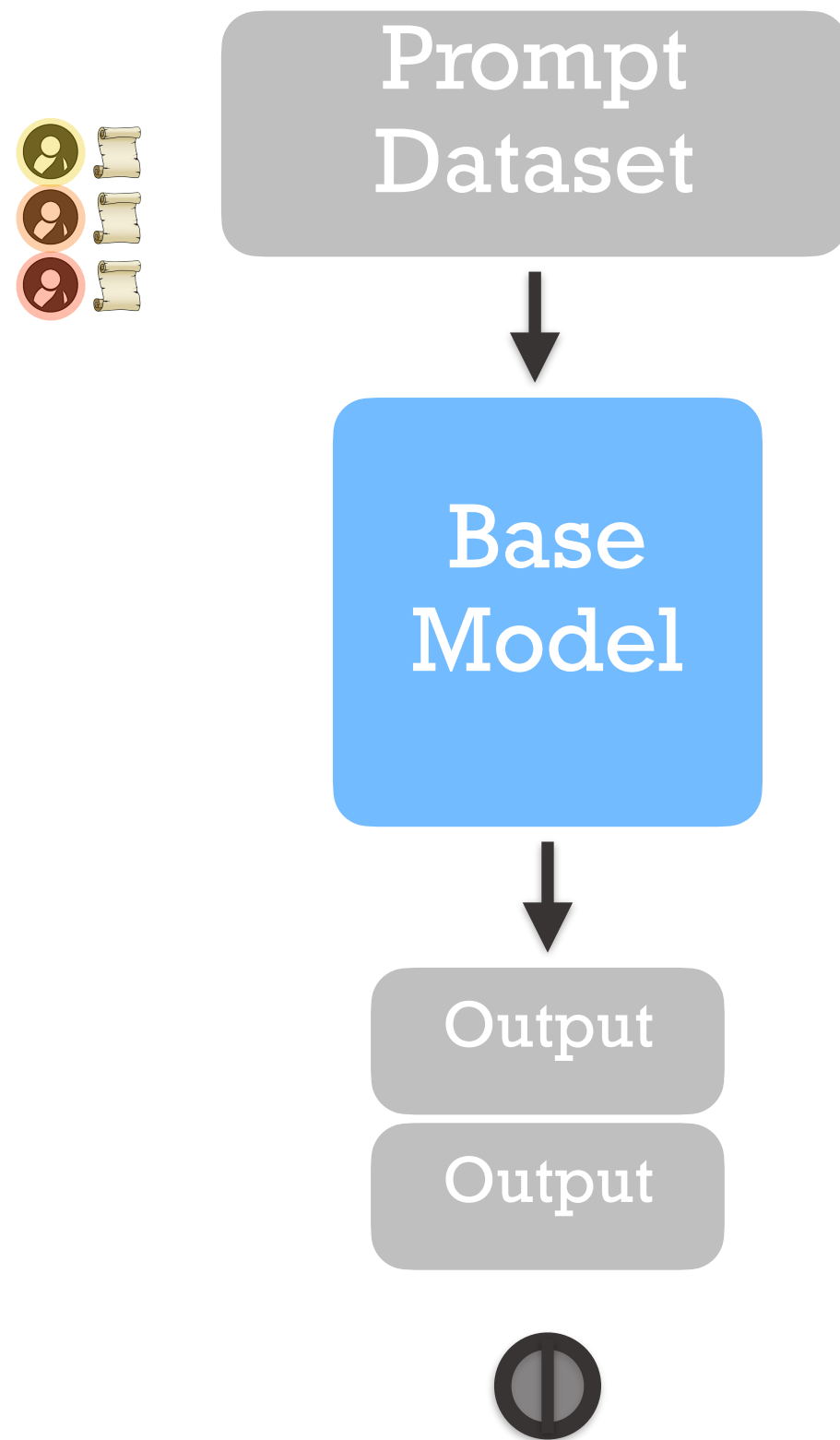
CONSENSUS STATEMENTS

- Should we lower the speed limit on the road?
 - Participant 1: statement 1...  
 - Participant 2: statement 2...  
 - Participant 3: statement 3...  

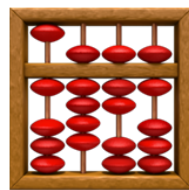




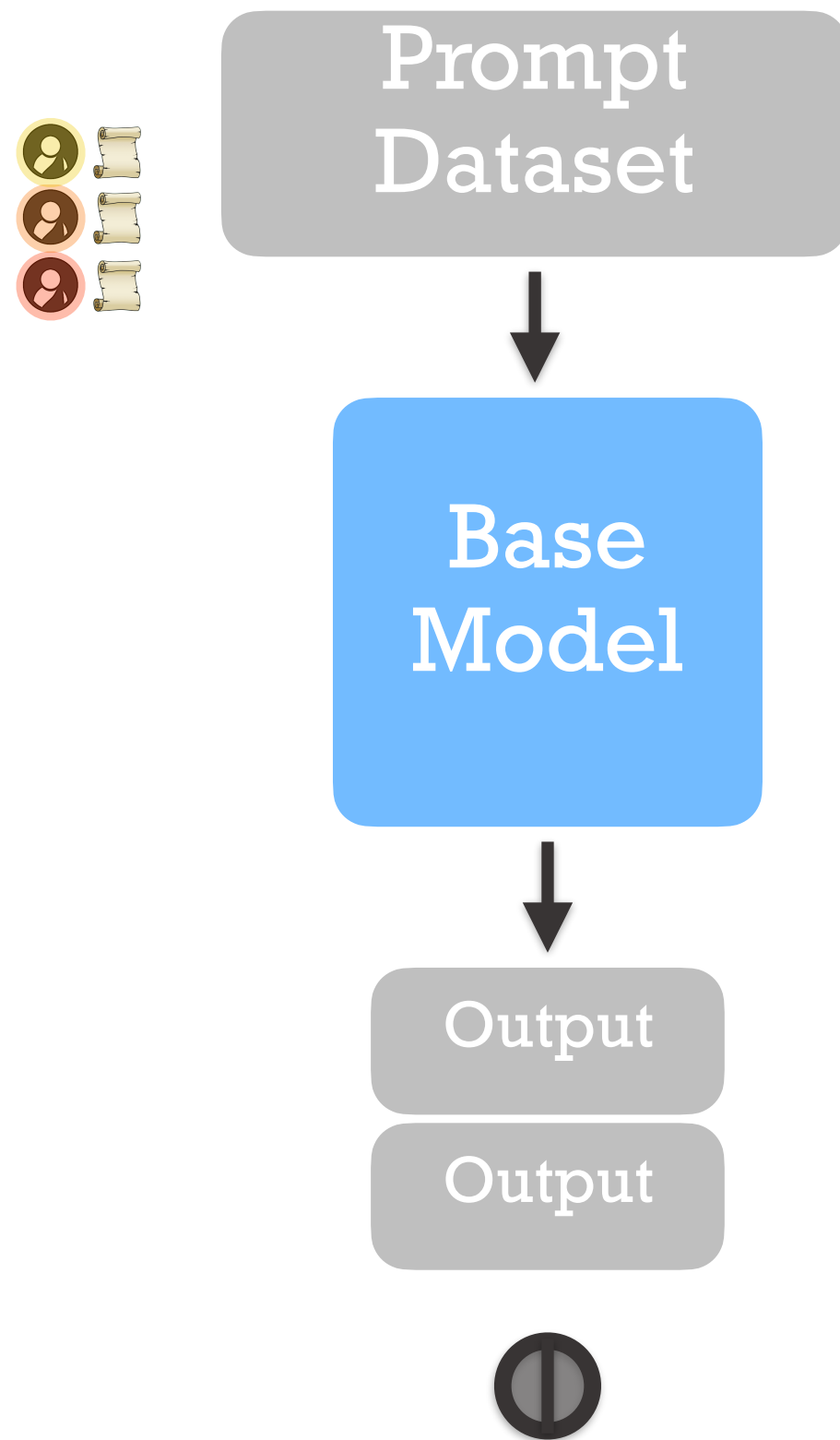
CONSENSUS STATEMENTS



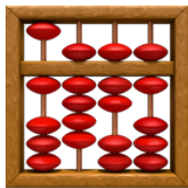
Consensus Statement: ...



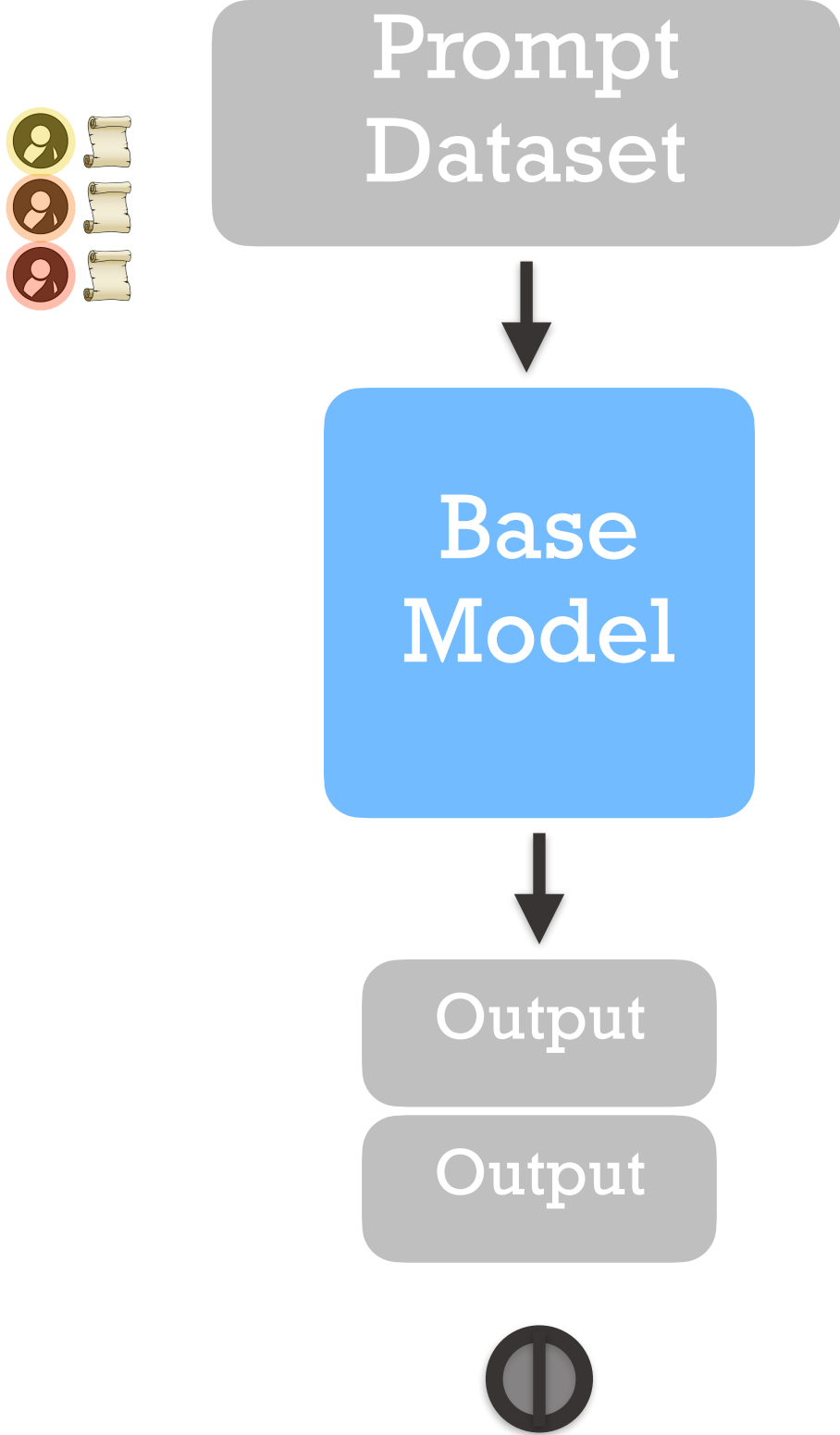
CONSENSUS STATEMENTS



Consensus Statement: ...

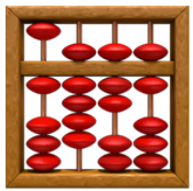


CONSENSUS STATEMENTS

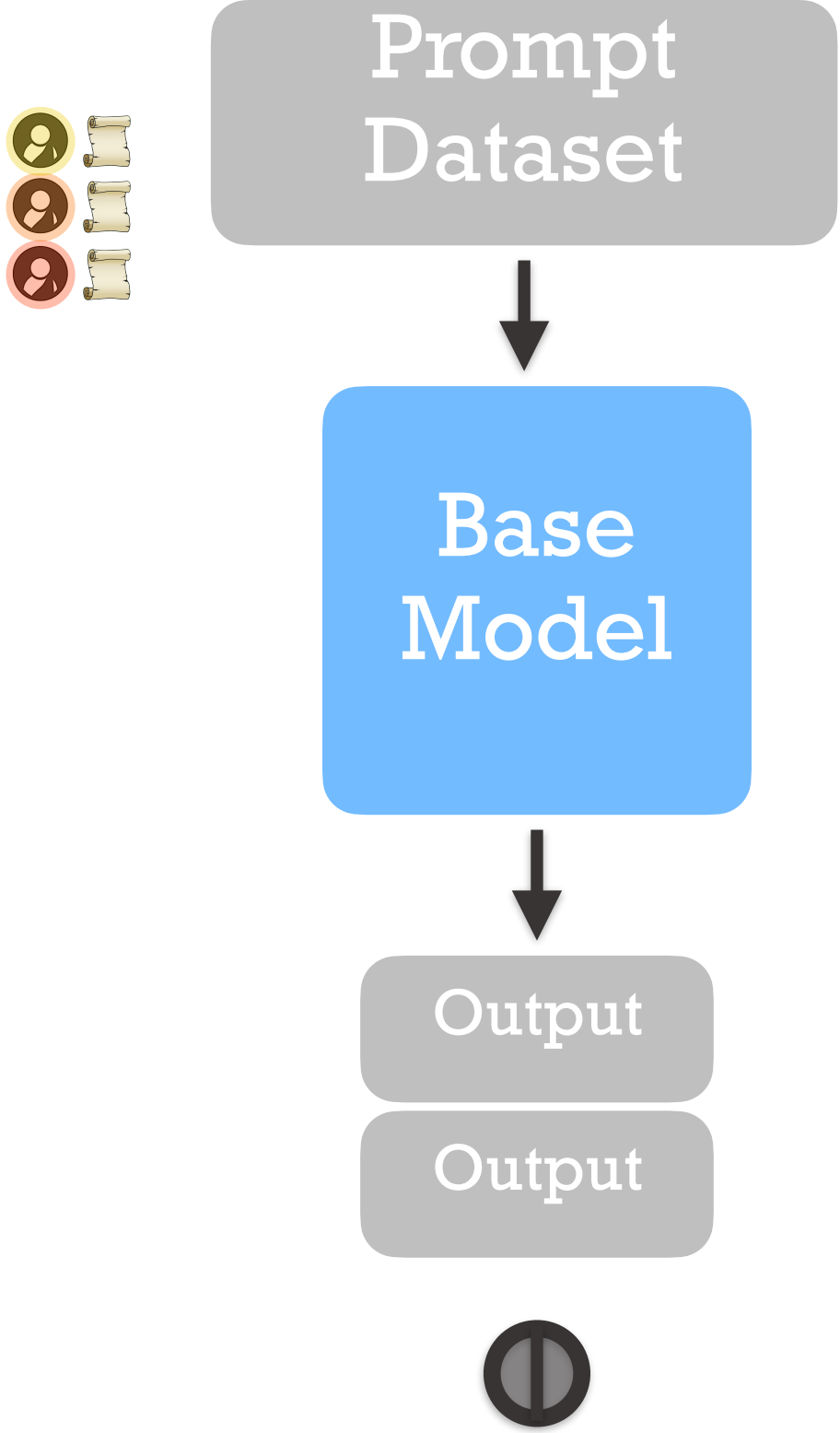


Consensus Statement: ...

- Consensus Statement: ...



CONSENSUS STATEMENTS



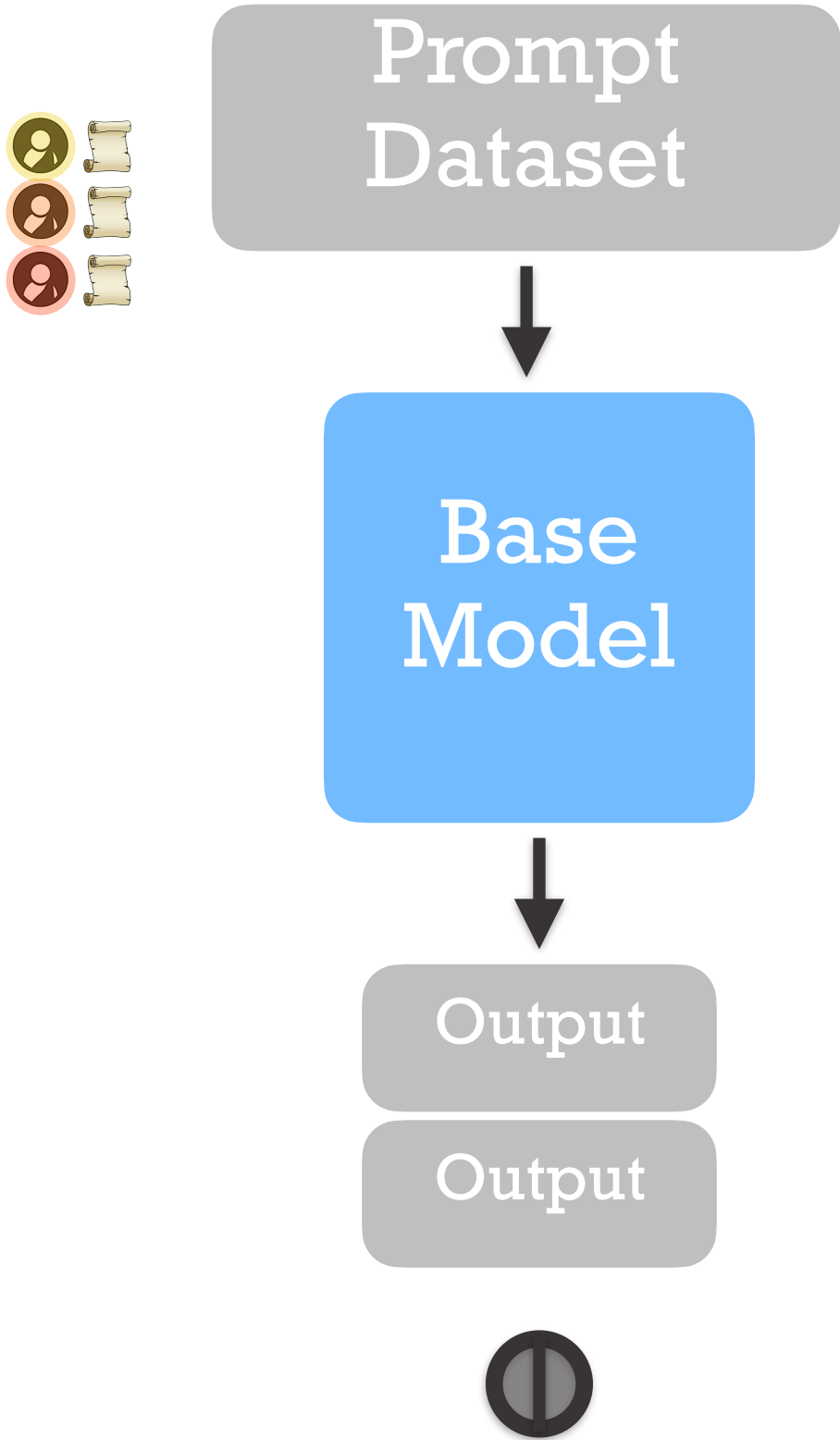
Consensus Statement: ...

- Consensus Statement: ...

- Consensus Statement: ...

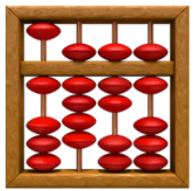


CONSENSUS STATEMENTS

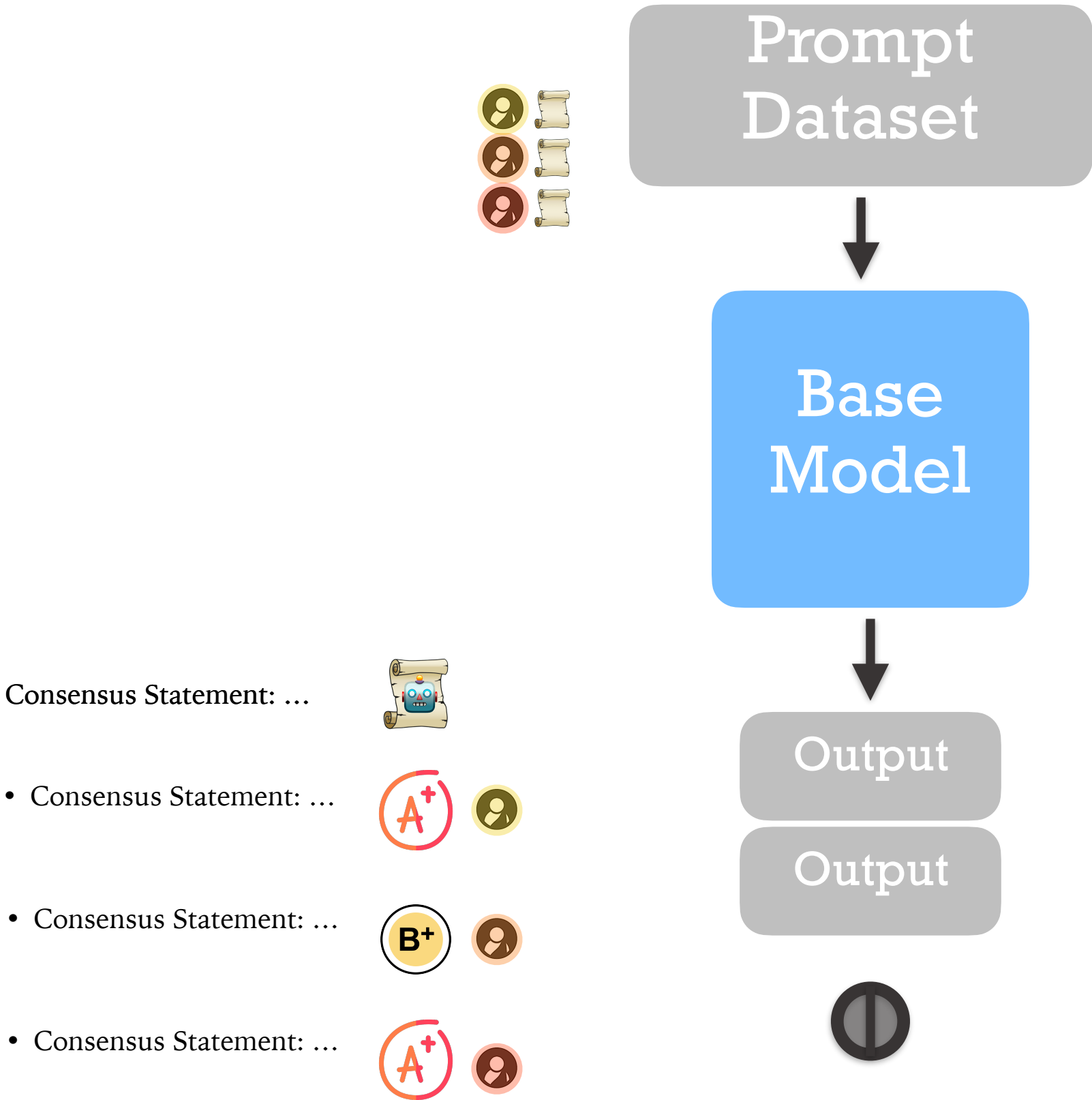


Consensus Statement: ...

- Consensus Statement: ...
- Consensus Statement: ...
- Consensus Statement: ...

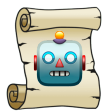
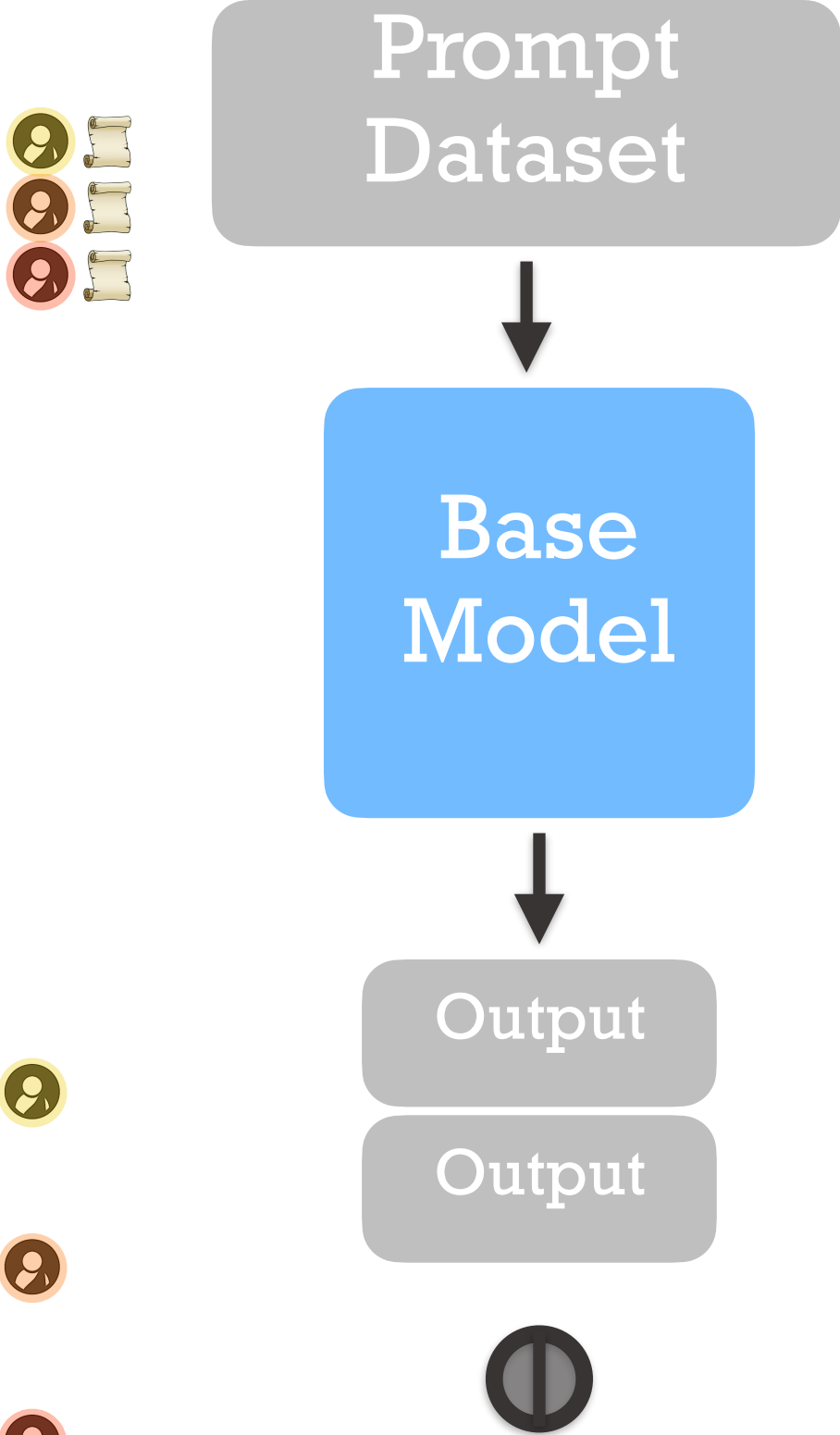


CONSENSUS STATEMENTS





CONSENSUS STATEMENTS

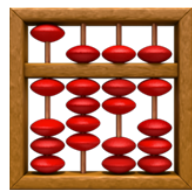


Consensus Statement: ...

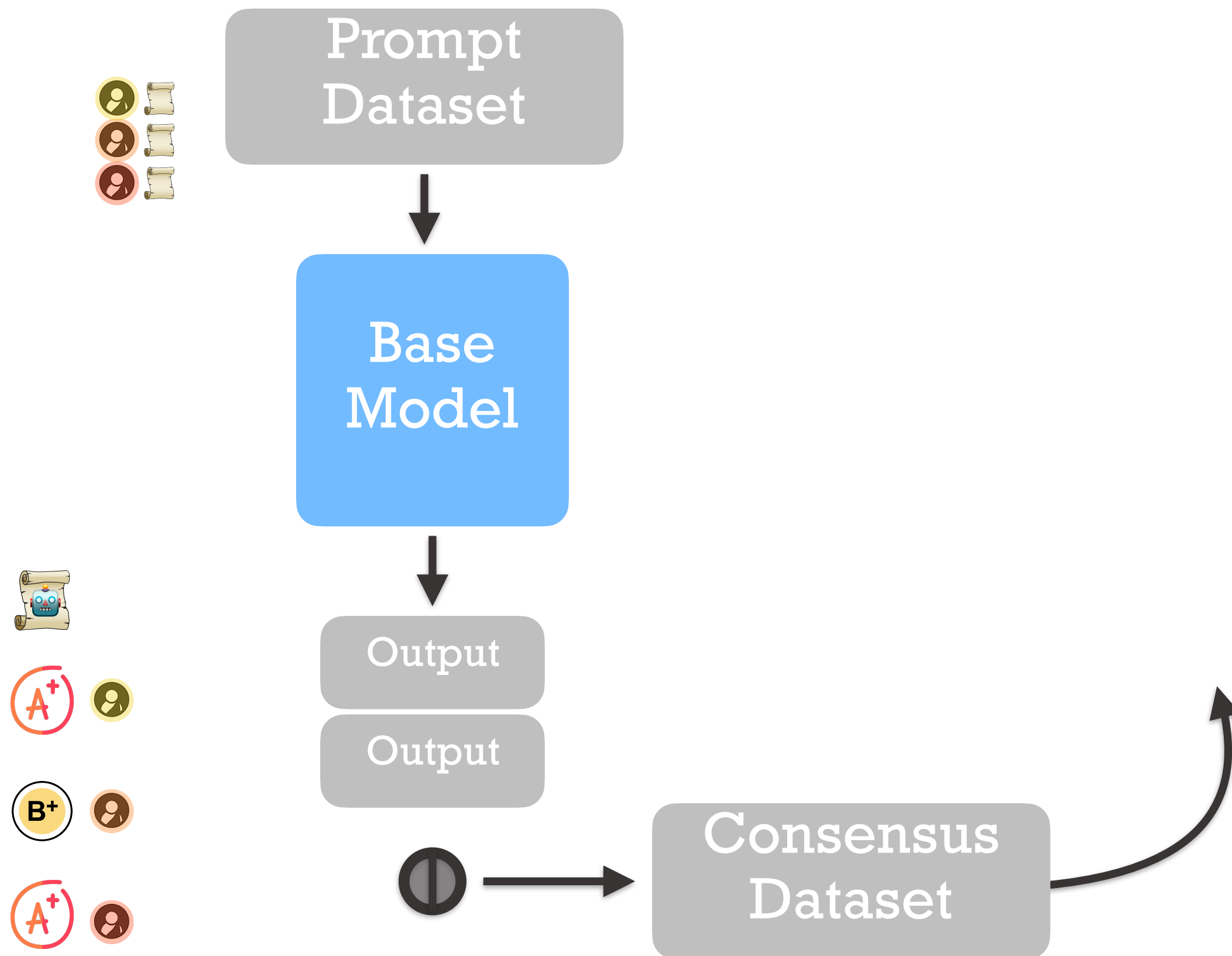
- Consensus Statement: ...
- 7

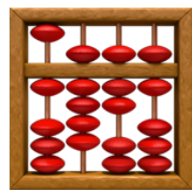
- Consensus Statement: ...
- 5

- Consensus Statement: ...
- 7

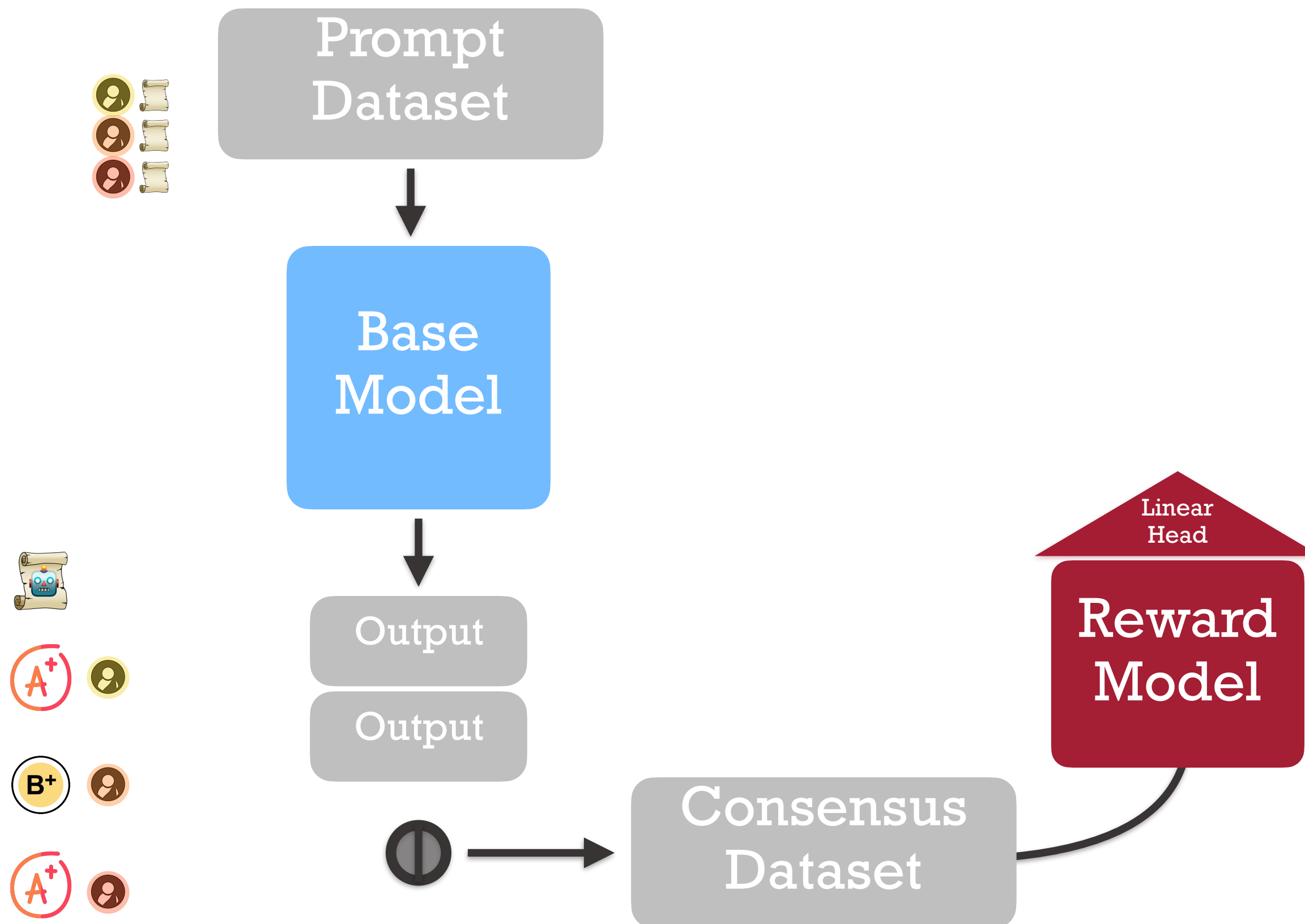


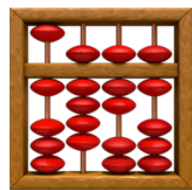
CONSENSUS STATEMENTS



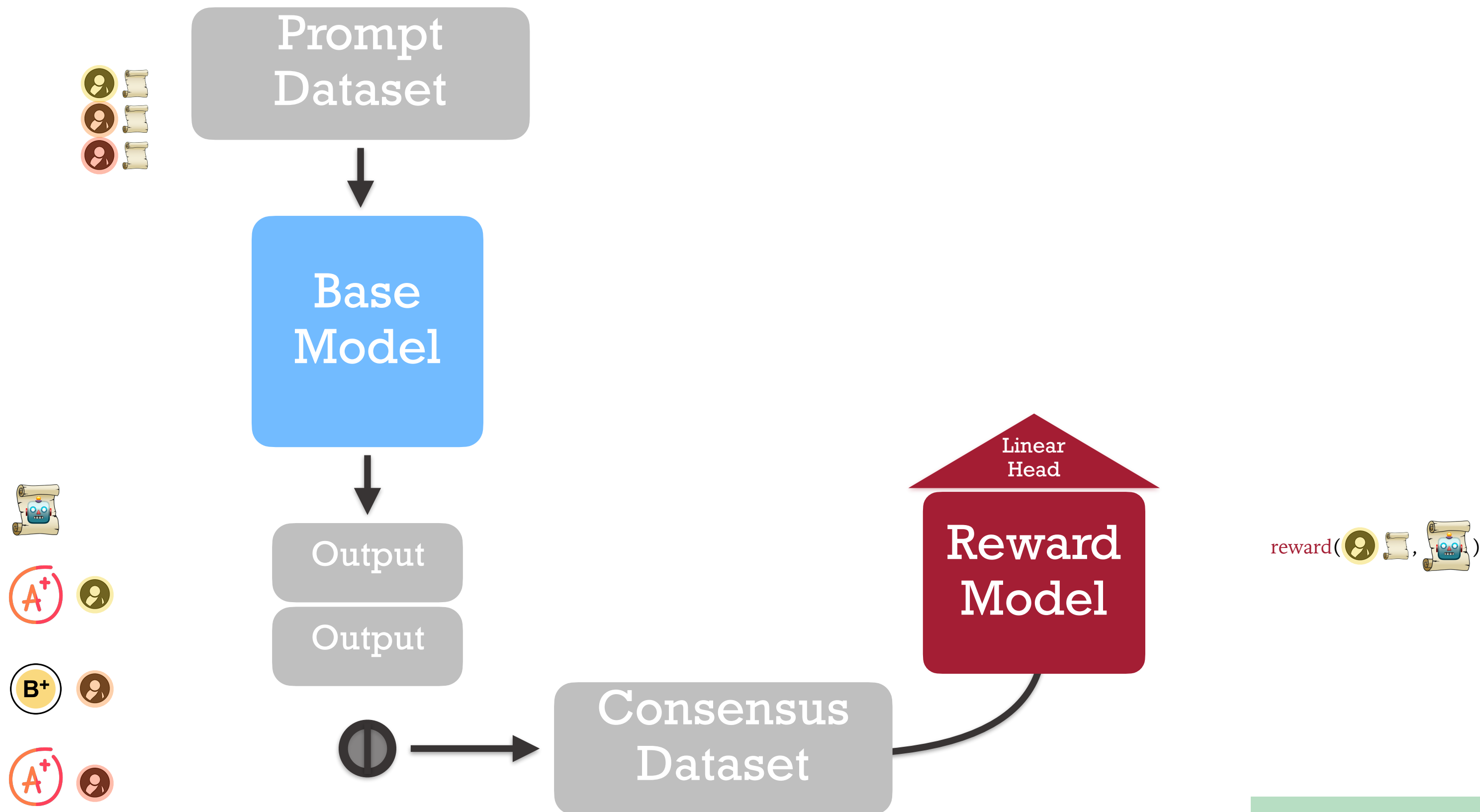


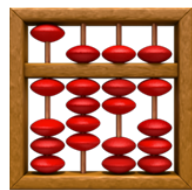
CONSENSUS STATEMENTS



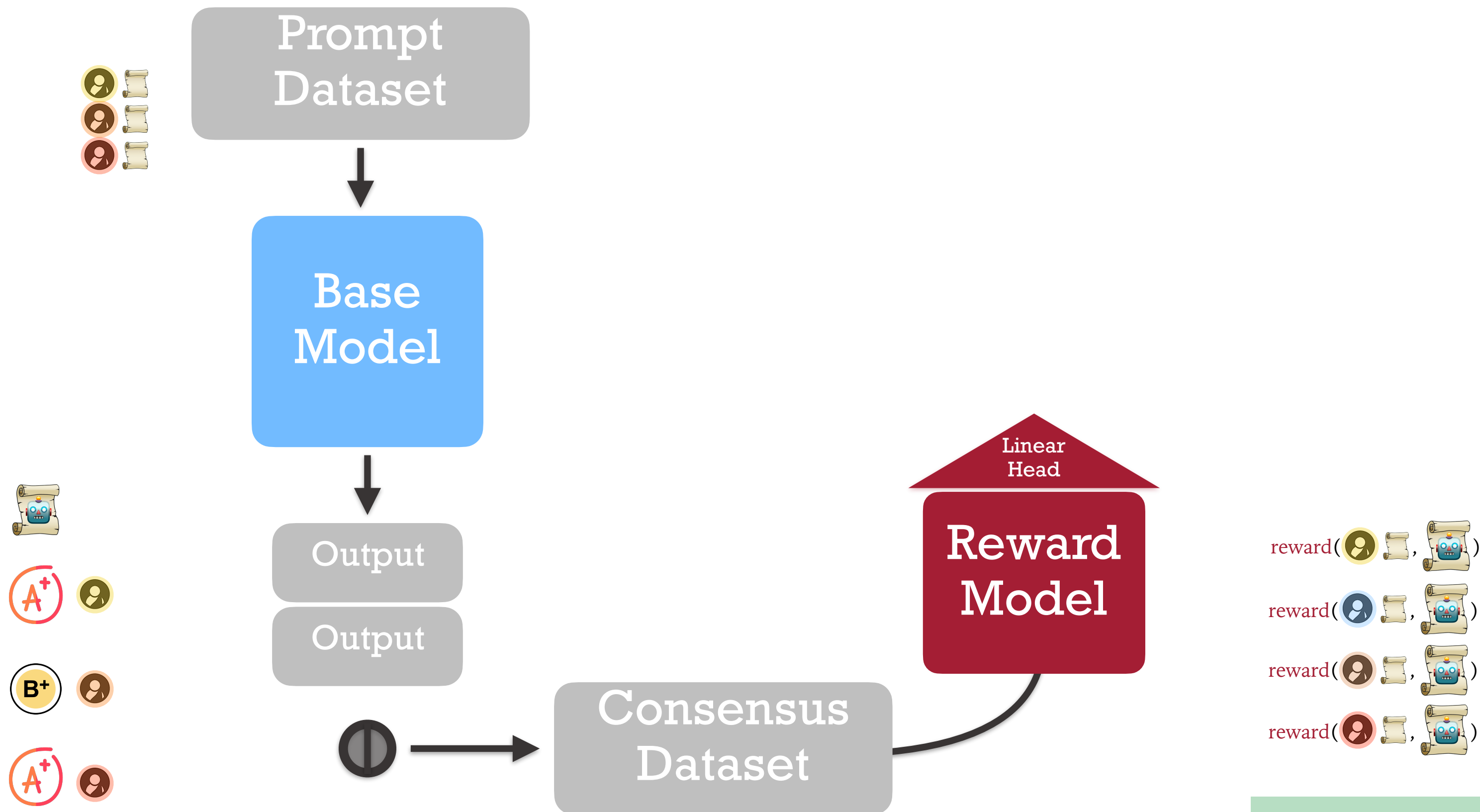


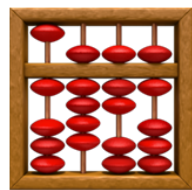
CONSENSUS STATEMENTS



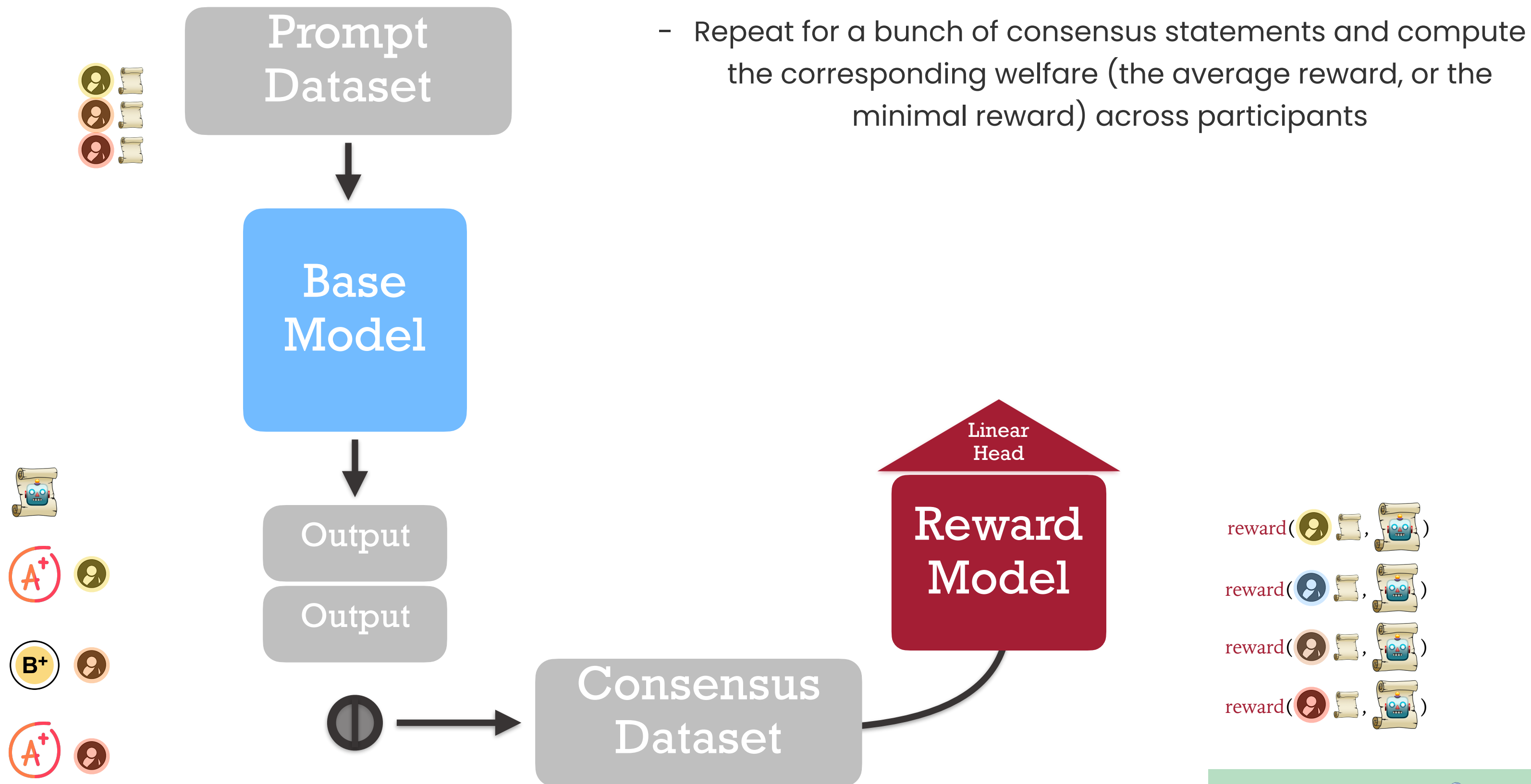


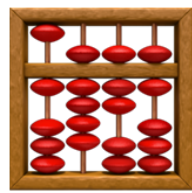
CONSENSUS STATEMENTS



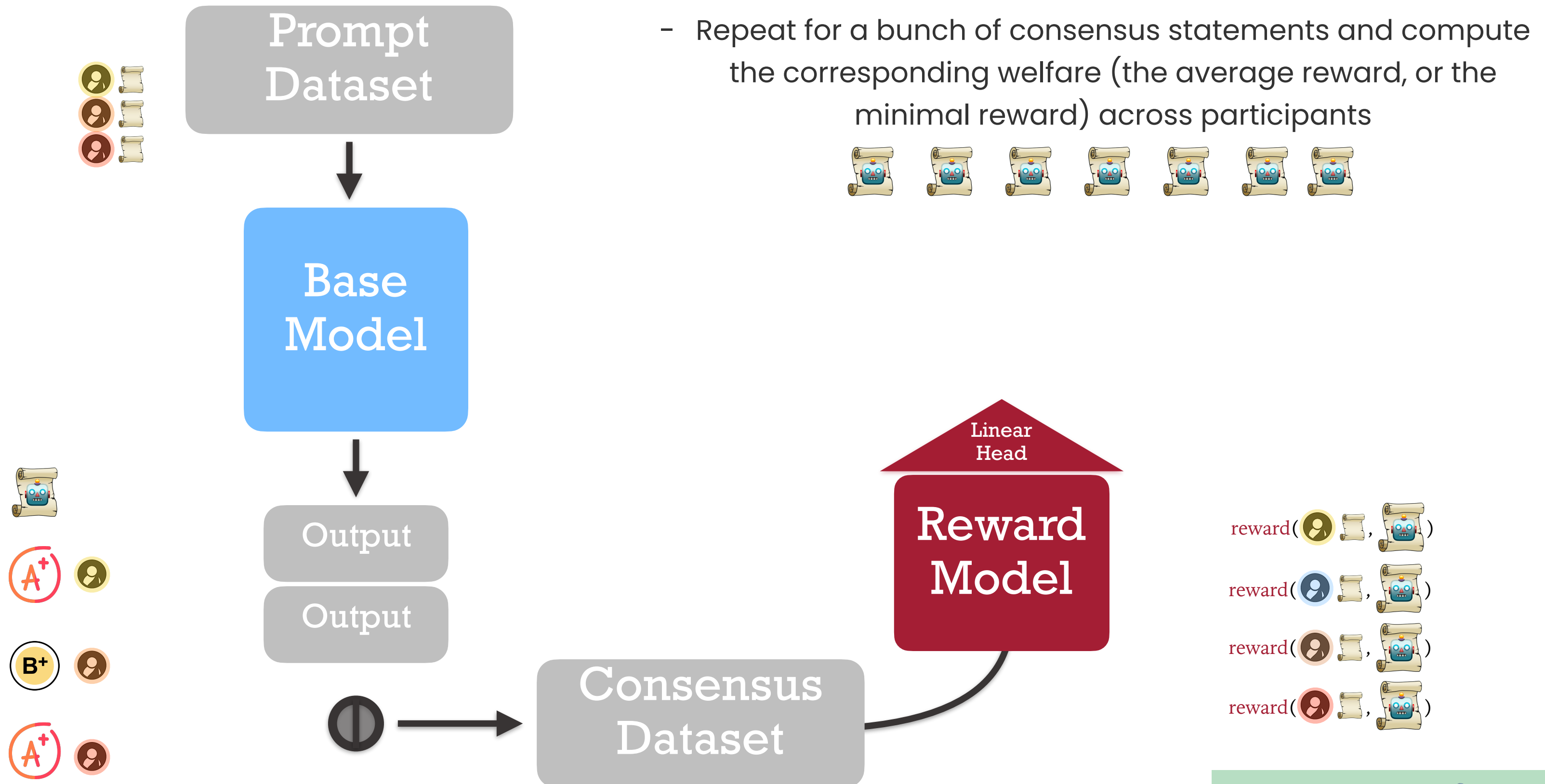


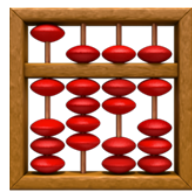
CONSENSUS STATEMENTS



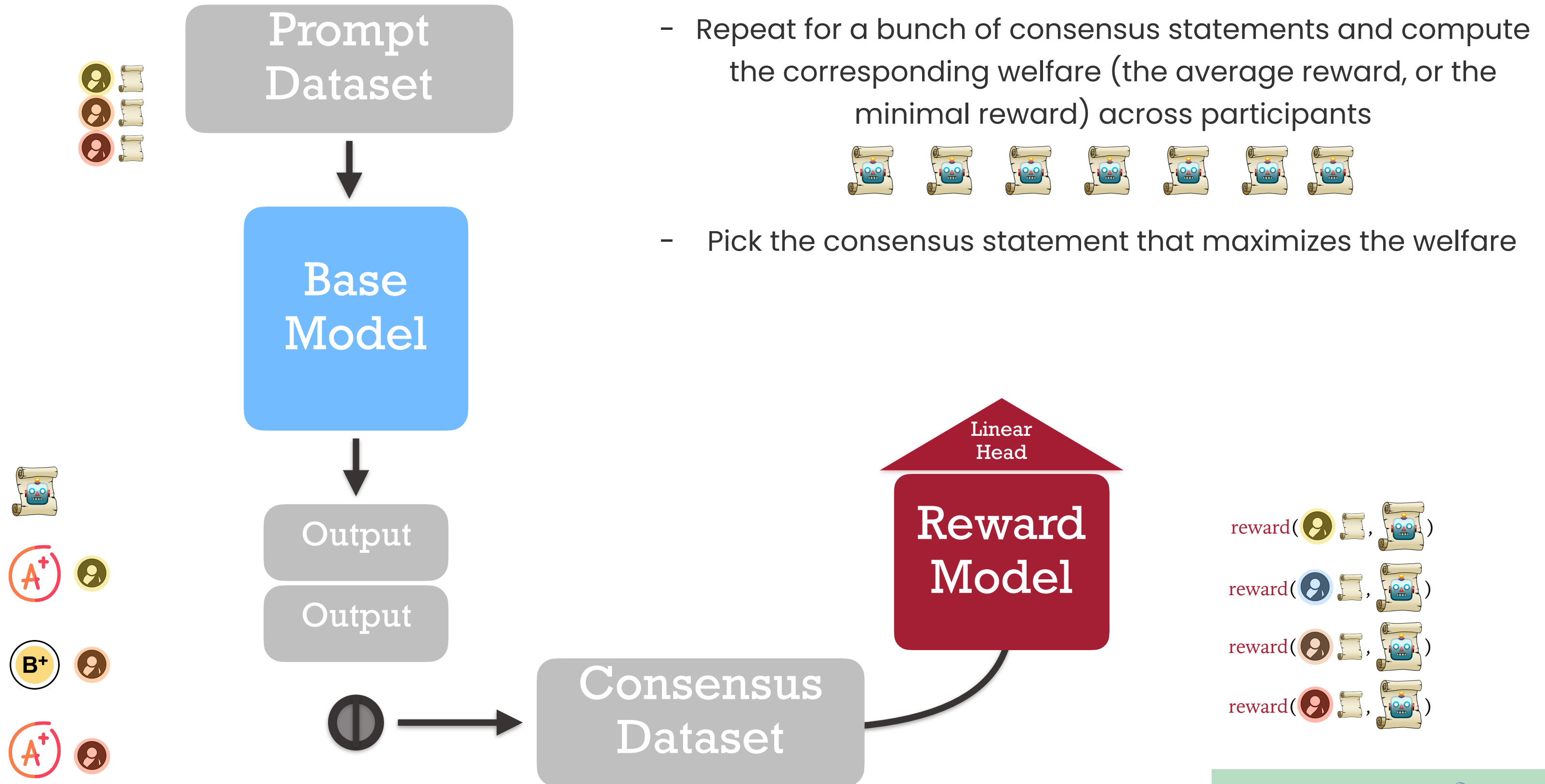


CONSENSUS STATEMENTS

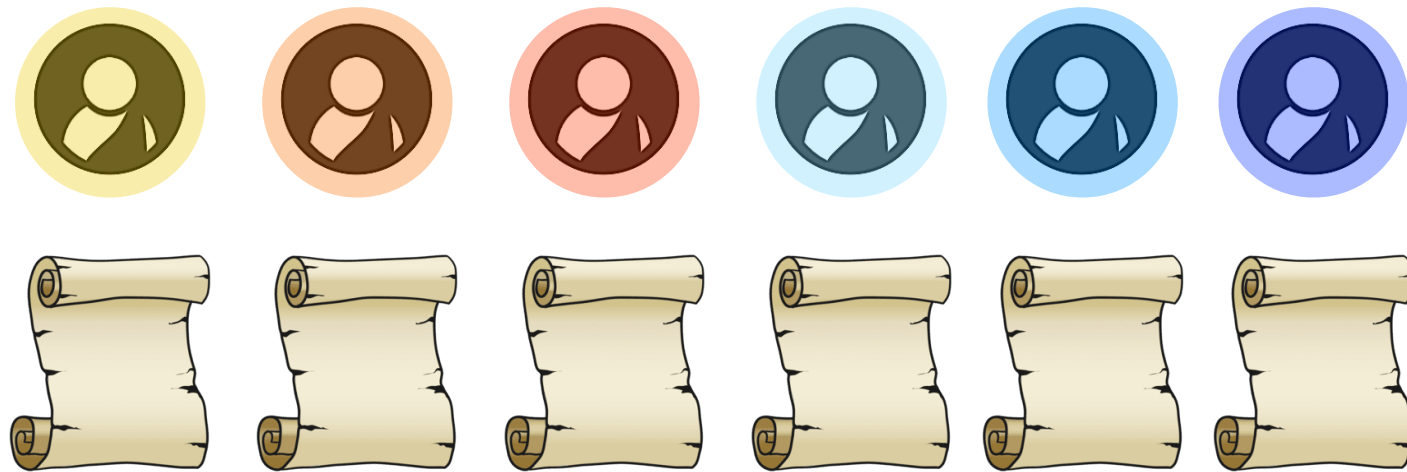




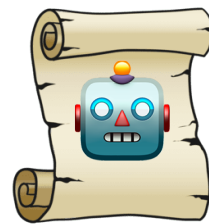
CONSENSUS STATEMENTS



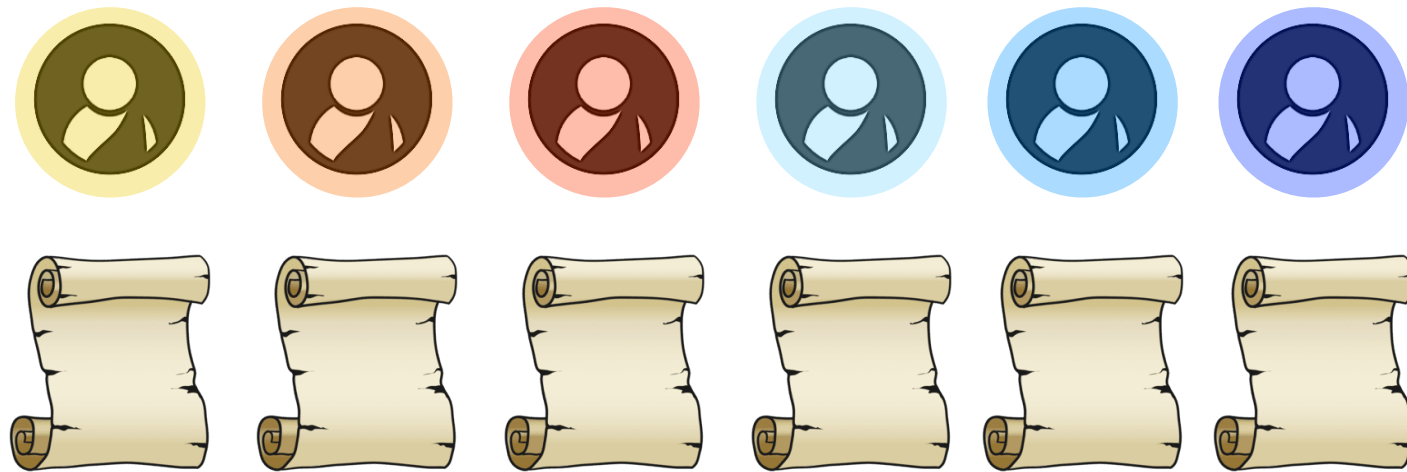
CONSENSUS STATEMENTS



Consensus
Statement

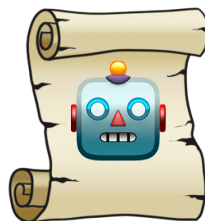


CONSENSUS STATEMENTS



- ✦ Preference for model candidates over human opinions

Consensus
Statement



Chapter Outline

3

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

Chapter Outline

3

Algorithms for Deliberation

The Basics of Transformers and Fine-Tuning

Neural Networks and Transformers

Prompting and Fine-Tuning

Finding Representative Statements

Building Consensus Statements

Building Representative Statements

REPRESENTATIVE STATEMENTS

REPRESENTATIVE STATEMENTS

- ✦ **Problem Statement:** n participants have written n free-text opinions (e.g., after a deliberation) that need to be consolidated into a set of k recommendations

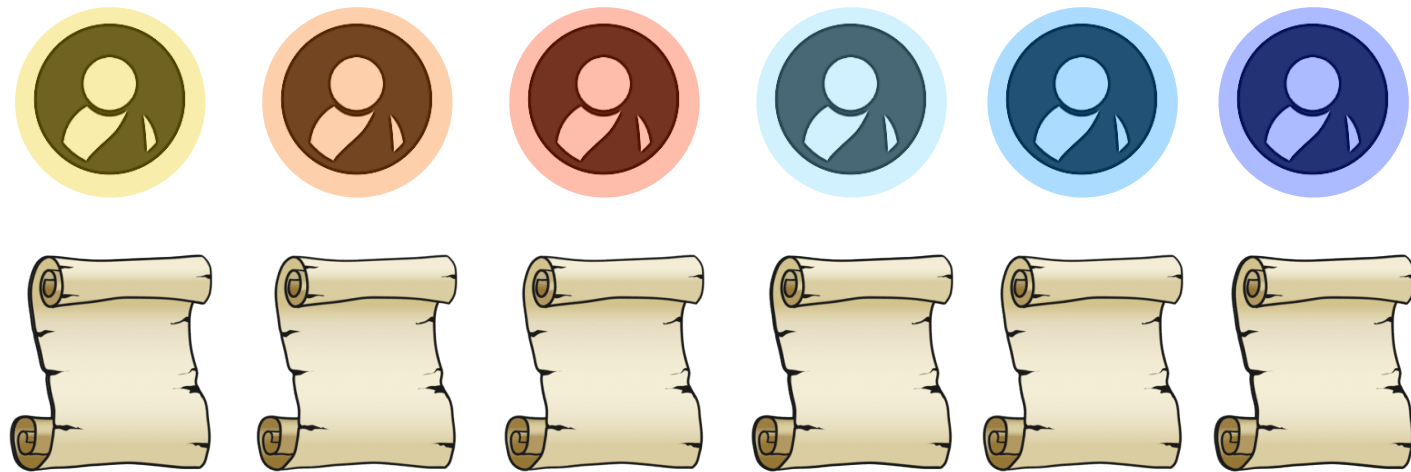
REPRESENTATIVE STATEMENTS

- ✦ **Problem Statement:** n participants have written n free-text opinions (e.g., after a deliberation) that need to be consolidated into a set of k recommendations
- ✦ **Challenges:** There are unforeseen alternatives (not present in the n opinions) on which the n participants have unknown preferences

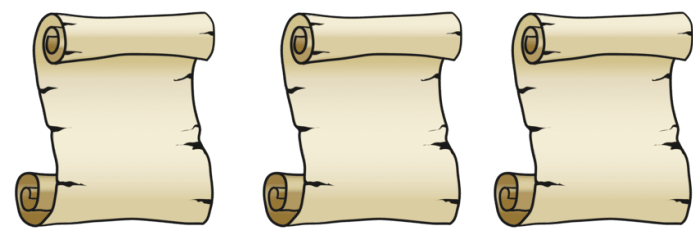
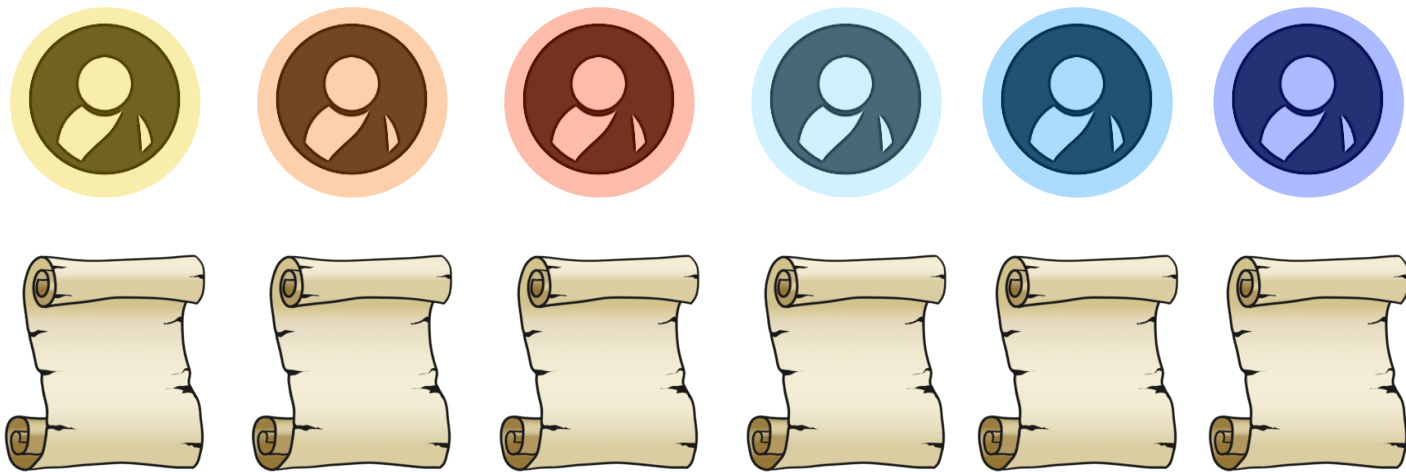
REPRESENTATIVE STATEMENTS

- ✦ **Problem Statement:** n participants have written n free-text opinions (e.g., after a deliberation) that need to be consolidated into a set of k recommendations
- ✦ **Challenges:** There are unforeseen alternatives (not present in the n opinions) on which the n participants have unknown preferences
- ✦ **Work by:** Fish, S., Gölz, P., Parkes, D. C., Procaccia, A. D., Rusak, G., Shapira, I., & Wüthrich, M. (2023). Generative social choice. *arXiv preprint arXiv:2309.01291*.

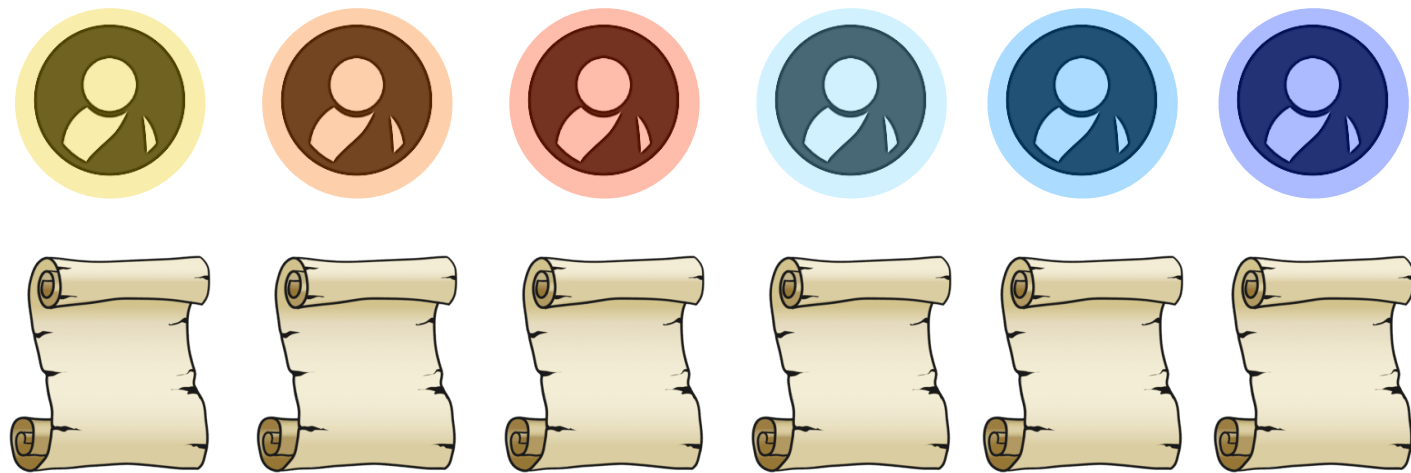
REPRESENTATIVE STATEMENTS



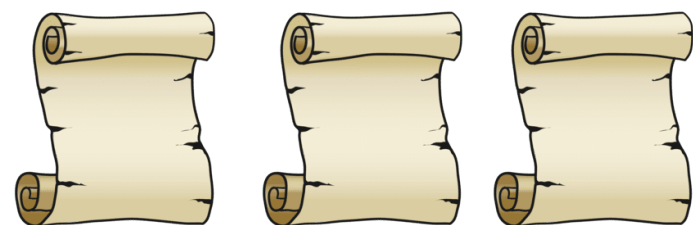
REPRESENTATIVE STATEMENTS



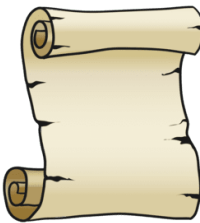
REPRESENTATIVE STATEMENTS



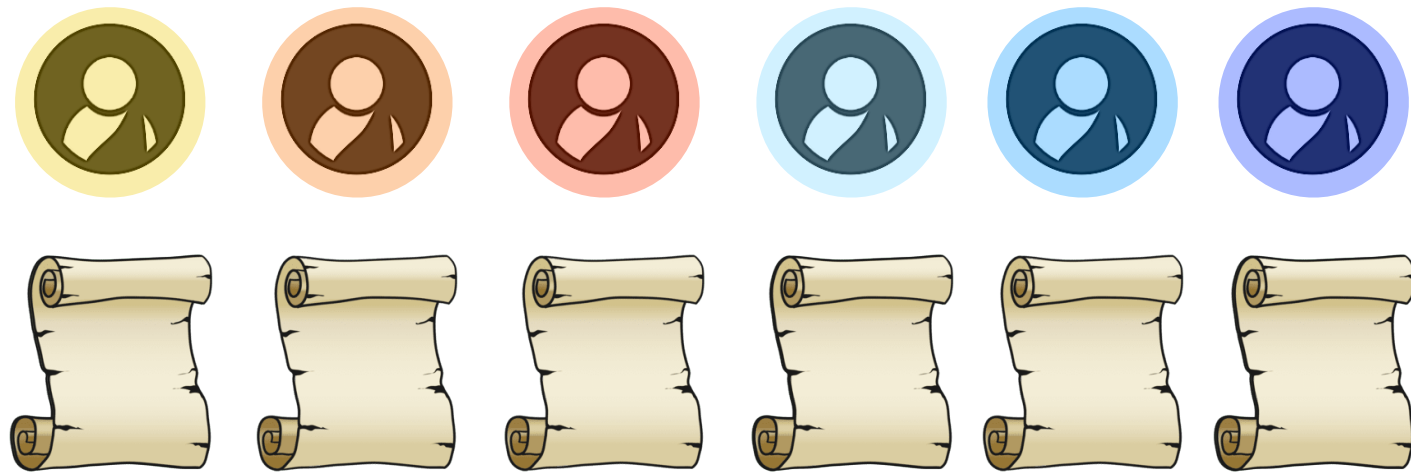
Policy
Recommendations



REPRESENTATIVE STATEMENTS



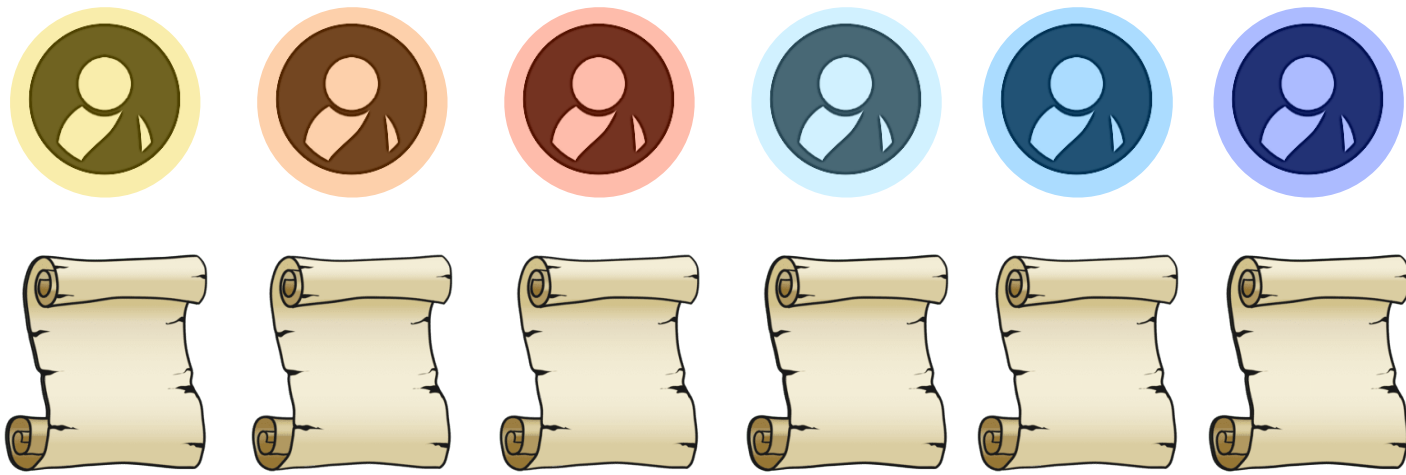
REPRESENTATIVE STATEMENTS



Step 1:

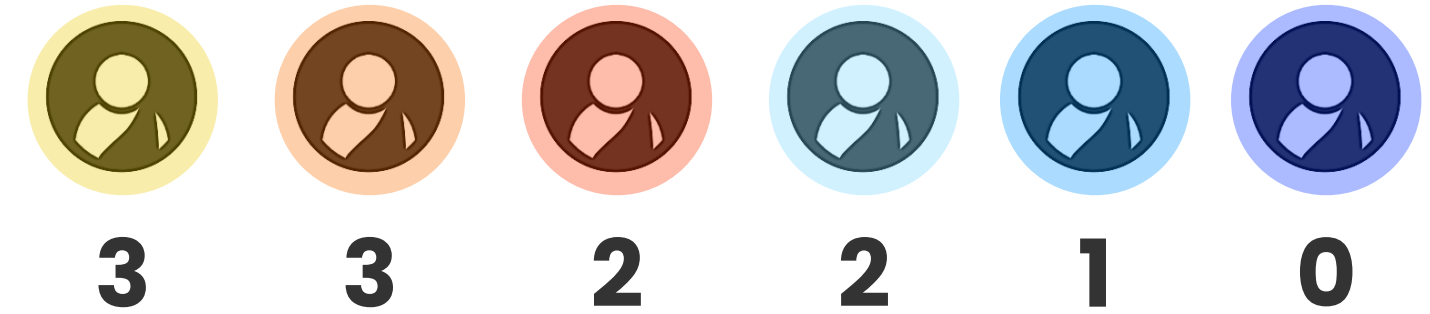
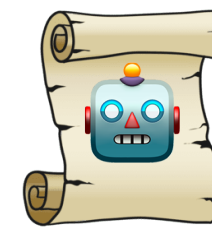
- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

REPRESENTATIVE STATEMENTS

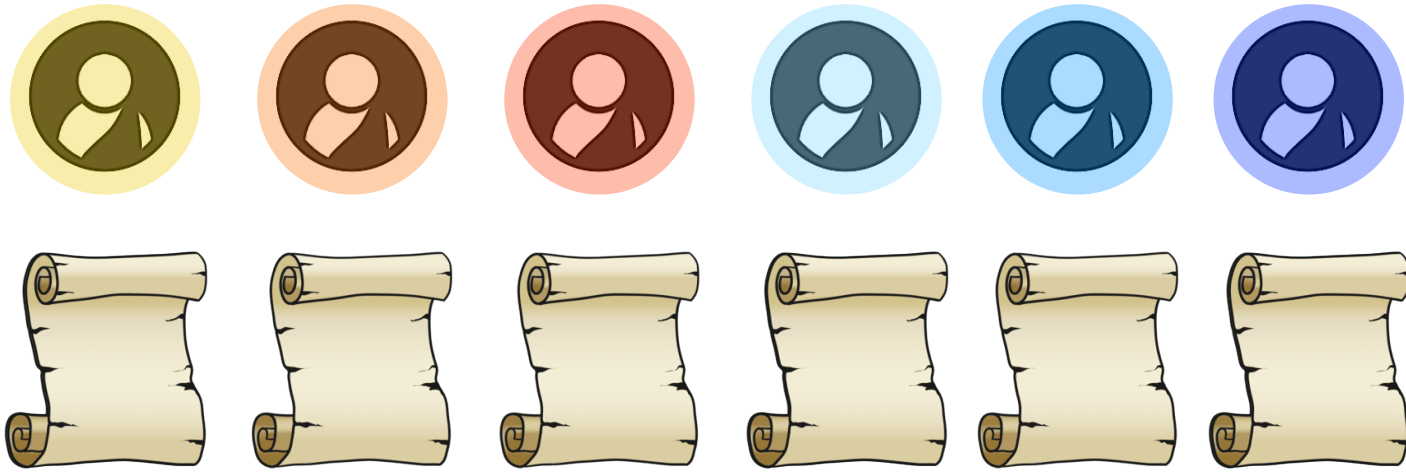


Step 1:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

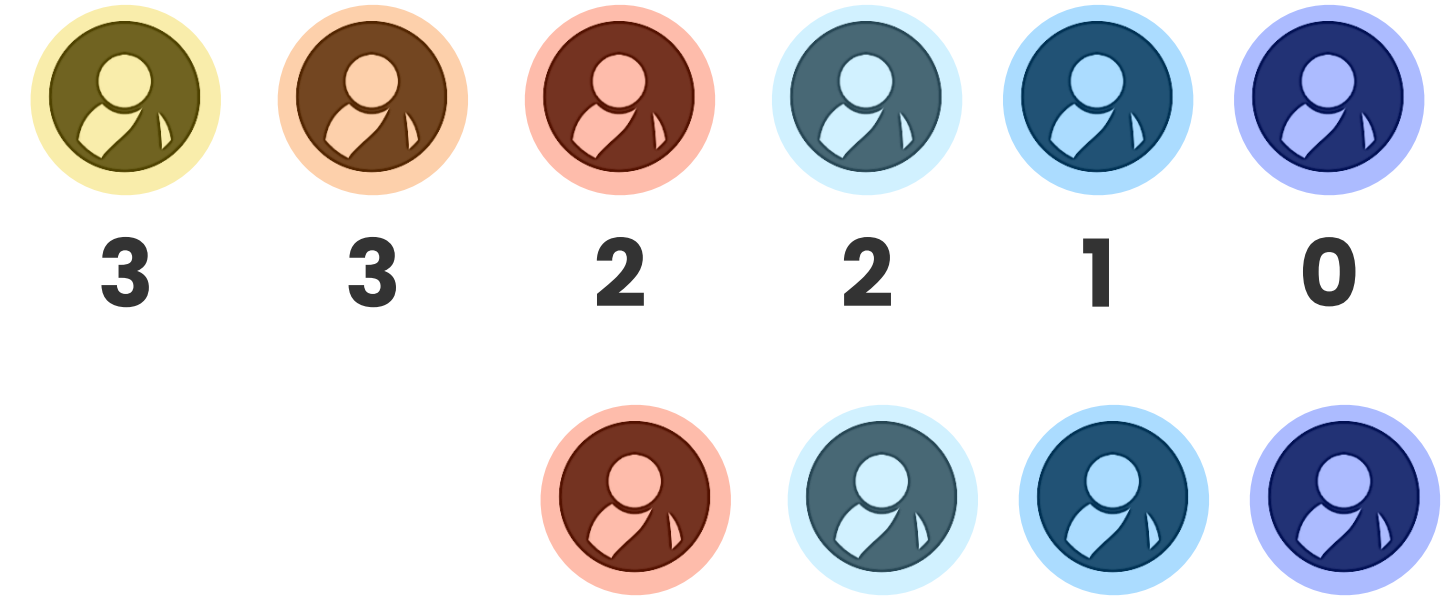
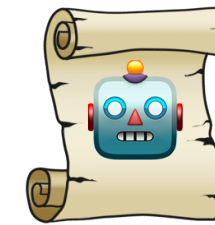


REPRESENTATIVE STATEMENTS

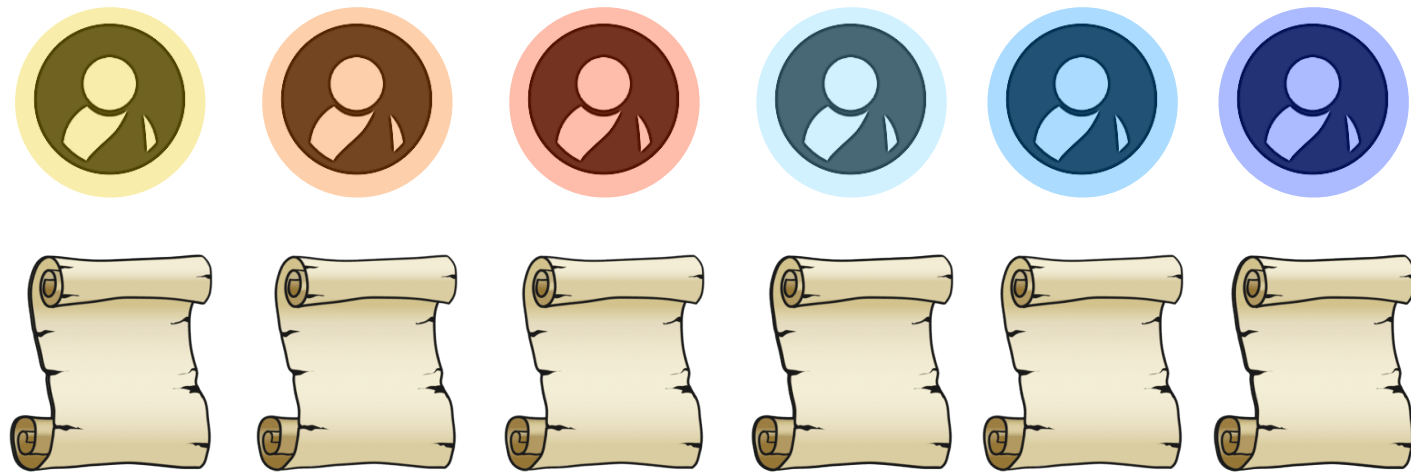


Step 1:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

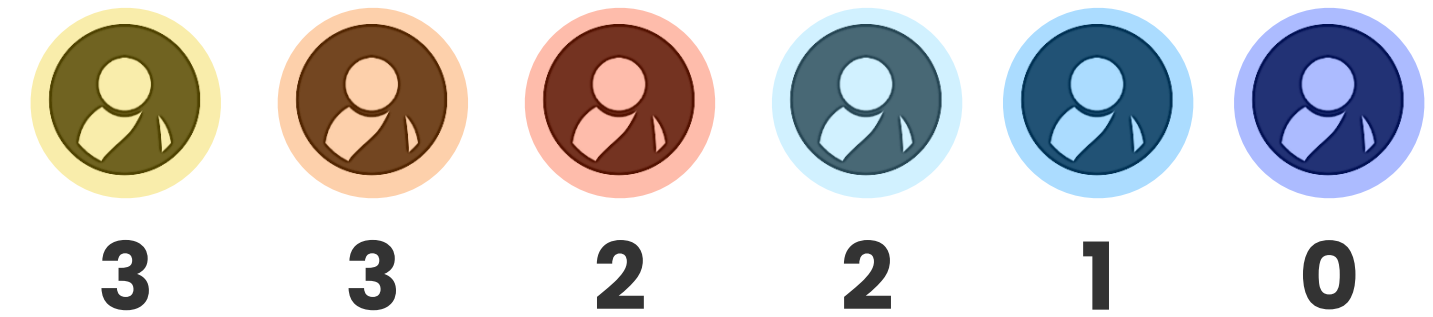
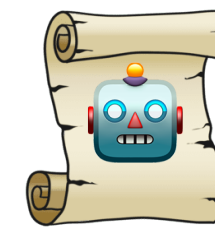


REPRESENTATIVE STATEMENTS



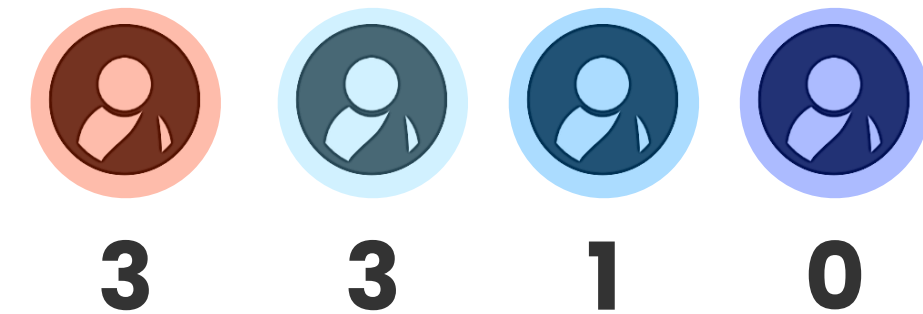
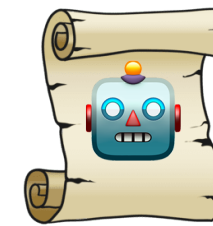
Step 1:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

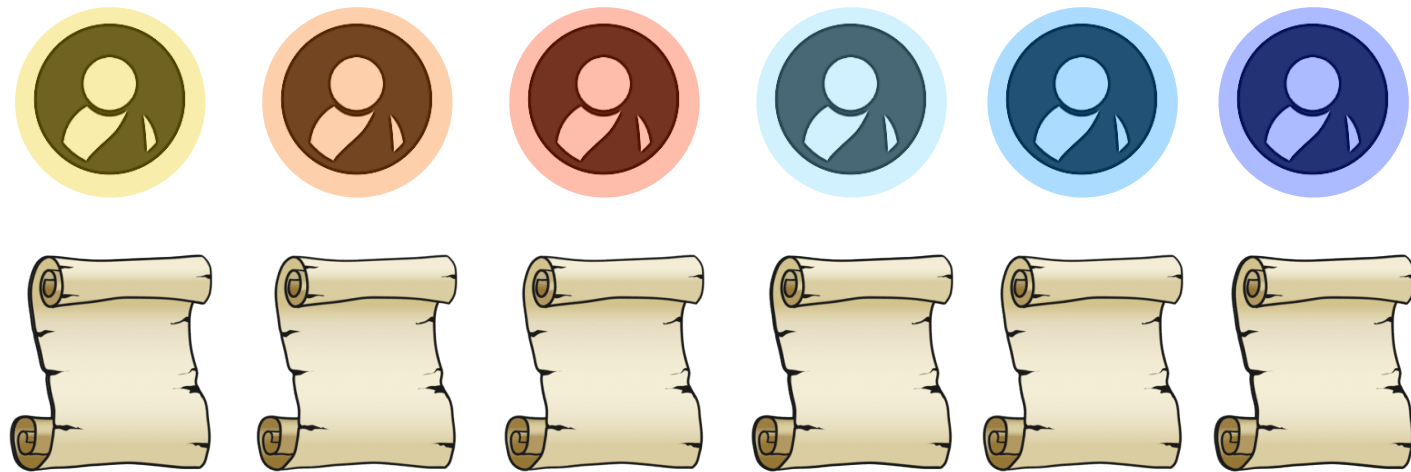


Step 2:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

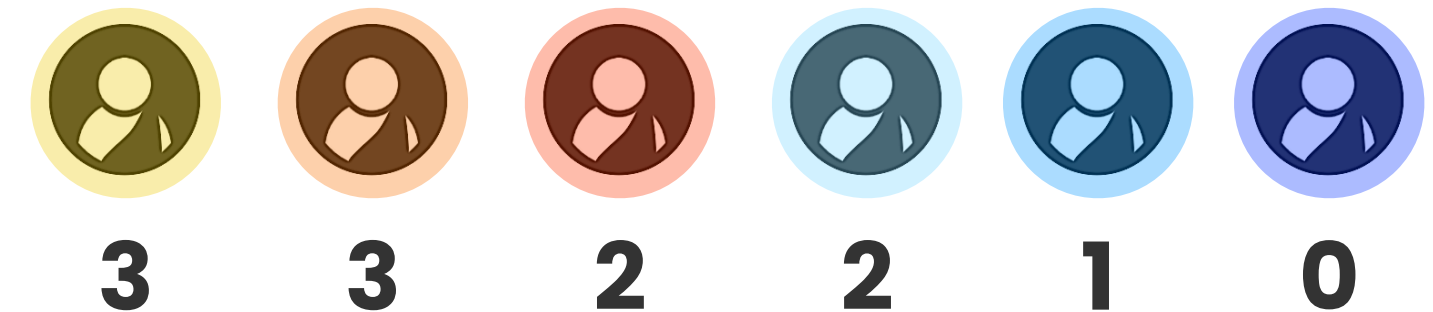
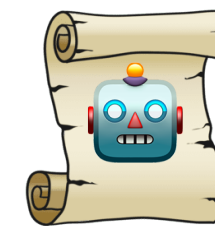


REPRESENTATIVE STATEMENTS



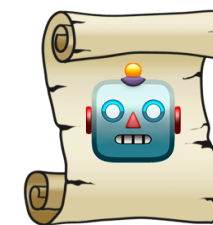
Step 1:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility



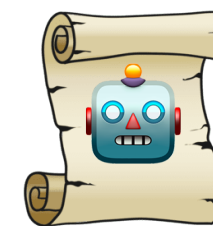
Step 2:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

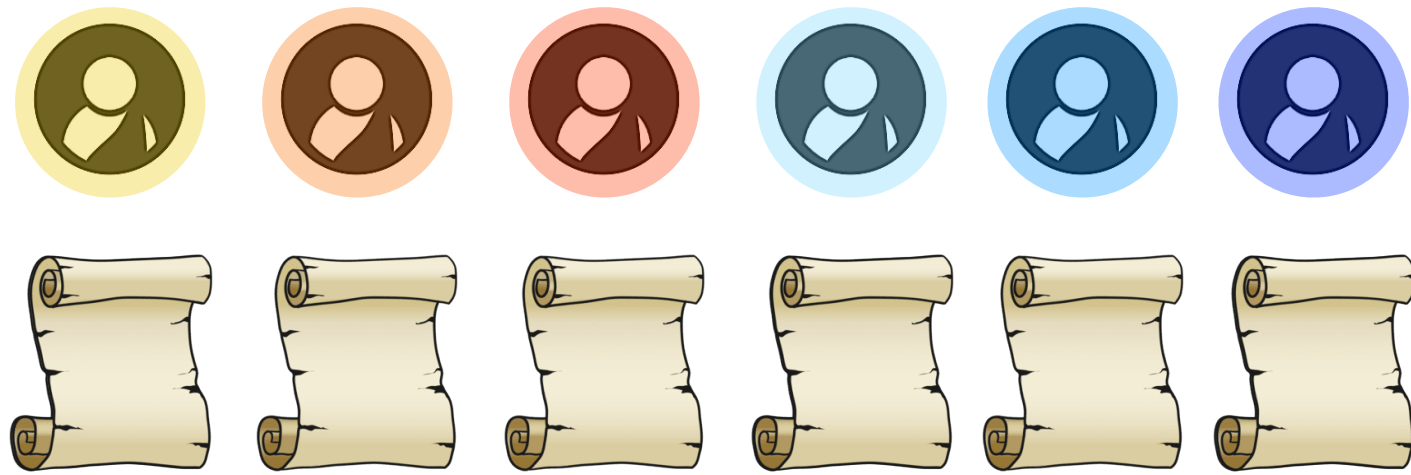


Step 3:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility



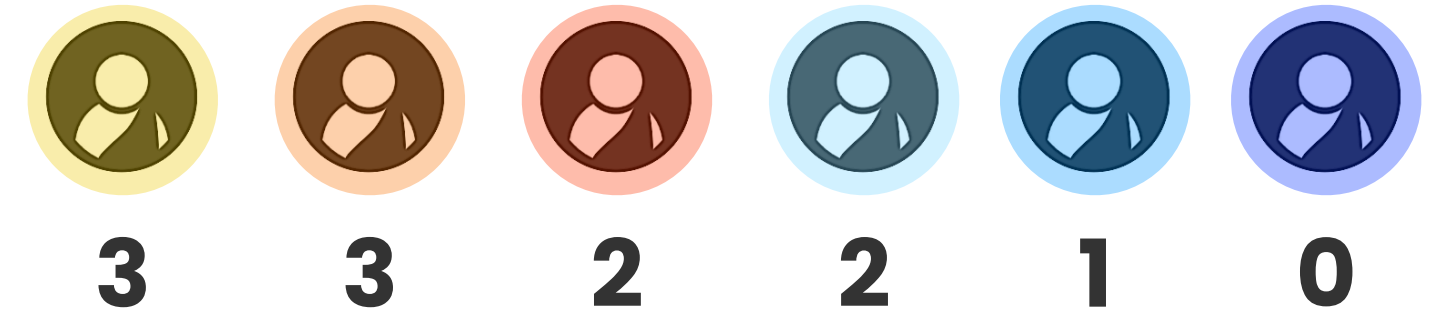
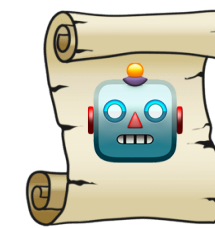
REPRESENTATIVE STATEMENTS



This is the result of an LLM query with a prompt including all the statements written by the participants

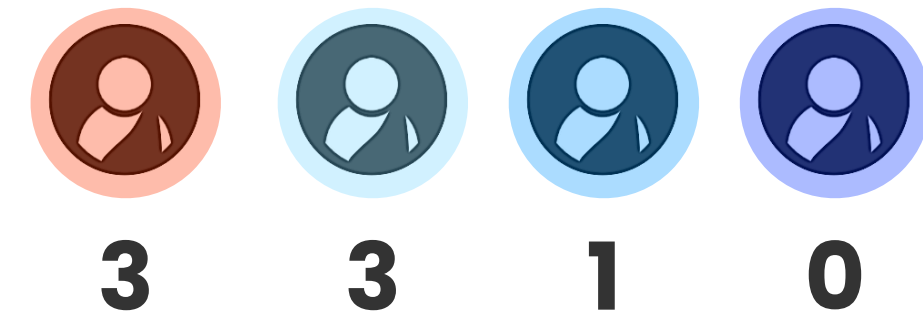
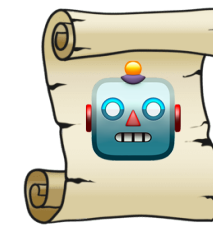
Step 1:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility



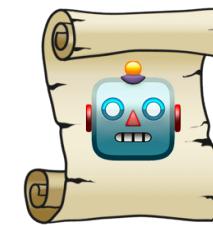
Step 2:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

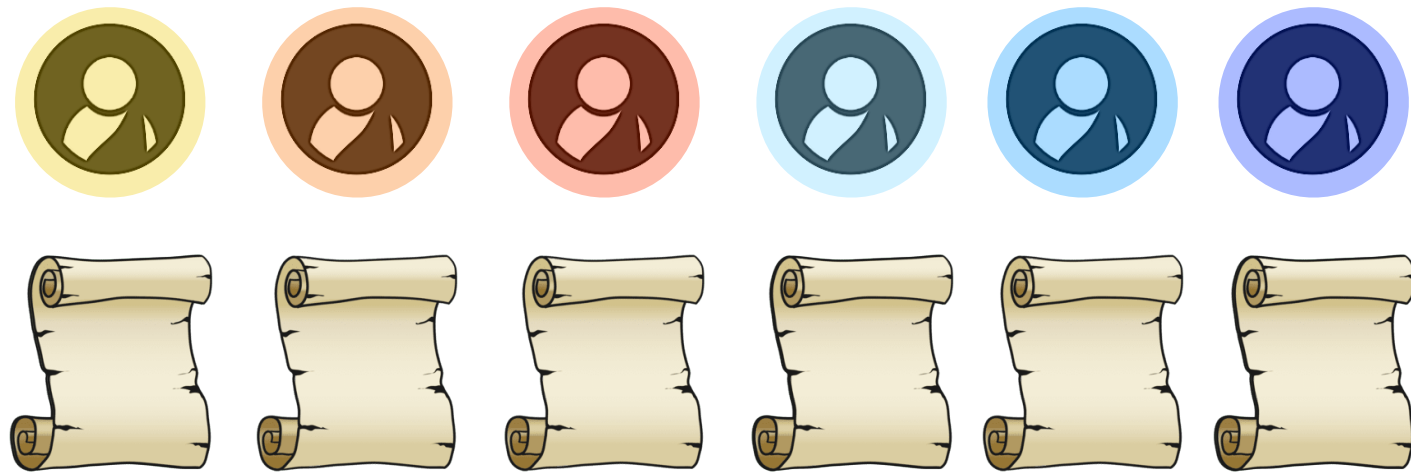


Step 3:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility



REPRESENTATIVE STATEMENTS



Step 1:

- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

Step 2:

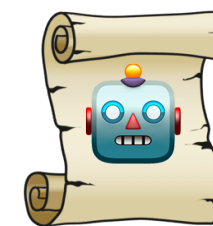
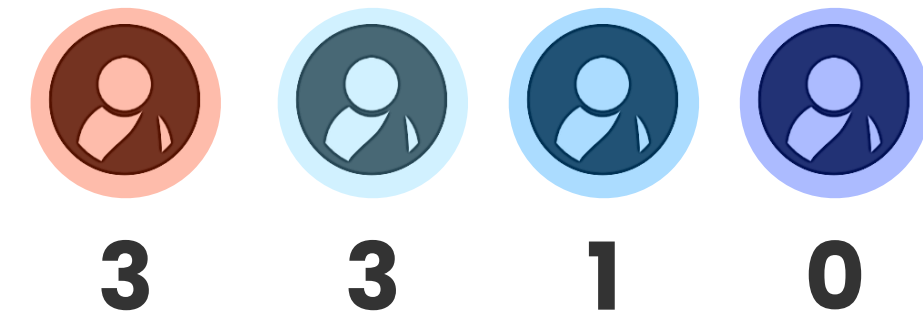
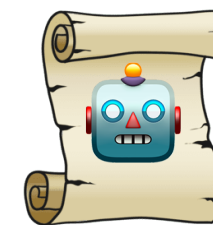
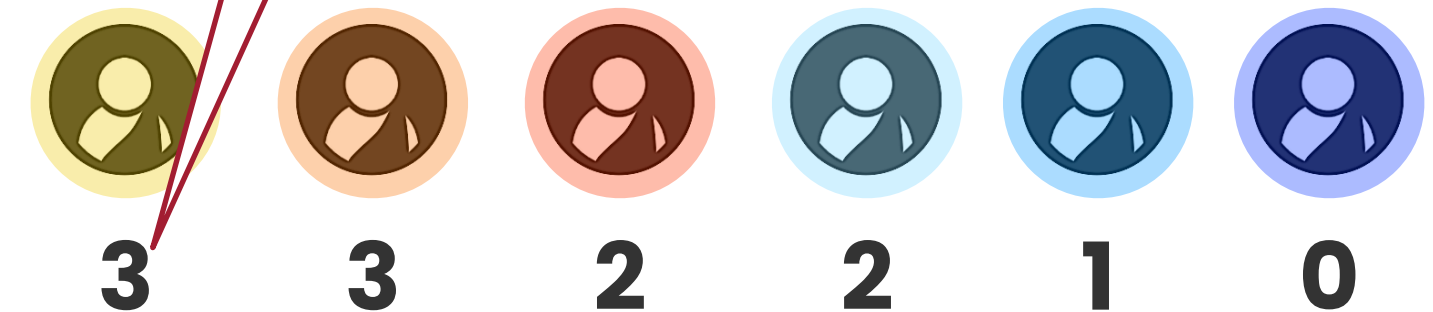
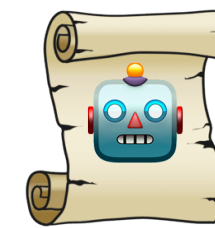
- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

Step 3:

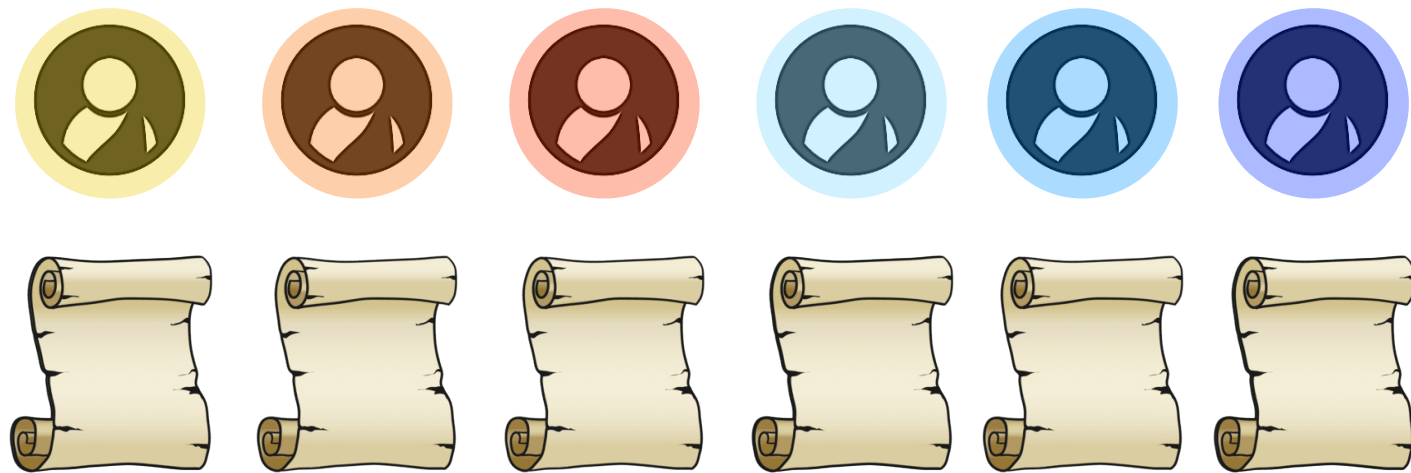
- Generate a statement that maximizes the 2nd largest utility
- Remove the two agents with maximum utility

This is the result of an LLM query with a prompt including all the statements written by the participants

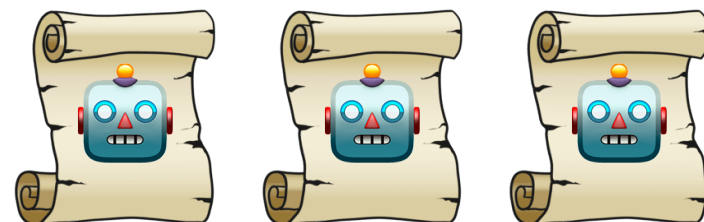
This is the result of an LLM query with a prompt including:
(i) survey response from the participant
(ii) few examples of statements with ratings and explanations (**few-shot learning!!**)
(iii) the LLM-generated statement and a question asking what would be the agent's rating



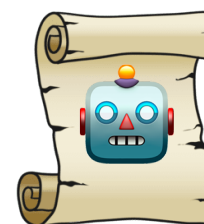
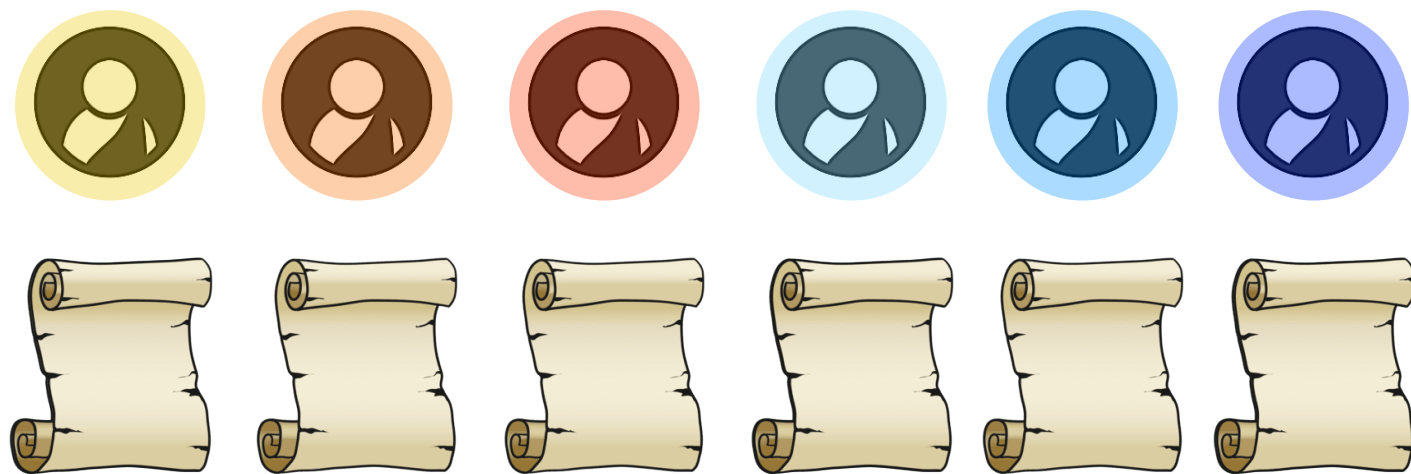
REPRESENTATIVE STATEMENTS



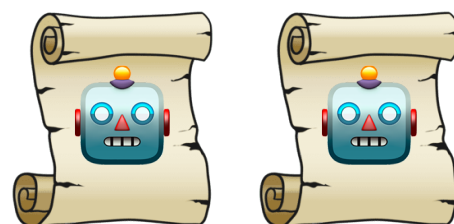
Policy
Recommendations



REPRESENTATIVE STATEMENTS



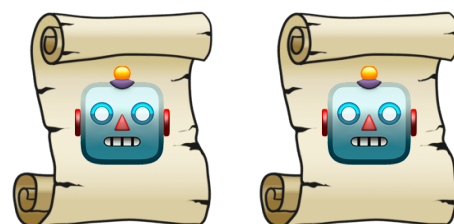
Policy
Recommendations



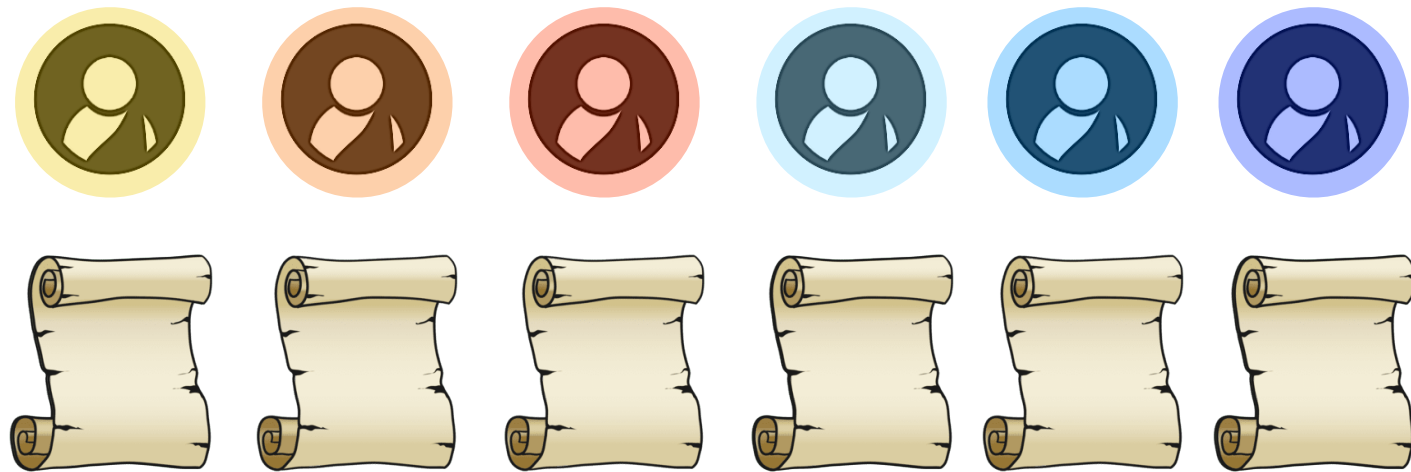
REPRESENTATIVE STATEMENTS



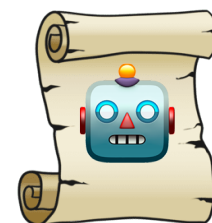
Policy
Recommendations



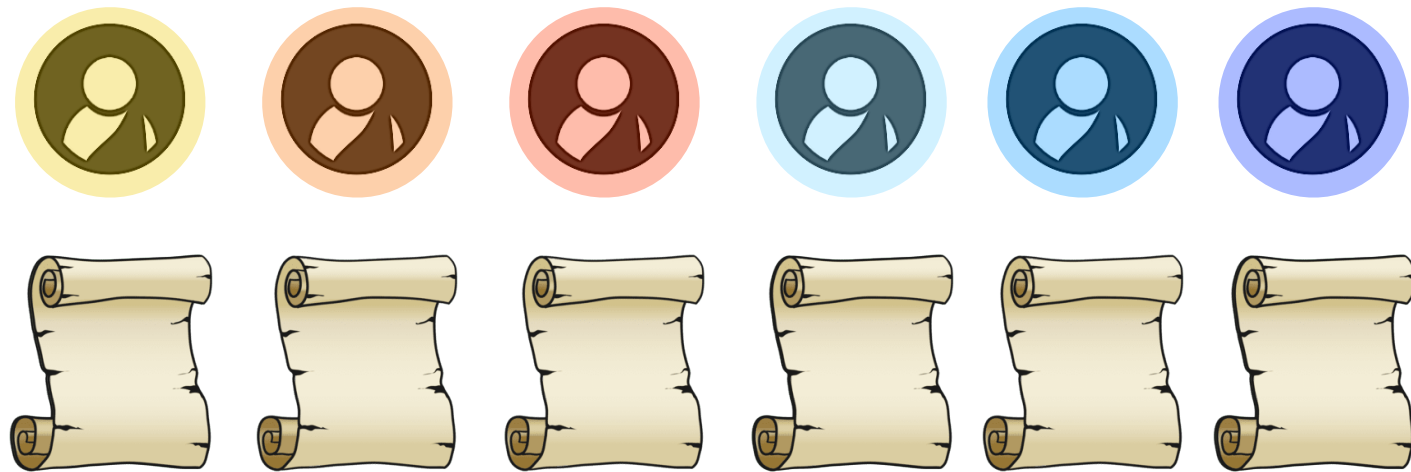
REPRESENTATIVE STATEMENTS



Policy
Recommendations

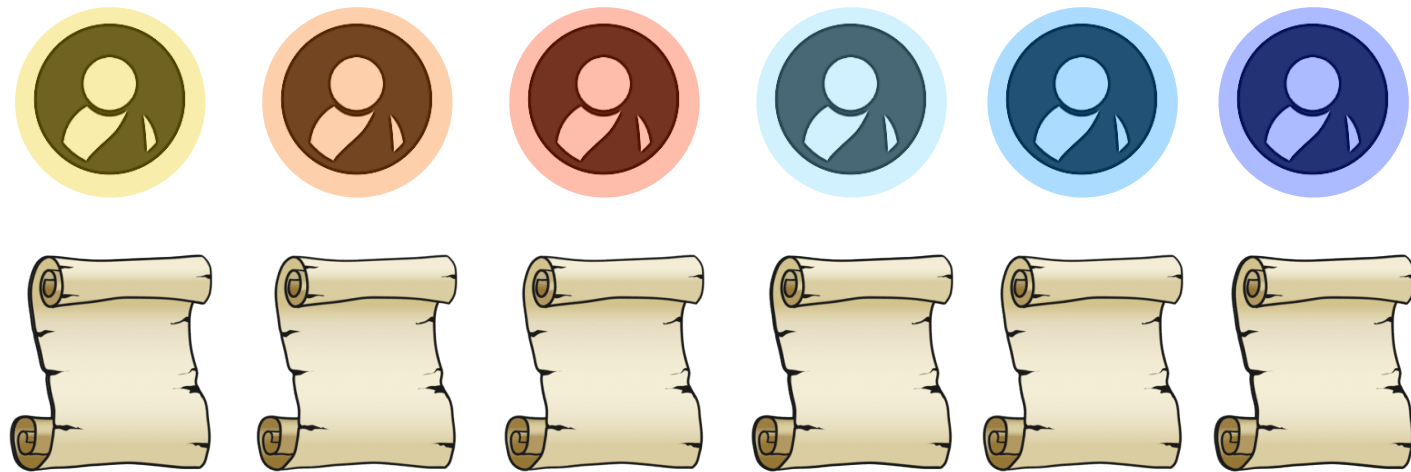


REPRESENTATIVE STATEMENTS



Policy
Recommendations

REPRESENTATIVE STATEMENTS



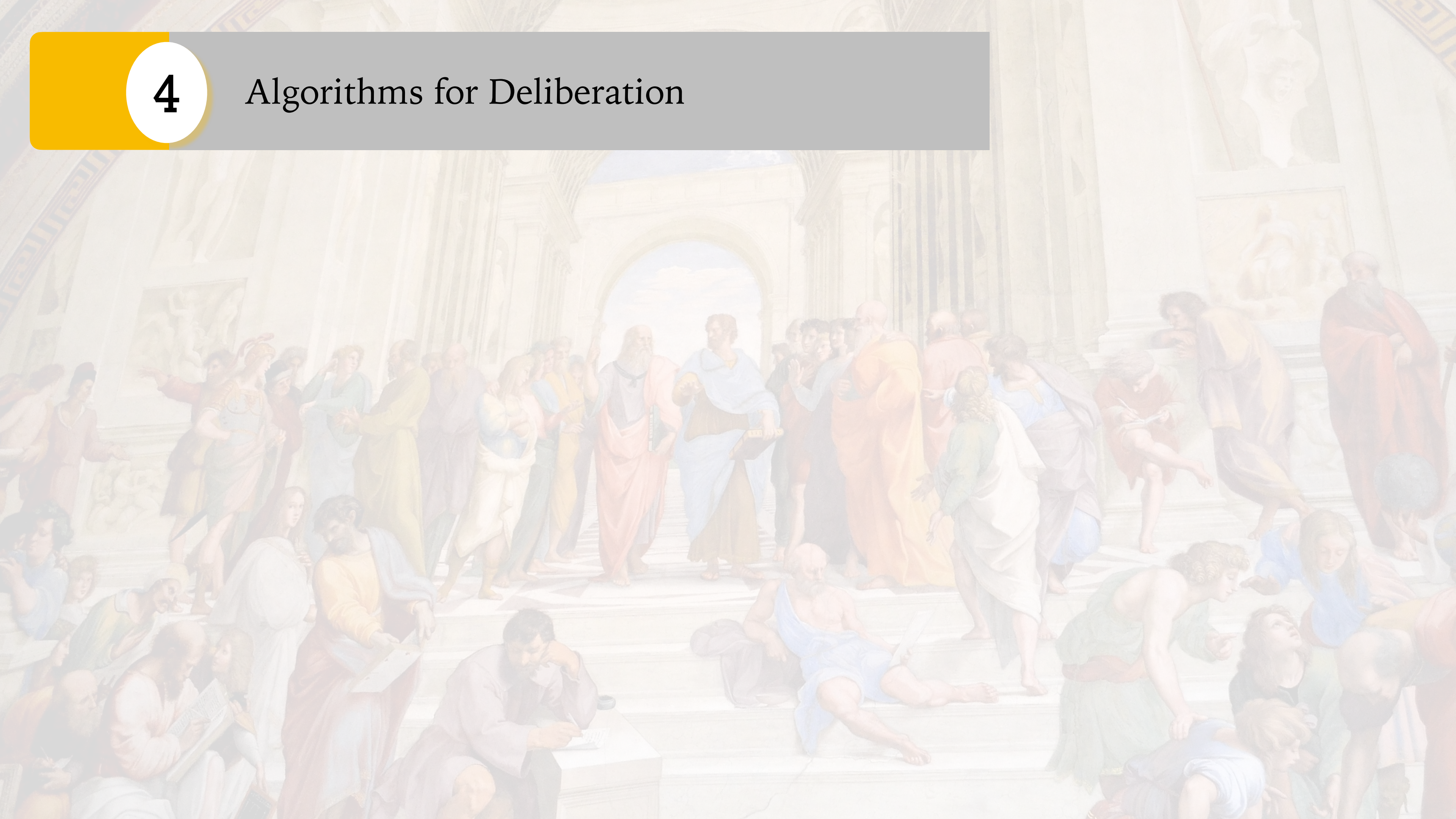
Policy
Recommendations



- ✦ **Balanced Justified Representation:** In a policy recommendation of size k with n participants, if there exists a group of size n/k that have high utility for a statement, the LLM-generated statement gives them at least the same utility.

4

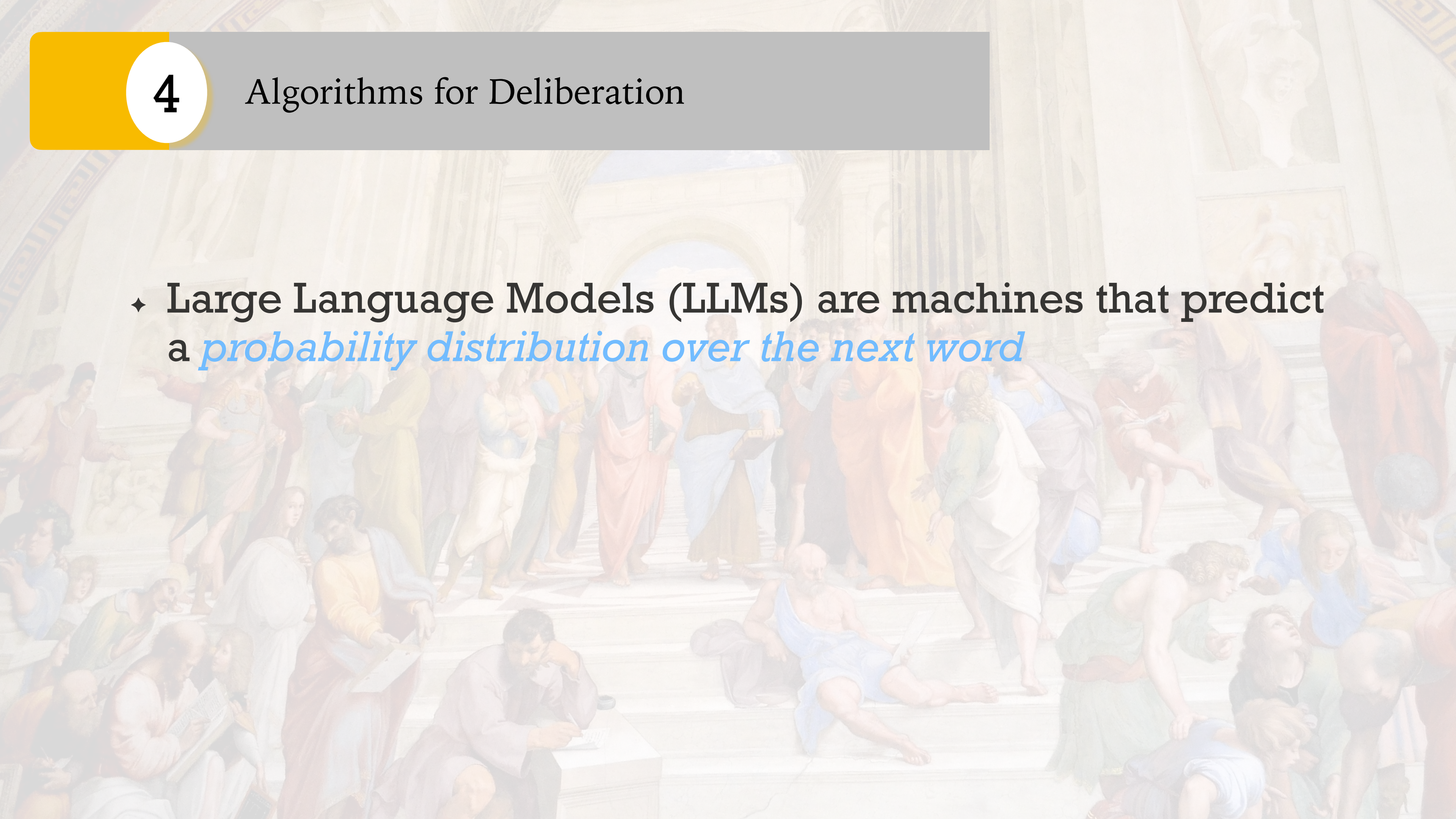
Algorithms for Deliberation



4

Algorithms for Deliberation

- ✦ Large Language Models (LLMs) are machines that predict a *probability distribution over the next word*



4

Algorithms for Deliberation

- ✦ Large Language Models (LLMs) are machines that predict a *probability distribution over the next word*
- ✦ LLMs can be used to find *consensus statements* across divided topics

4

Algorithms for Deliberation

- ✦ Large Language Models (LLMs) are machines that predict a *probability distribution over the next word*
- ✦ LLMs can be used to find *consensus statements* across divided topics
- ✦ LLMs can be used to write policy recommendations that account for a *plurality of perspectives*

ALGORITHMS FOR DELIBERATION

Question for all:

Do these algorithms qualify as deliberative technology? What are there pros and cons? Do you have ideas to improve them?

June 2024

Manon Revel

Deliberative Technologies, Computational Democracy,
and Peace-building in Polarised Contexts

Employee Fellow
Harvard University | Berkman Klein Center

Pfiou! We are done! Thanks for your attention :)

