On the Emergence of Minority Disadvantage: Testing the Cultural Red King Hypothesis

Aydin Mohseni[†], Cailin O'Connor[†], & Hannah Rubin[‡]

[†]University of California, Irvine
Department of Logic and Philosophy of Science,

[‡]University of Notre Dame
Department of Philosophy

A key role for computational models:

Directing theoretical and empirical research in ways that would not otherwise be obvious.

Cailin O'Connor

Associate Professor

Logic and Philosophy of Science

University of California, Irvine

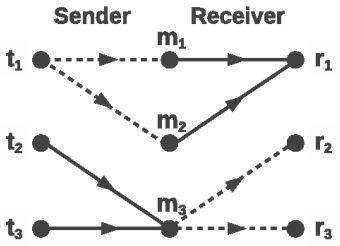
Hannah Rubin

Assistant Professor

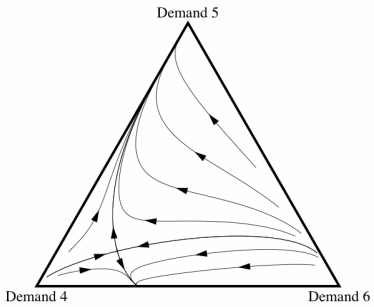
Philosophy

University of Notre Dame

Department of Logic
and Philosophy of Science
UCI School of Social Sciences

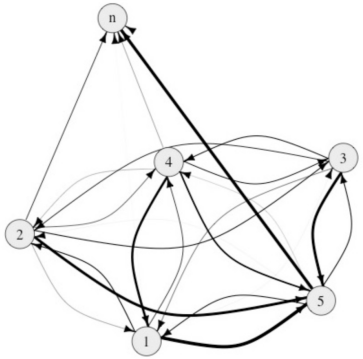


Signaling games, evolution of communication → *Language & Meaning*



Evolution of moral cognition, conventions, and social structures → *Metaethics*

→ *Political Philosophy*



Social structure and incentives in science → *Social Epistemology*

1 Motivation

Historical theories of justice (e.g., [Nozick, 1974]) locate justice at the level of transactions.

A challenge for this view:
many factors can lead to unequal outcomes.

Which factors are *acceptable*?

Increasing returns to scale

(Kaldor, 1974)

Differential returns to labor *&* capital

(Picketty, 2013)

Unequal outcomes

Increasing returns to scale

(Kaldor, 1974)

Differential returns to labor *&* capital

(Picketty, 2013)

Unequal outcomes

Group size differences

"Suppose a dominant group, say whites or 'Aryans', agreed to trade with the complementary minority only on very unfavorable terms. Indeed, they might not have to agree in any concrete sense: suppose each one happened for his own reasons to resolve to so act...Are we to say that the results are just?"

—Kenneth Arrow, *Advances in experimental social psychology,* 1978, p.272.

We explore *one way* that unequal outcomes can track social identities, like race and gender, even when

{
i. initial distributions of resources/abilities are identical;

ii. all interactions are uncoerced;

iii. and no discriminatory norms exist.

Red King Hypothesis

Red King Hypothesis

Bergstrom & Lachman (2003)

The Red King Effect

The Red King effect: When the slowest runner wins the coevolutionary race

Carl T. Bergstrom*† and Michael Lachmann‡

*Department of Zoology, University of Washington, Seattle, WA 98195; and ‡Max Planck Institute for Mathematics in the Sciences, 04103 Leipzig, Germany

Edited by Brian Skyrms, University of California, Irvine, CA, and approved November 12, 2002 (received for review August 16, 2002)

Mutualisms provide benefits to those who participate in them. As a mutualism evolves, how will these benefits come to be allocated among the participants? We approach this question by using evolutionary game theory and explore the ways in which the coevolutionary process determines the allocation of benefits in mutualistic interactions. Motivated by the Red Queen theory, which states that coevolutionary processes favor rapid rates of evolution, we pay particular attention to the role of evolutionary rates in the establishment of mutualism and the partitioning of benefits among mutualist partners. We find that, contrary to the Red Queen, in mutualism evolution the slowly evolving species is likely to gain a disproportionate share of the benefits. Moreover, population structure serves to magnify the advantage to the slower species.

When individuals of two different species engage in a mutualistic interaction, both benefit; and yet certain changes in the interaction might offer additional benefits to one species or the other (or even to both). To understand how beneficial interspecific associations evolve and are maintained, we need to answer two basic questions. First, we need to know how interspecific cooperation can persist over evolutionary time, and what keeps the interaction from breaking down as individuals succumb to incentives to "cheat" on their partners. Second, given that cooperation is somehow maintained, we need to know how the resulting benefits will be allotted to the participants. To date, theoretical work on the evolution of mutualism has focused almost exclusively on the former question. In this paper, we use evolutionary game theory to address the latter one: how does the evolutionary process distribute the benefits of mutualism?

In some cases, the mechanics of an interaction may dictate an obvious allocation of benefits. Consider the mutualistic interactions in which a cleaner wrasse *Labroides dimidiatus* removes parasites from a larger "client" fish (1). In an idealized interaction where there is no potential for cleaners to feed on live tissue or for clients to prey on cleaners (2, 3), the actual allocation of benefits will be relatively straightforward. The wrasse receives access to a ready food source, and the client enjoys a reduced parasite load (4).

In other situations, the mechanics of the interaction fail to single out any one specific way to parcel up the benefits. In the well-studied ant-lycaenid butterfly mutualism (5), ants protect caterpillars from parasitoids. As parasitism is a huge contributor to mortality, ant-associated caterpillars enjoy enormous increases in survivorship to and during pupation (6). As an incentive for continued protection, the caterpillars take on substantial energetic and fitness costs to provide their ant attendants with sugar- and protein-rich exocrine secretions (7, 8). But as a mutualism evolves, how much nutrient provisions will lycaenid caterpillars offer to the ants? And how much should the ants "demand" in return for tending to the caterpillars? No single salient solution stands out, and indeed the level of nutrient provisioning appears to be subject to context-dependent fine-tuning by the caterpillars (9). Like the aforementioned lycaenids, species ranging from aphids and treehoppers to acacia bushes have developed mutualistic associations with ants in which food is exchanged for defense (10, 11). In each of these systems, similar questions about allocating benefits arise. Other mutualisms that lack an obvious way of parceling up benefits include plant–pollinator interactions, symbioses between insects and gut microbes, and endosymbioses.

In our efforts to understand how the benefits from a mutualism will be allocated, we will pay particular attention to the role of the relative evolutionary rates, and thus the rate of strategy change, of the species involved. Mutualist partners may evolve at different rates for a number of reasons, including differences in generation time, differences in the importance of the interaction, differences in population size, and differences in the amount of segregating genetic variation (12). Analogous asymmetries in the rate of strategy change may also arise when members of one species select strategies by learning instead of by genetic evolution. Whatever the source of asymmetry, differences in evolutionary rates are commonly thought to influence coevolutionary outcomes, though previous work in this area has eschewed mutualism in favor of antagonistic interactions, such as the contests that occur between predator and prey, between host and parasite, or among competitors for a common ecological resource. In these antagonistic relationships, coevolution is typically thought to select for accelerated evolution. Pairs of species become locked into arms races with each rushing to evolve the upper hand in the interaction. As a result of this Red Queen process (13), each species is forced to evolve ever more rapidly just to break even. In the words of Lewis Carroll, "it takes all the running you can do, to keep in the same place."

Here, we concentrate on mutualism rather than antagonism. Can mutualisms, despite their cooperative elements, also be viewed as evolutionary races to outmaneuver the partner and win a greater share of the surplus? Previous authors have argued that the answer is yes: the Red Queen effect should operate under these circumstances as well (14). Just as antagonists are forced to evolve rapidly to avoid falling behind in the struggle with their competitors, we might expect that mutualists will need to evolve rapidly to avoid being exploited and ultimately parasitized by their partners. In light of these predictions, our results are surprising: we find that in contrast to the Red Queen theory, mutualistic interactions often favor slow rates of evolution.

Methods and Models

Throughout the present paper, we take the common approach (15) of treating mutualism as an evolutionary game in which players evolve strategies according to basic Darwinian (replicator) dynamics (16–18). Because previous studies have concentrated on explaining what factors prevent mutualism from breaking down into parasitism or other forms of exploitation, they have focused on games used to study the evolution of cooperation: the prisoner's dilemma, public goods games, and related scenarios. This body of work has shown how interspecific cooperation can be maintained by mechanisms such as reciprocal altruism (19–21), partner choice (22, 23), byproduct benefits

This paper was submitted directly (Track II) to the PNAS office.

†To whom correspondence should be addressed. E-mail: cbergstr@u.washington.edu

EVOLUTION

Red King Hypothesis

Bergstrom & Lachman (2003)

The Red King Effect

The Red King effect: When the slowest runner wins the coevolutionary race

Carl T. Bergstrom*† and Michael Lachmann‡

*Department of Zoology, University of Washington, Seattle, WA 98195; and ‡Max Planck Institute for Mathematics in the Sciences, 04103 Leipzig, Ger

Edited by Brian Skyrms, University of California, Irvine, CA, and approved November 12, 2002 (received for review August 16, 2002)

Mutualisms provide benefits to those who participate in them. As a mutualism evolves, how will these benefits come to be allocated among the participants? We approach this question by using evolutionary game theory and explore the ways in which the coevolutionary process determines the allocation of benefits in mutualistic interactions. Motivated by the Red Queen theory, which states that coevolutionary processes favor rapid rates of evolution, we pay particular attention to the role of evolutionary rates in the establishment of mutualism and the partitioning of benefits among mutualist partners. We find that, contrary to the Red Queen, in mutualism evolution the slowly evolving species is likely to gain a disproportionate share of the benefits. Moreover, population structure serves to magnify the advantage to the slower species.

When individuals of two different species engage in a mutualistic interaction, both benefit; and yet certain changes in the interaction might offer additional benefits to one species or the other (or even to both). To understand how beneficial interspecific associations evolve and are maintained, we need to answer two basic questions. First, we need to know how interspecific cooperation can persist over evolutionary time, and what keeps the interaction from breaking down as individuals succumb to incentives to "cheat" on their partners. Second, given that cooperation is somehow maintained, we need to know how the resulting benefits will be allotted to the participants. To date, theoretical work on the evolution of mutualism has focused almost exclusively on the former question. In this paper, we use evolutionary game theory to address the latter one: how does the evolutionary process distribute the benefits of mutualism?

In some cases, the mechanics of an interaction may dictate an obvious allocation of benefits. Consider the mutualistic interactions in which a cleaner wrasse *Labroides dimidiatus* removes parasites from a larger "client" fish (1). In an idealized interaction where there is no potential for cleaners to feed on live tissue or for clients to prey on cleaners (2, 3), the actual allocation of benefits will be relatively straightforward. The wrasse receives access to a ready food source, and the client enjoys a reduced parasite load (4).

In other situations, the mechanics of the interaction fail to single out any one specific way to parcel up the benefits. In the well-studied ant-lycaenid butterfly mutualism (5), ants protect caterpillars from parasitoids. As parasitism is a huge contributor to mortality, ant-associated caterpillars enjoy enormous increases in survivorship to and during pupation (6). As an incentive for continued protection, the caterpillars take on substantial energetic and fitness costs to provide their ant attendants with sugar- and protein-rich exocrine secretions (7, 8). But as a mutualism evolves, how much nutrient provisions will lycaenid caterpillars offer to the ants? And how much should the ants "demand" in return for tending to the caterpillars? No single salient solution stands out, and indeed the level of nutrient provisioning appears to be subject to context-dependent fine-tuning by the caterpillars (9). Like the aforementioned lycaenids, species ranging from aphids and treehoppers to acacia bushes have developed mutualistic associations with ants in which food

similar questions about allocating benefits arise. Other m
isms that lack an obvious way of parceling up benefits in
plant–pollinator interactions, symbioses between insects ar
microbes, and endosymbioses.

In our efforts to understand how the benefits from a t
alism will be allocated, we will pay particular attention to th
of the relative evolutionary rates, and thus the rate of str
change, of the species involved. Mutualist partners may evo
different rates for a number of reasons, including differen
generation time, differences in the importance of the intera
differences in population size, and differences in the amou
segregating genetic variation (12). Analogous asymmetries
rate of strategy change may also arise when members o
species select strategies by learning instead of by genetic c
tion. Whatever the source of asymmetry, differences in e
tionary rates are commonly thought to influence coevoluti
outcomes, though previous work in this area has esch
mutualism in favor of antagonistic interactions, such a
contests that occur between predator and prey, between ho
parasite, or among competitors for a common ecologic
source. In these antagonistic relationships, coevolution is
cally thought to select for accelerated evolution. Pairs of sp
become locked into arms races with each rushing to evolv
upper hand in the interaction. As a result of this Red Q
process (13), each species is forced to evolve ever more ra
just to break even. In the words of Lewis Carroll, "it takes a
running you can do, to keep in the same place."

Here, we concentrate on mutualism rather than antago
Can mutualisms, despite their cooperative elements, al
viewed as evolutionary races to outmaneuver the partne
win a greater share of the surplus? Previous authors have a
that the answer is yes: the Red Queen effect should op
under these circumstances as well (14). Just as antagonis
forced to evolve rapidly to avoid falling behind in the str
with their competitors, we might expect that mutualists will
to evolve rapidly to avoid being exploited and ultimately
sitized by their partners. In light of these predictions, our r
are surprising: we find that in contrast to the Red Queen theory,
mutualistic interactions often favor slow rates of evolution.

Methods and Models

Throughout the present paper, we take the common approach (15) of treating mutualism as an evolutionary game in which players evolve strategies according to basic Darwinian (replicator) dynamics (16–18). Because previous studies have concentrated on explaining what factors prevent mutualism from breaking down into parasitism or other forms of exploitation, they have focused on games used to study the evolution of cooperation: the prisoner's dilemma, public goods games, and related scenarios. This body of work has shown how interspecific cooperation can be maintained by mechanisms such as reciprocal altruism (19–21), partner choice (22, 23), byproduct benefits

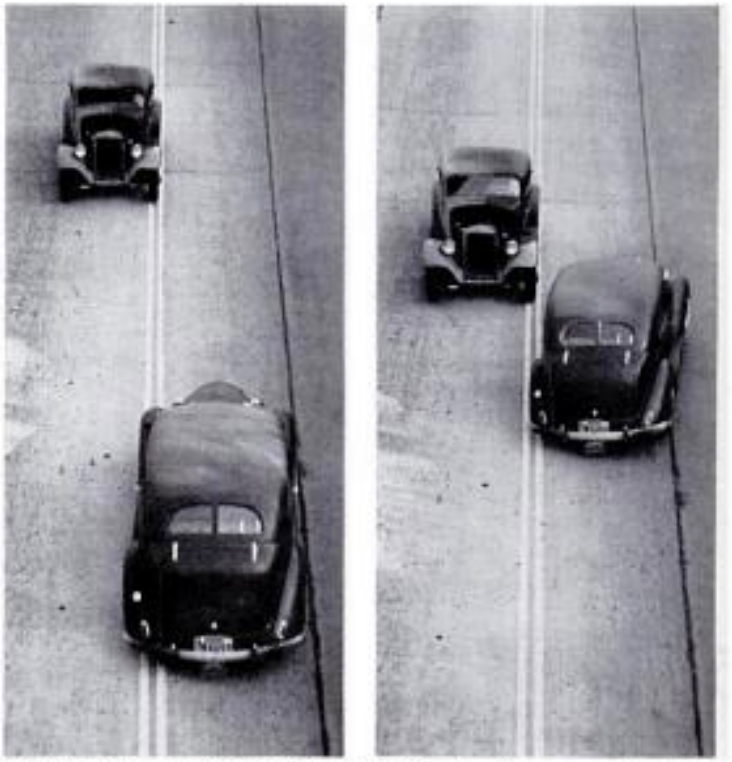
This paper was submitted directly (Track II) to the PNAS office.

†To whom correspondence should be addressed. E-mail: cbergstr@u.washington.edu

EVOLUTION

Mutualisms

A game of chicken



Red King Hypothesis

Bergstrom & Lachman (2003)

The Red King Effect

Bruner (2017)

Minority (Dis)advantage in Population Games

The Red King effect: When the coevolutionary race

Carl T. Bergstrom*† and Michael Lachmann‡

*Department of Zoology, University of Washington, Seattle, WA 98195; and ‡N

Edited by Brian Skyrms, University of California, Irvine, CA, and approved Nove

Mutualisms provide benefits to those who participate in them. As a mutualism evolves, how will these benefits come to be allocated among the participants? We approach this question by using evolutionary game theory and explore the ways in which the coevolutionary process determines the allocation of benefits in mutualistic interactions. Motivated by the Red Queen theory, which states that coevolutionary processes favor rapid rates of evolution, we pay particular attention to the role of evolutionary rates in the establishment of mutualism and the partitioning of benefits among mutualist partners. We find that, contrary to the Red Queen, in mutualism evolution the slowly evolving species is likely to gain a disproportionate share of the benefits. Moreover, population structure serves to magnify the advantage to the slower species.

When individuals of two different species engage in a mutualistic interaction, both benefit; and yet certain changes in the interaction might offer additional benefits to one species or the other (or even to both). To understand how beneficial interspecific associations evolve and are maintained, we need to answer two basic questions. First, we need to know how interspecific cooperation can persist over evolutionary time, and what keeps the interaction from breaking down as individuals succumb to incentives to "cheat" on their partners. Second, given that cooperation is somehow maintained, we need to know how the resulting benefits will be allotted to the participants. To date, theoretical work on the evolution of mutualism has focused almost exclusively on the former question. In this paper, we use evolutionary game theory to address the latter one: how does the evolutionary process distribute the benefits of mutualism?

In some cases, the mechanics of an interaction may dictate an obvious allocation of benefits. Consider the mutualistic interactions in which a cleaner wrasse *Labroides dimidiatus* removes parasites from a larger "client" fish (1). In an idealized interaction where there is no potential for cleaners to feed on live tissue or for clients to prey on cleaners (2, 3), the actual allocation of benefits will be relatively straightforward. The wrasse receives access to a ready food source, and the client enjoys a reduced parasite load (4).

In other situations, the mechanics of the interaction fail to single out any one specific way to parcel up the benefits. In the well-studied ant-lycaenid butterfly mutualism (5), ants protect caterpillars from parasitoids. As parasitism is a huge contributor to mortality, ant-associated caterpillars enjoy enormous increases in survivorship to and during pupation (6). As an incentive for continued protection, the caterpillars take on substantial energetic and fitness costs to provide their ant attendants with sugar- and protein-rich exocrine secretions (7, 8). But as a mutualism evolves, how much nutrient provisions will lycaenid caterpillars offer to the ants? And how much should the ants "demand" in return for tending to the caterpillars? No single salient solution stands out, and indeed the level of nutrient provisioning appears to be subject to context-dependent fine-tuning by the caterpillars (9). Like the aforementioned lycaenids, species ranging from aphids and treehoppers to acacia bushes have developed mutualistic associations with ants in which food is exchanged for defense (10, 11). In each of these systems, similar questions about allocating benefits arise. Other mutualisms that lack an obvious way of parceling up benefits include

Synthese
DOI 10.1007/s11229-017-1487-8

CrossMark

Minority (dis)advantage in population games

Justin P. Bruner[1]

Received: 20 December 2016 / Accepted: 30 June 2017

Abstract We identify a novel 'cultural red king effect' that, in many cases, results in stable arrangements which are to the detriment of minority groups. In particular, we show inequalities disadvantaging minority groups can naturally arise under an adaptive process when minority and majority members must routinely determine how to divide resources amongst themselves. We contend that these results show how inequalities disadvantaging minorities can likely arise by dint of their relative size and need not be a result of either explicit nor implicit prejudices, nor due to intrinsic differences between minority and majority members.

Keywords Social philosophy · Social norms · Game theory · Evolutionary game theory · Bargaining · Distributive justice

Red King Hypothesis

Bergstrom & Lachman (2003)

The Red King Effect

Bruner (2017)

Minority (Dis)advantage in Population Games

The Red King effect: When the coevolutionary race

Carl T. Bergstrom*† and Michael Lachmann‡

*Department of Zoology, University of Washington, Seattle, WA 98195; and ‡

Edited by Brian Skyrms, University of California, Irvine, CA, and approved Nove

Mutualisms provide benefits to those who participate in them. As a mutualism evolves, how will these benefits come to be allocated among the participants? We approach this question by using evolutionary game theory and explore the ways in which the coevolutionary process determines the allocation of benefits in mutualistic interactions. Motivated by the Red Queen theory, which states that coevolutionary processes favor rapid rates of evolution, we pay particular attention to the role of evolutionary rates in the establishment of mutualism and the partitioning of benefits among mutualist partners. We find that, contrary to the Red Queen, in mutualism evolution the slowly evolving species is likely to gain a disproportionate share of the benefits. Moreover, population structure serves to magnify the advantage to the slower species.

When individuals of two different species engage in a mutualistic interaction, both benefit; and yet certain changes in the interaction might offer additional benefits to one species or the other (or even to both). To understand how beneficial interspecific associations evolve and are maintained, we need to answer two basic questions. First, we need to know how interspecific cooperation can persist over evolutionary time, and what keeps the interaction from breaking down as individuals succumb to incentives to "cheat" on their partners. Second, given that cooperation is somehow maintained, we need to know how the resulting benefits will be allotted to the participants. To date, theoretical work on the evolution of mutualism has focused almost exclusively on the former question. In this paper, we use evolutionary game theory to address the latter one: how does the evolutionary process distribute the benefits of mutualism?

In some cases, the mechanics of an interaction may dictate an obvious allocation of benefits. Consider the mutualistic interactions in which a cleaner wrasse *Labroides dimidiatus* removes parasites from a larger "client" fish (1). In an idealized interaction where there is no potential for cleaners to feed on live tissue or for clients to prey on cleaners (2, 3), the actual allocation of benefits will be relatively straightforward. The wrasse receives access to a ready food source, and the client enjoys a reduced parasite load (4).

In other situations, the mechanics of the interaction fail to single out any one specific way to parcel up the benefits. In the well-studied ant-lycaenid butterfly mutualism (5), ants protect caterpillars from parasitoids. As parasitism is a huge contributor to mortality, ant-associated caterpillars enjoy enormous increases in survivorship to and during pupation (6). As an incentive for continued protection, the caterpillars take on substantial energetic and fitness costs to provide their ant attendants with sugar- and protein-rich exocrine secretions (7, 8). But as a mutualism evolves, how much nutrient provisions will lycaenid caterpillars offer to the ants? And how much should the ants "demand" in return for tending to the caterpillars? No single salient solution stands out, and indeed the level of nutrient provisioning appears to be subject to context-dependent fine-tuning by the caterpillars (9). Like the aforementioned lycaenids, species ranging from aphids and treehoppers to acacia bushes have developed mutualistic associations with ants in which food is exchanged for defense (10, 11). In each of these systems,

similar questions about allocating benefits arise. Other mutualisms that lack an obvious way of parceling up benefits include

Synthese
DOI 10.1007/s11229-017-1487-8

CrossMark

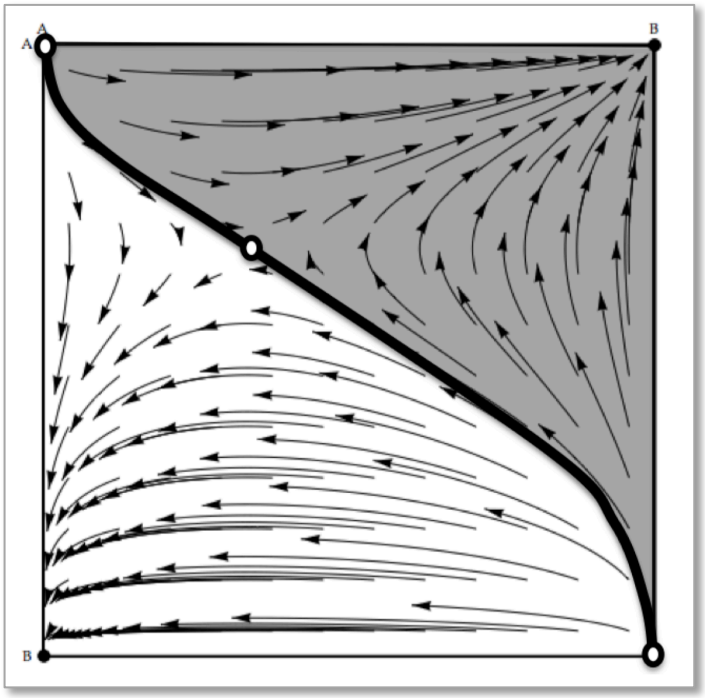
Minority (dis)advantage in population games

Justin P. Bruner[1]

Received: 20 December 2016 / Accepted: 30 June 2017

Abstract We identify a novel 'cultural red king effect' that, in many cases, results in stable arrangements which are to the detriment of minority groups. In particular, we show inequalities disadvantaging minority groups can naturally arise under an adaptive process when minority and majority members must routinely determine how to divide resources amongst themselves. We contend that these results show how inequalities disadvantaging minorities can likely arise by dint of their relative size and need not be a result of either explicit nor implicit prejudices, nor due to intrinsic differences between minority and majority members.

Keywords Social philosophy · Social norms · Game theory · Evolutionary game theory · Bargaining · Distributive justice



Δ speed of evolution

$\Downarrow$

Δ population size

Red King Hypothesis

Bergstrom & Lachman (2003)

The Red King Effect

Bruner (2017)

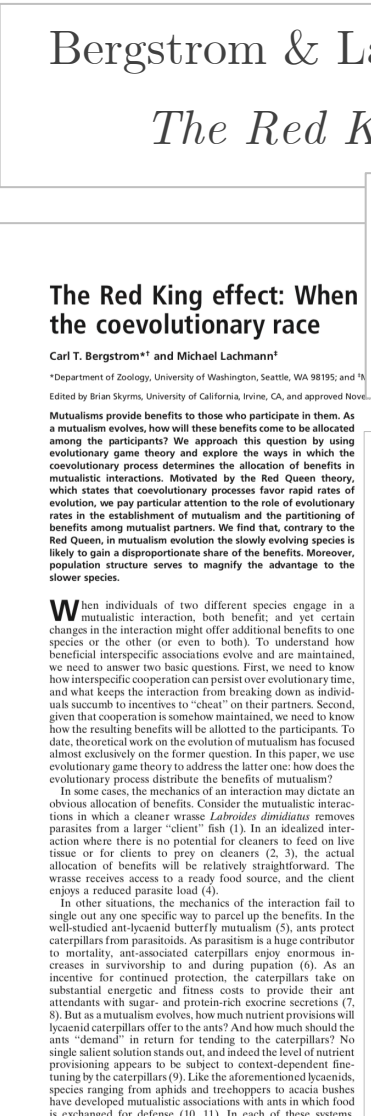
Minority (Dis)advantage in Population Games

O'Connor & Bruner (2017)

Dynamics and Diversity in Epistemic Communities

O'Connor, et al (2018)

The Evolution of Intersectional Disadvantage



The Red King effect: When the coevolutionary race

Carl T. Bergstrom*† and Michael Lachmann‡

*Department of Zoology, University of Washington, Seattle, WA 98195; and ‡N

Edited by Brian Skyrms, University of California, Irvine, CA, and approved Nove

Mutualisms provide benefits to those who participate in them. As a mutualism evolves, how will these benefits come to be allocated among the participants? We approach this question by using evolutionary game theory and explore the ways in which the coevolutionary process determines the allocation of benefits in mutualistic interactions. Motivated by the Red Queen theory, which states that coevolutionary processes favor rapid rates of evolution, we pay particular attention to the role of evolutionary rates in the establishment of mutualism and the partitioning of benefits among mutualist partners. We find that, contrary to the Red Queen, in mutualism evolution the slowly evolving species is likely to gain a disproportionate share of the benefits. Moreover, population structure serves to magnify the advantage to the slower species.

When individuals of two different species engage in a mutualistic interaction, both benefit; and yet certain changes in the interaction might offer additional benefits to one species or the other (or even to both). To understand how beneficial interspecific associations evolve and are maintained, we need to answer two basic questions. First, we need to know how interspecific cooperation can persist over evolutionary time, and what keeps the interaction from breaking down as individuals succumb to incentives to "cheat" on their partners. Second, given that cooperation is somehow maintained, we need to know how the resulting benefits will be allotted to the participants. To date, theoretical work on the evolution of mutualism has focused almost exclusively on the former question. In this paper, we use evolutionary game theory to address the latter one: how does the evolutionary process distribute the benefits of mutualism?

In some cases, the mechanics of an interaction may dictate an obvious allocation of benefits. Consider the mutualistic interactions in which a cleaner wrasse *Labroides dimidiatus* removes parasites from a larger "client" fish (1). In an idealized interaction where there is no potential for cleaners to feed on live tissue or for clients to prey on cleaners (2, 3), the actual allocation of benefits will be relatively straightforward. The wrasse receives access to a ready food source, and the client enjoys a reduced parasite load (4).

In other situations, the mechanics of the interaction fail to single out any one specific way to parcel up the benefits. In the well-studied ant-lycaenid butterfly mutualism (5), ants protect caterpillars from parasitoids. As parasitism is a huge contributor to mortality, ant-associated caterpillars enjoy enormous increases in survivorship to and during pupation (6). As an incentive for continued protection, the caterpillars take on substantial energetic and fitness costs to provide their ant attendants with sugar- and protein-rich exocrine secretions (7, 8). But as a mutualism evolves, how much nutrient provisions will lycaenid caterpillars offer to the ants? And how much should the ants "demand" in return for tending to the caterpillars? No single salient solution stands out, and indeed the level of nutrient provisioning appears to be subject to context-dependent fine-tuning by the caterpillars (9). Like the aforementioned lycaenids, species ranging from aphids and treehoppers to acacia bushes have developed mutualistic associations with ants in which food is exchanged for defense (10, 11). In each of these systems,

similar questions about allocating benefits arise. Other mutual-
isms that lack an obvious way of parceling up benefits include

Synthese
DOI 10.1007/s11229-017-1487-8

Minority (dis)advantage in population games

Justin P. Bruner[1]

Received: 20 December 2016 / Accepted: 30 June 2017
© Springer Science+Business Media B.V. 2017

Abstract We identify a novel 'cultural red ki
stable arrangements which are to the detrime
show inequalities disadvantaging minority gro
process when minority and majority members
resources amongst themselves. We contend t
disadvantaging minorities can likely arise by
be a result of either explicit nor implicit prej
between minority and majority members.

Keywords Social philosophy · Social norms
theory · Bargaining · Distributive justice

ERKENNTNIS

Dynamics and Diversity in Episte

Cailin O'Connor and Justin

April 19, 2017

Abstract

Bruner (2017) shows that in cultural interactions,
will learn to interact with members of majority groups m
to meet majorities more often as a brute fact of their
a result, may come to be disadvantaged in situations
In this paper, we discuss the implications of this effec
We use evolutionary game theoretic methods to show t
up disadvantaged in academic interactions like bargai
result of this effect. These outcomes are more likely, in
minority group. They occur despite assumptions that n
do not differ with respect to skill level, personality, p
any sort. Furthermore, as we will argue, these disadvan
groups may negatively impact the progress of epistemi

BSPS British Society for the Philosophy of Science

The Evolution of Intersectional Oppression

Cailin O'Connor, Liam K. Bright, Justin P. Bruner

Intersectionality theory explores the special sorts of disadvantage that arise as the result of occupying multiple disadvantaged demographic categories. One significant methodological problem for the quantitative study of intersectionality is the difficulty of acquiring data sets large enough to produce significant results when one is looking for intersectional effects. For this rea-

2 Methodology

Theory

Evolutionary game theory

experiment

Experimental economics

3 Theory and Predictions

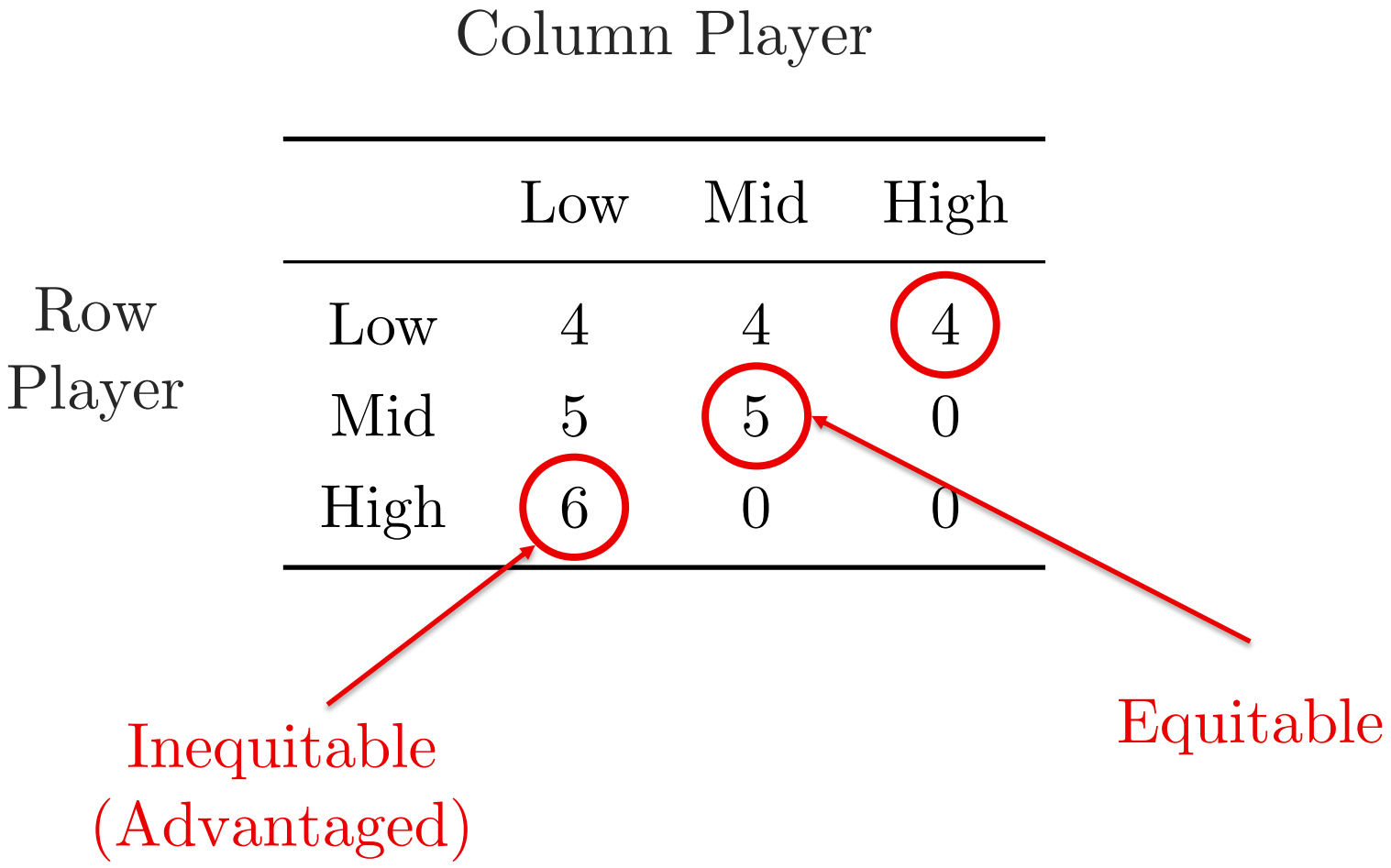
Simplified Nash demand game

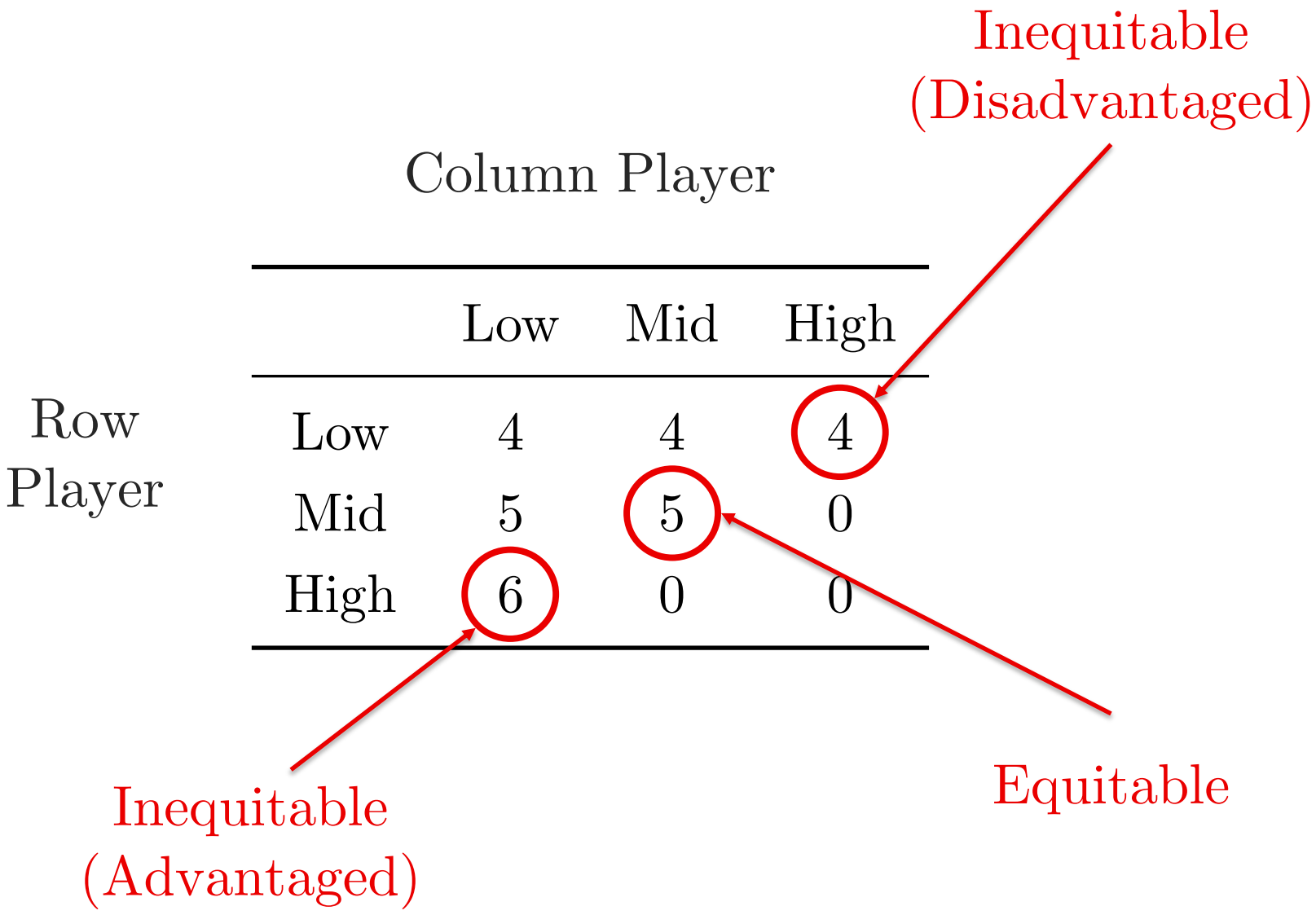
		Column Player		
		Low	Mid	High
Row Player	Low	4	4	4
	Mid	5	5	0
	High	6	0	0

Column Player

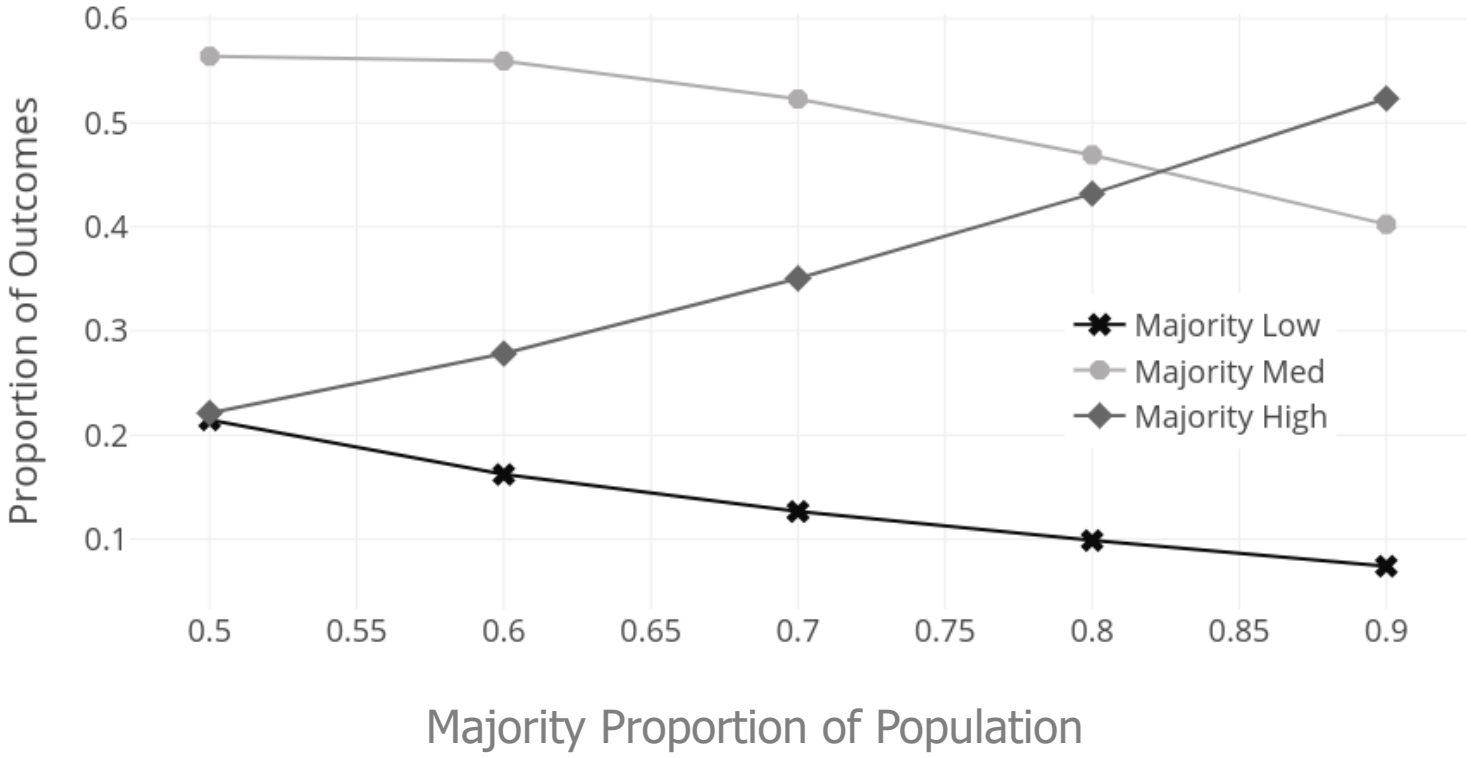
Row Player	Low	Mid	High
Low	4	4	4
Mid	5	5	0
High	6	0	0

Equitable


Column Player
Row Player
Low
Mid
High
Low 4 4 4
Mid 5 5 0
High 6 0 0
Inequitable (Advantaged)
Equitable


Inequitable
(Disadvantaged)
Column Player
Low
Mid
High
Row
Player
Low
4
4
4
Mid
5
5
0
High
6
0
0
Inequitable
(Advantaged)
Equitable

Demonstration of Red King effect with replicator dynamics model



Robustness

Dynamics:

- Replicator dynamics
- Reinforcement learning
- Logit dynamics
- BNN dynamics
- Smith dynamics

Drivers:

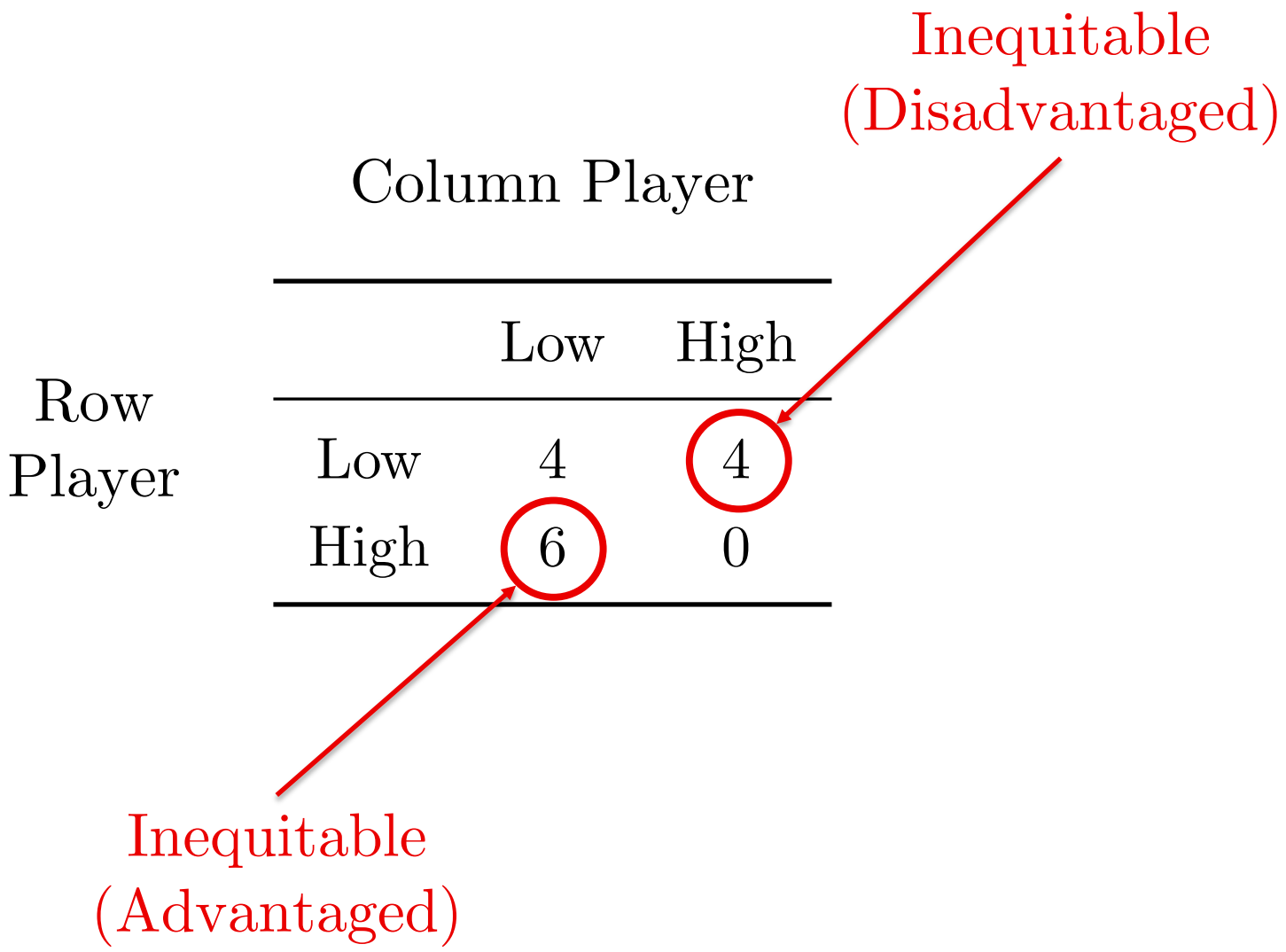
- Rate of evolution
- Learning speed
- Population size
- Network structure
- Memory length

Differential response rates

Goal

Formulate a maximally simplified setup

that should still reproduce the effect.


Inequitable
(Disadvantaged)
Column Player
Low
High
Row
Player
Low
4
4
High
6
0
Inequitable
(Advantaged)

4 Experimental Setup

i. Amazon Mechanical Turk

ii. ESS Laboratory

Experimental Social Science Laboratory

UCI School of Social Sciences

iii. oTree

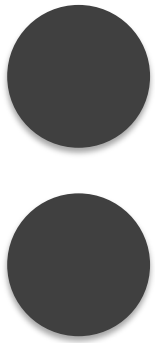
oTree

An open-source platform
for behavioral research

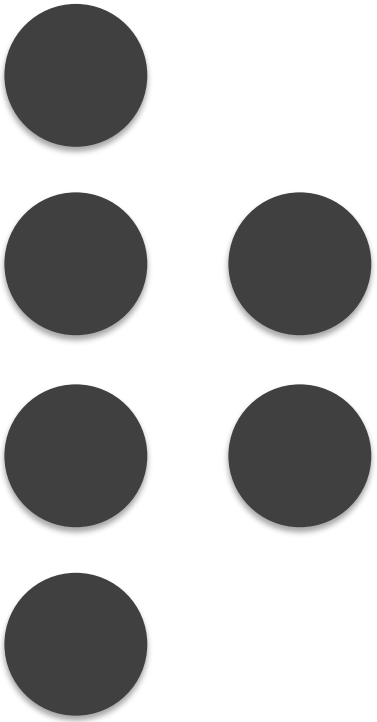
14 trials

112 participants

Minority



Majority



Instructions

In an interaction, you and the other individual will each be given the option to choose either 4 or 6. If your choice plus the other participant's choice add up to less than 10, then you will both receive points according to your choices. If your choice plus the other participant's choice add up to more than 10, then you will both receive 0 points.

Each of you must independently and simultaneously make a decision. Your payoffs will be determined by both choices as shown below:

In each cell, the amount (in points) to the left is the payoff for you and to the right for the other participant.

		The Other Participant	
		Choose 4	**Choose 6**
You	**Choose 4**	4, 4	4, 6
	Choose 6	6, 4	0, 0

For your convenience, these instructions will remain available to you on all subsequent screens of this study.

Introduction 1

Welcome to this experiment by UC Irvine. Thank you for participating.

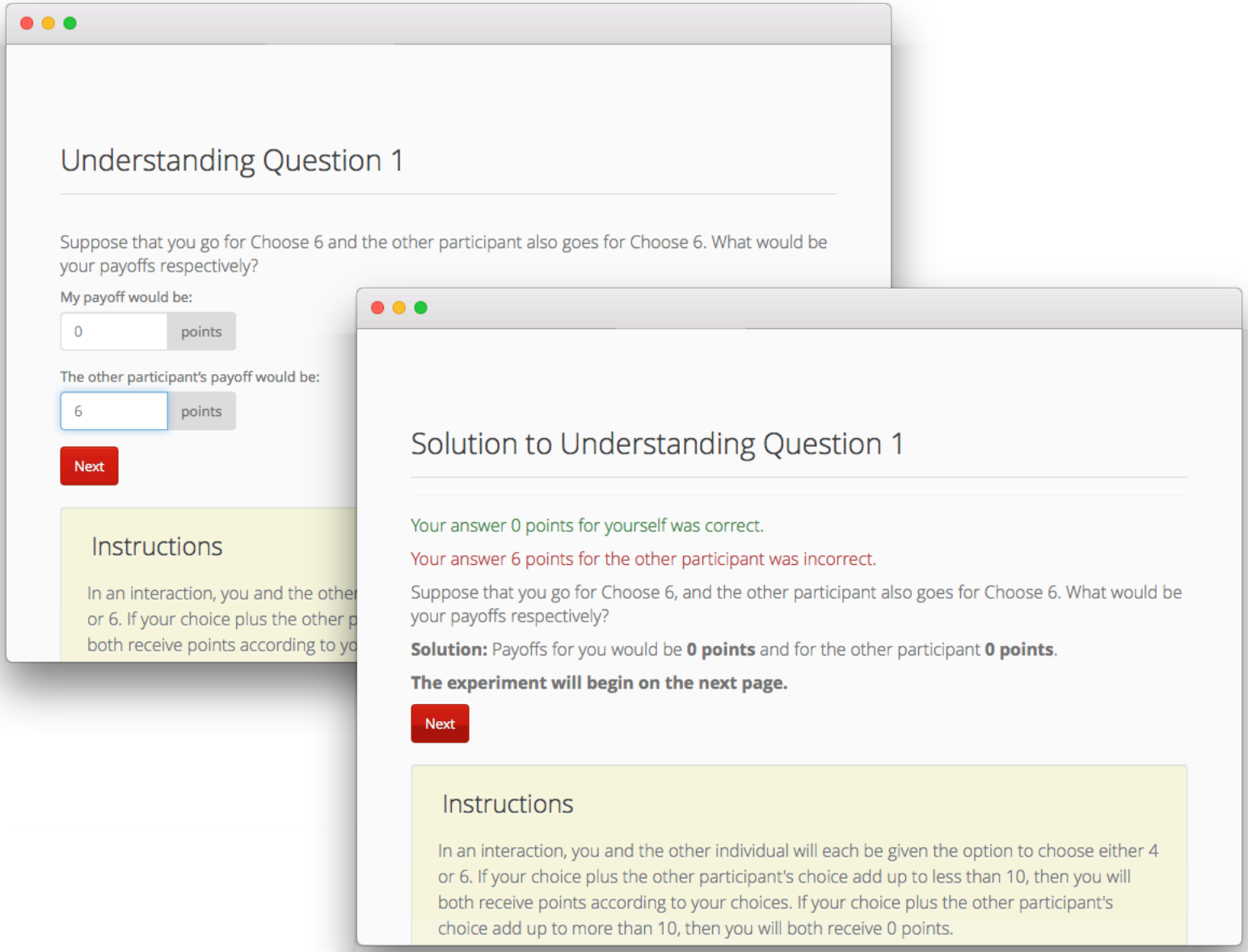
You are about to participate in a study of decision-making, and you will be paid for your participation at the end of this session. What you earn depends partly on your decisions and partly on the decisions of other participants. You goal is to earn as much as you can, as it will augment your payment from the experiment.

Next

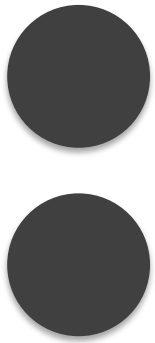
Instructions

In an interaction, you and the other individual will each be given the option to choose either 4 or 6. If your choice plus the other participant's choice add up to less than 10, then you will both receive points according to your choices. If your choice plus the other participant's choice add up to more than 10, then you will both receive 0 points.

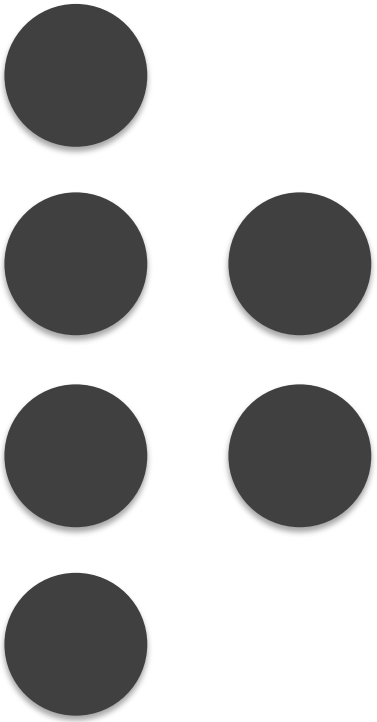
Each of you must independently and simultaneously make a decision. Your payoffs will be determined by both choices as shown below:

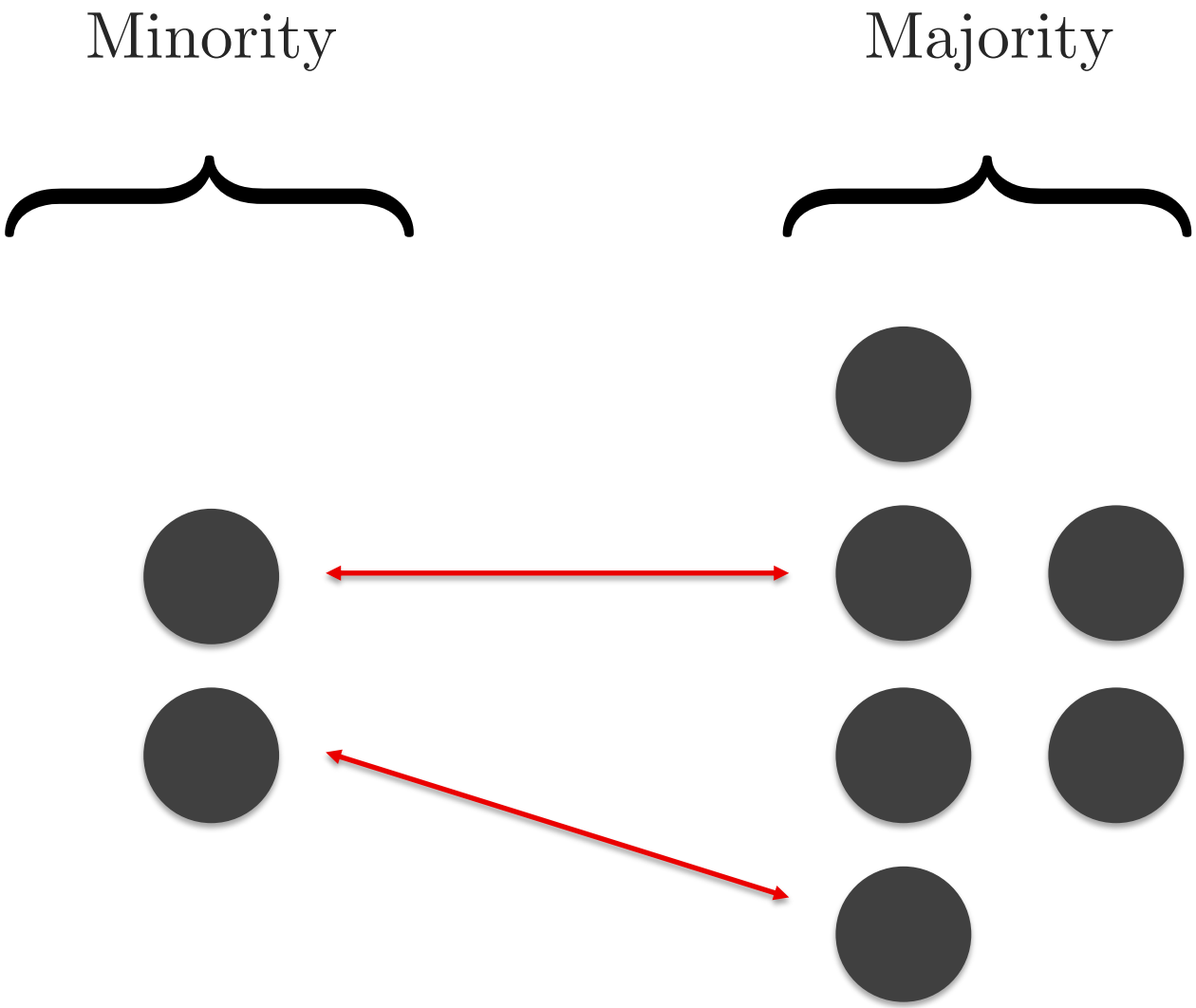

Understanding Question 1
Suppose that you go for Choose 6 and the other participant also goes for Choose 6. What would be your payoffs respectively?
My payoff would be:
0
points
The other participant's payoff would be:
6
points
Next
Instructions
In an interaction, you and the other
or 6. If your choice plus the other p
both receive points according to yo
Solution to Understanding Question 1
Your answer 0 points for yourself was correct.
Your answer 6 points for the other participant was incorrect.
Suppose that you go for Choose 6, and the other participant also goes for Choose 6. What would be your payoffs respectively?
Solution: Payoffs for you would be 0 points and for the other participant 0 points.
The experiment will begin on the next page.
Next
Instructions
In an interaction, you and the other individual will each be given the option to choose either 4 or 6. If your choice plus the other participant's choice add up to less than 10, then you will both receive points according to your choices. If your choice plus the other participant's choice add up to more than 10, then you will both receive 0 points.

Minority

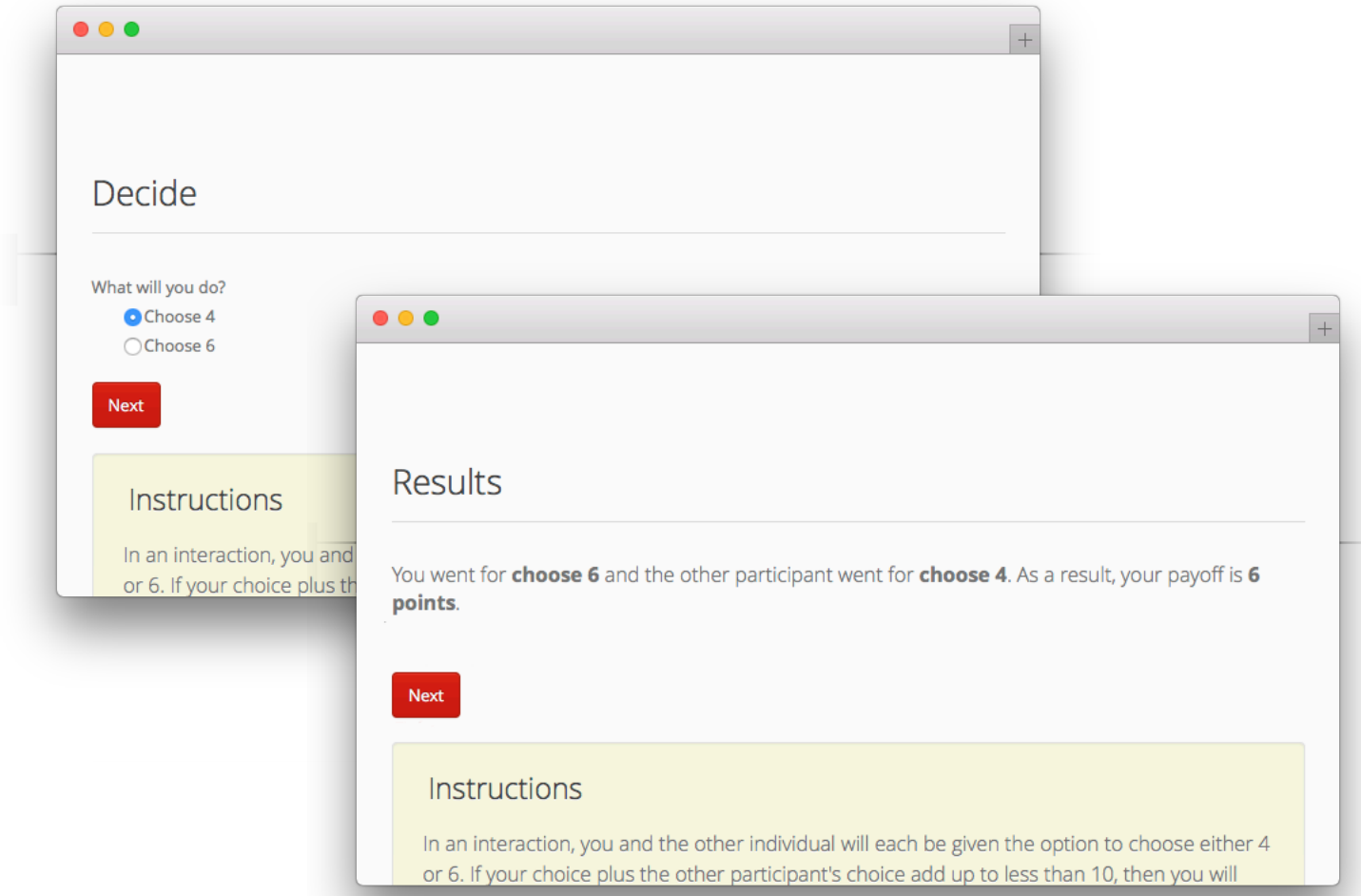


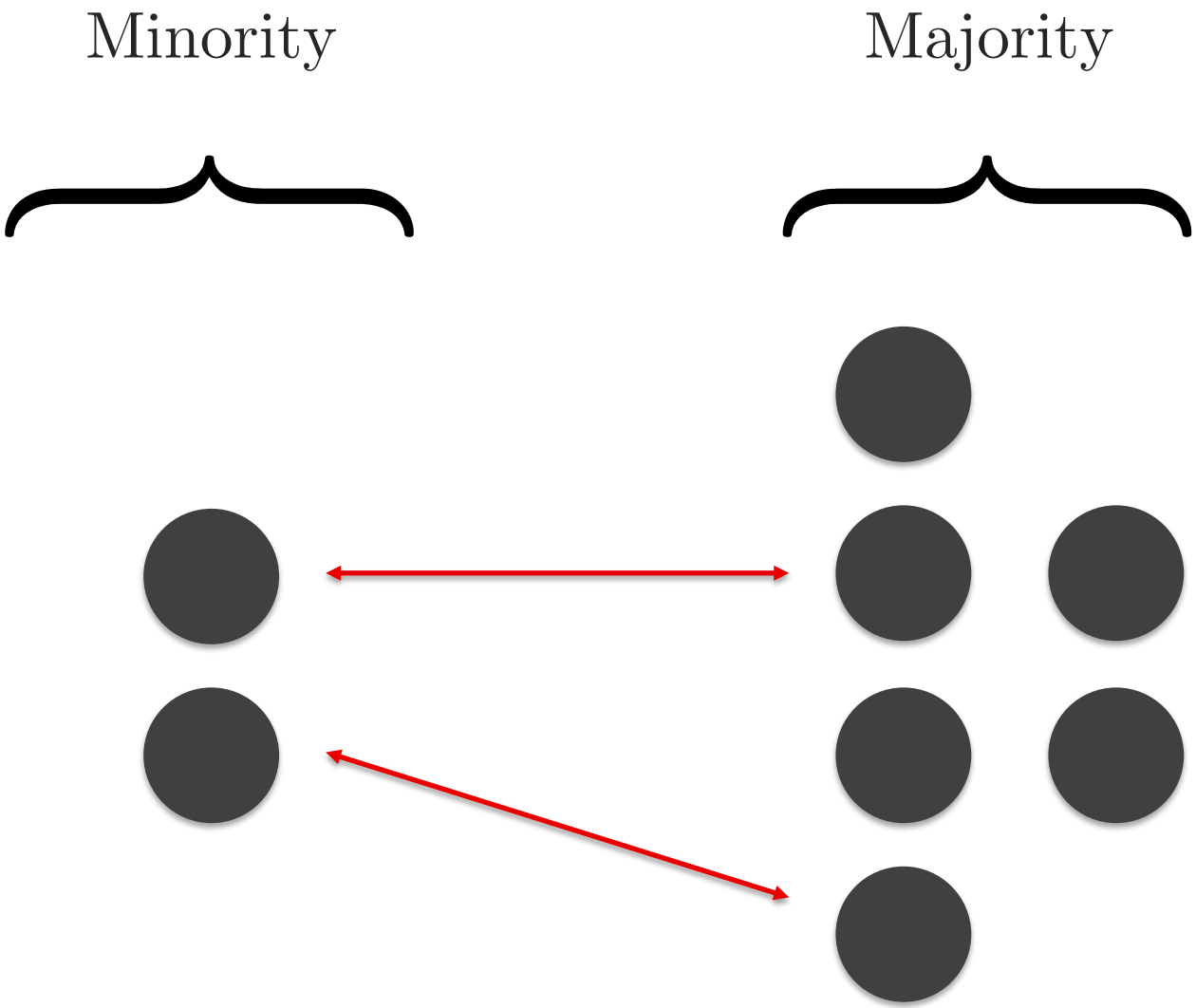
Majority



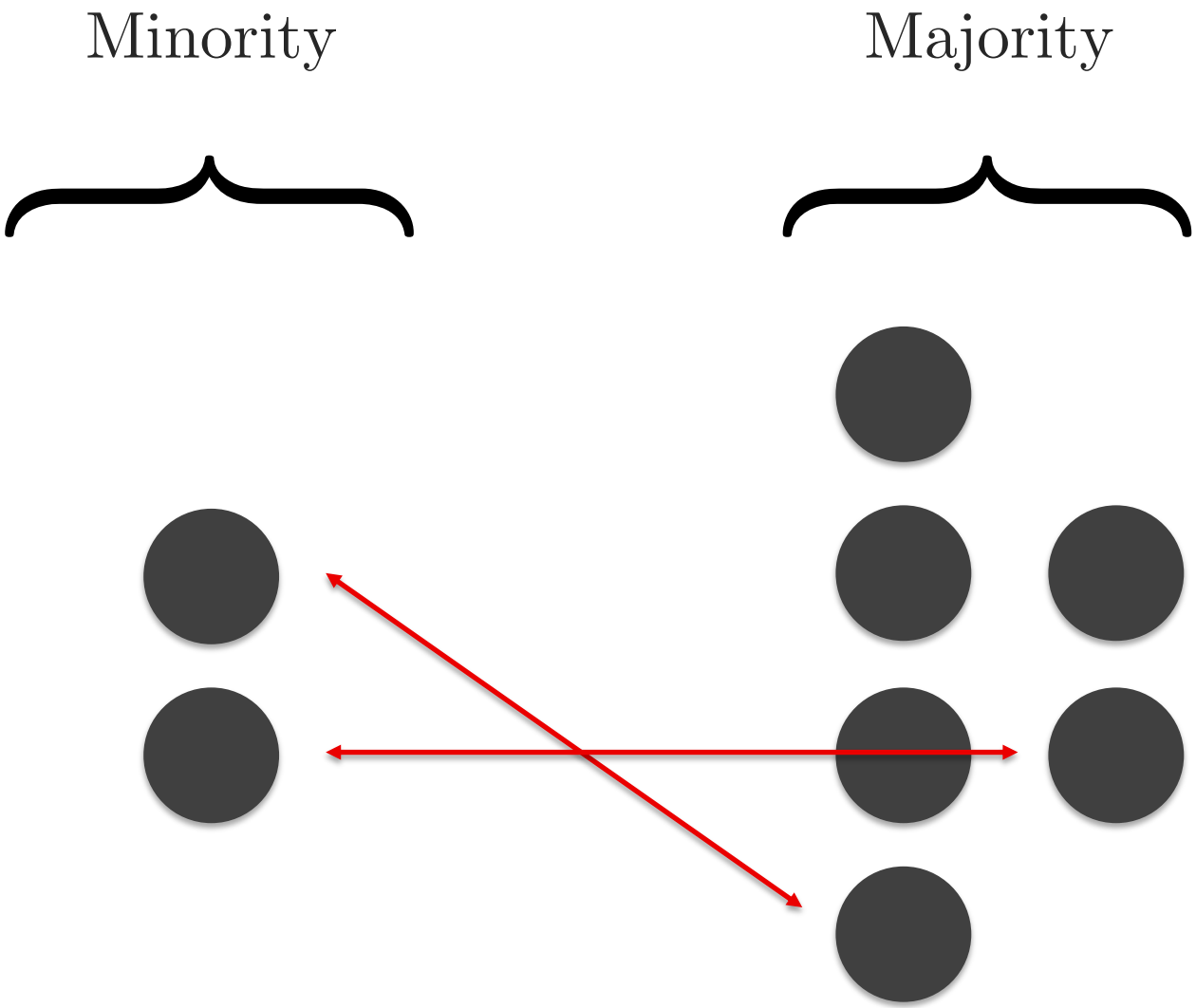


Round 1

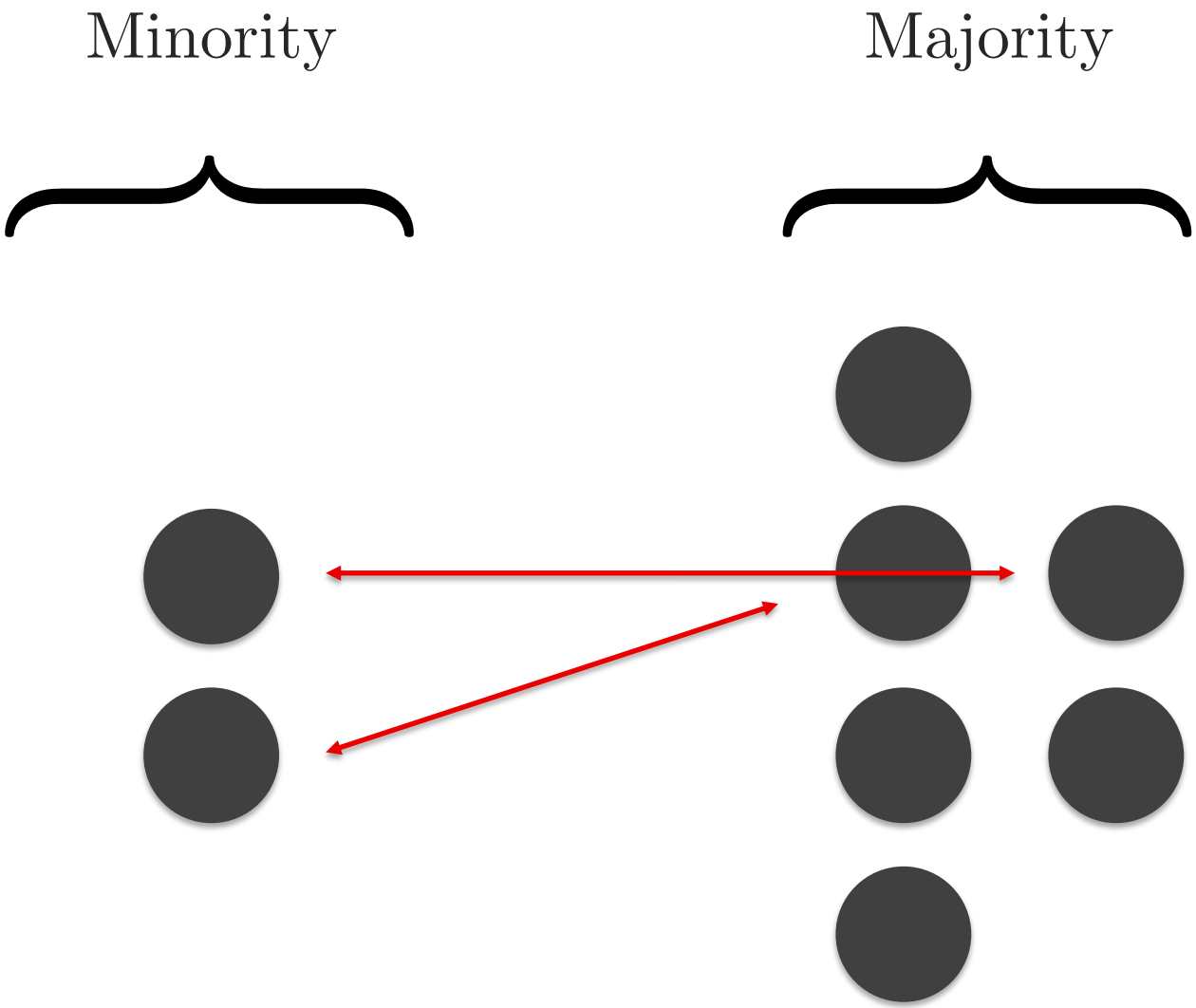

Decide
What will you do?
Choose 4
Choose 6
Next
Instructions
In an interaction, you and
or 6. If your choice plus th
Results
You went for **choose 6** and the other participant went for **choose 4**. As a result, your payoff is **6 points**.
Next
Instructions
In an interaction, you and the other individual will each be given the option to choose either 4 or 6. If your choice plus the other participant's choice add up to less than 10, then you will



Round 1



Round 2



Round 2

100 total rounds

Minority

Play 100 rounds

Majority

Play 33 rounds

Session duration

< 30 minutes

Session payment

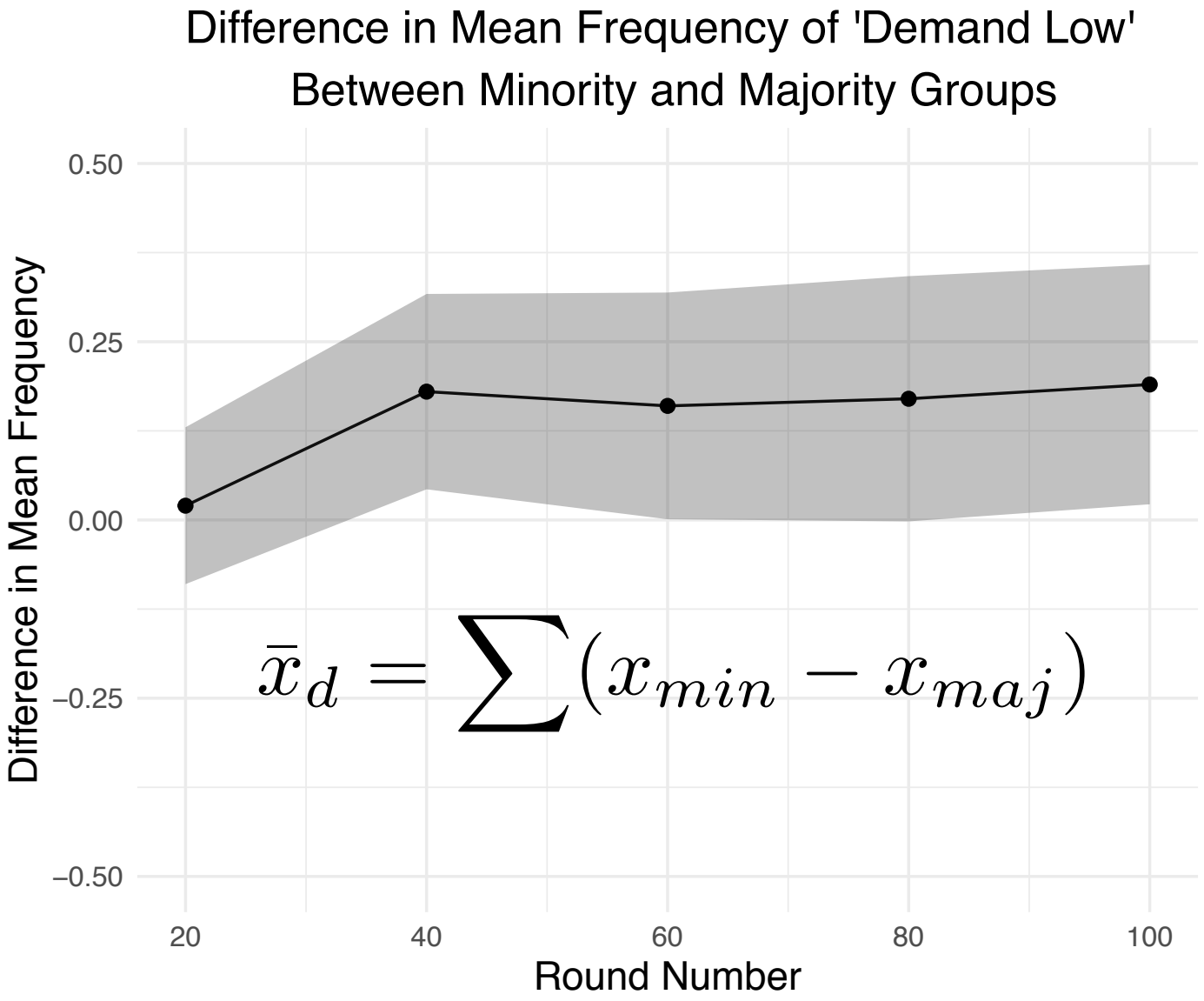
Show up pay : \$7

Performance : \$0 to 6\$

5 Results and Analysis

Prediction 1: **Minority Disadvantage**

Minority groups will end up playing 'demand low' with greater mean frequency than majority groups.


Difference in Mean Frequency of 'Demand Low'
Between Minority and Majority Groups
Difference in Mean Frequency
0.50
0.25
0.00
−0.25
−0.50
20
40
60
80
100
Round Number
$\bar{x}_d = \sum (x_{min} - x_{maj})$

Prediction 1: **Minority Disadvantage**

$$\bar{x}_d = 0.19$$

$$s_{\bar{x}_d} = 0.05$$

Prediction 1: **Minority Disadvantage**

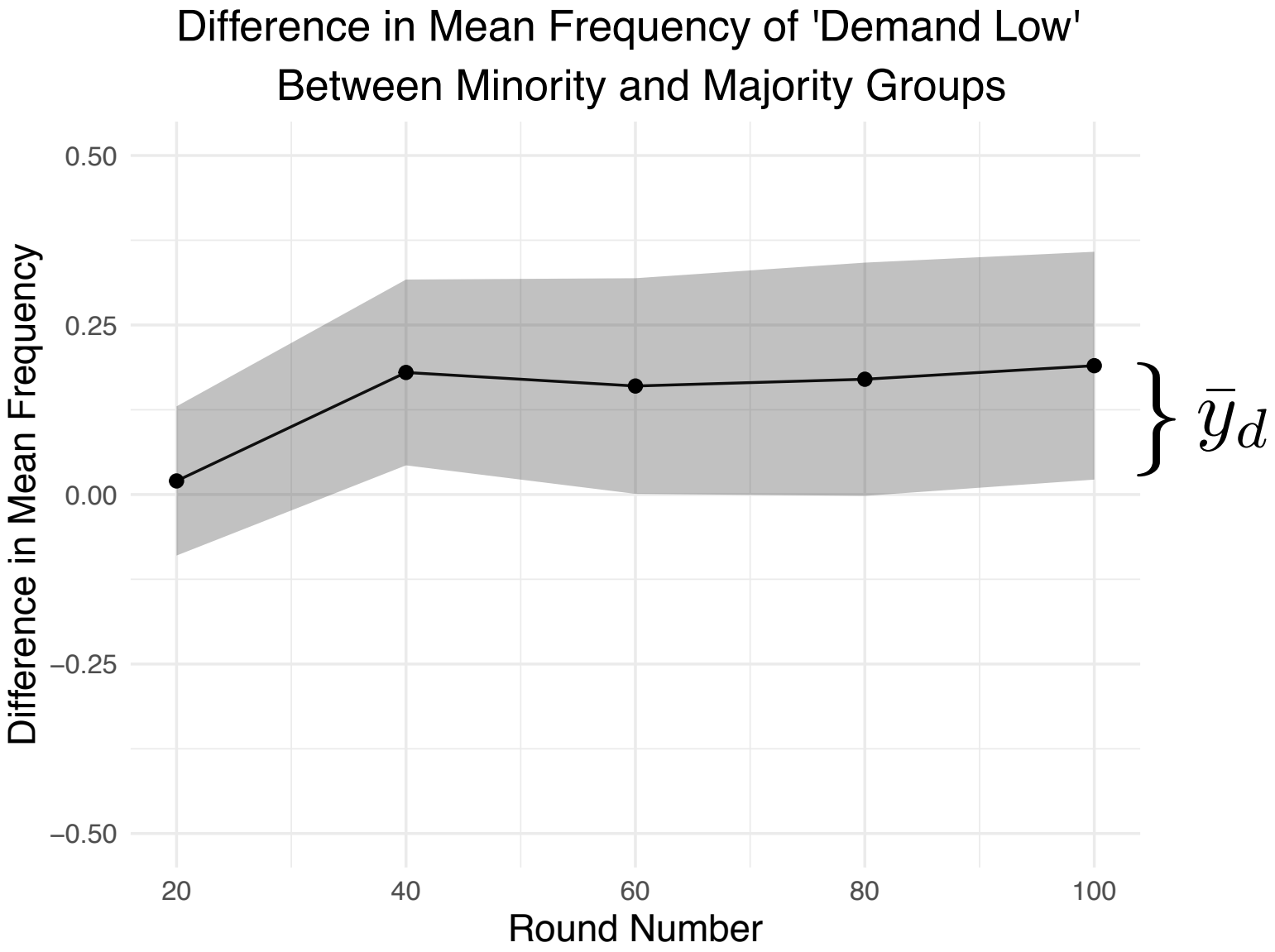
$$p = 0.04$$

$$1 - \beta = 0.58$$

$$BF = 7.22$$

Prediction 2: **Progressive Disadvantage**

The *difference in mean frequency* of minority groups and majority groups playing 'demand low' *will increase* over the course of play.


Difference in Mean Frequency of 'Demand Low'
Between Minority and Majority Groups
Difference in Mean Frequency
0.50
0.25
0.00
−0.25
−0.50
20
40
60
80
100
Round Number
$\bar{y}_d$

Prediction 2: **Progressive Disadvantage**

$$\bar{y}_d = 0.17$$

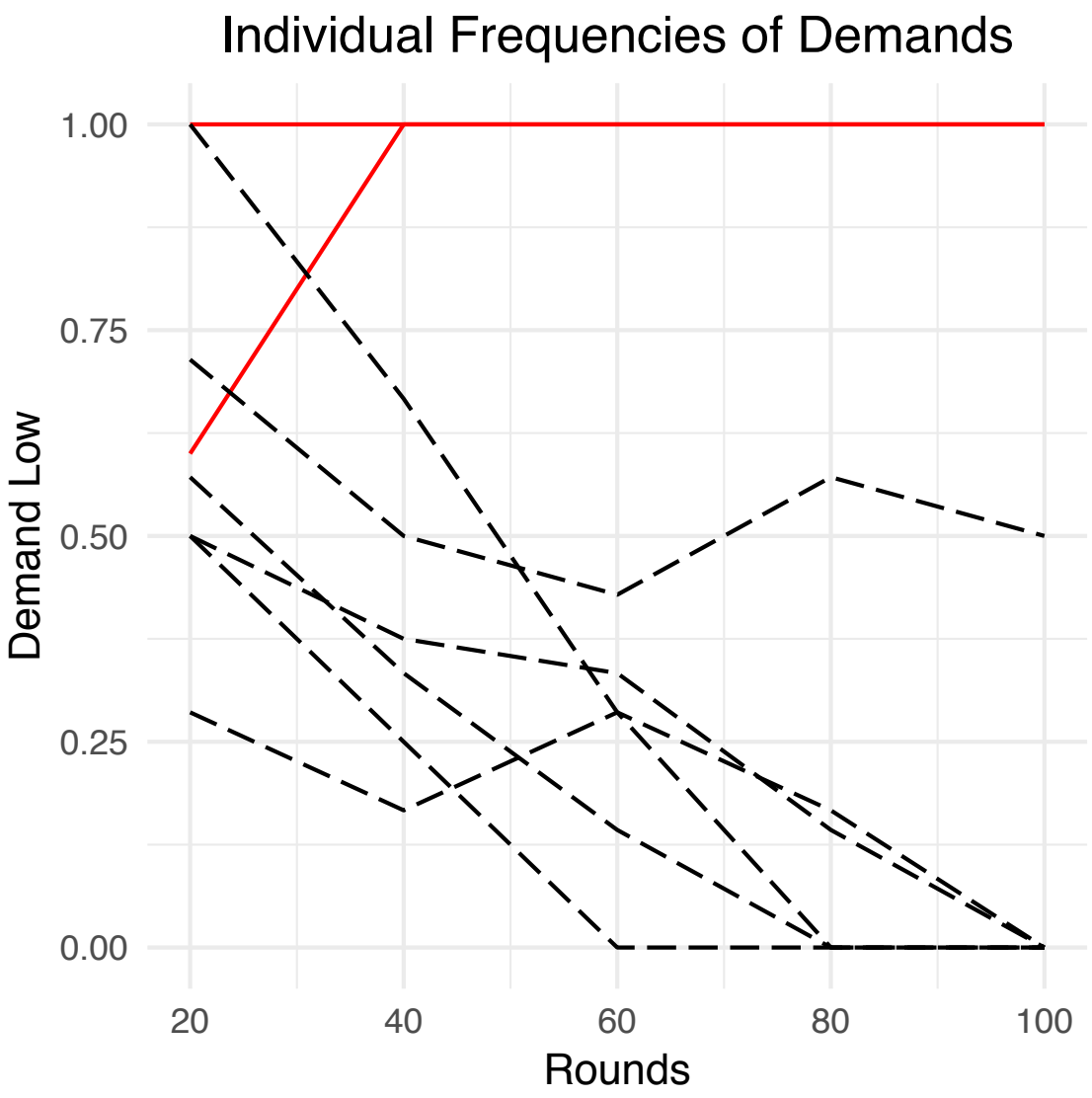
$$s_{\bar{y}_d} = 0.02$$

Prediction 2: **Progressive Disadvantage**

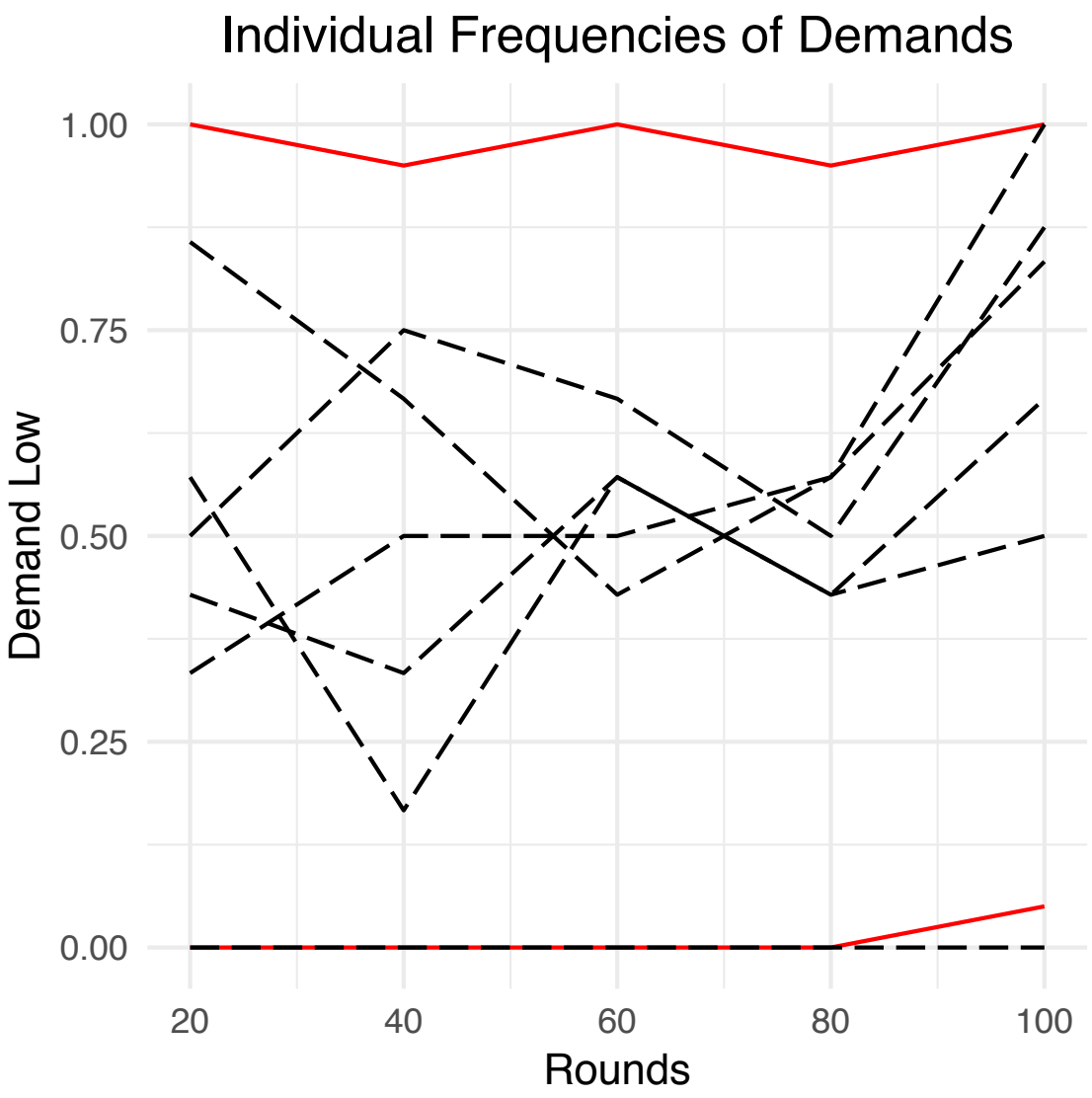
$$p = 0.03$$

$$1 - \beta = 0.63$$

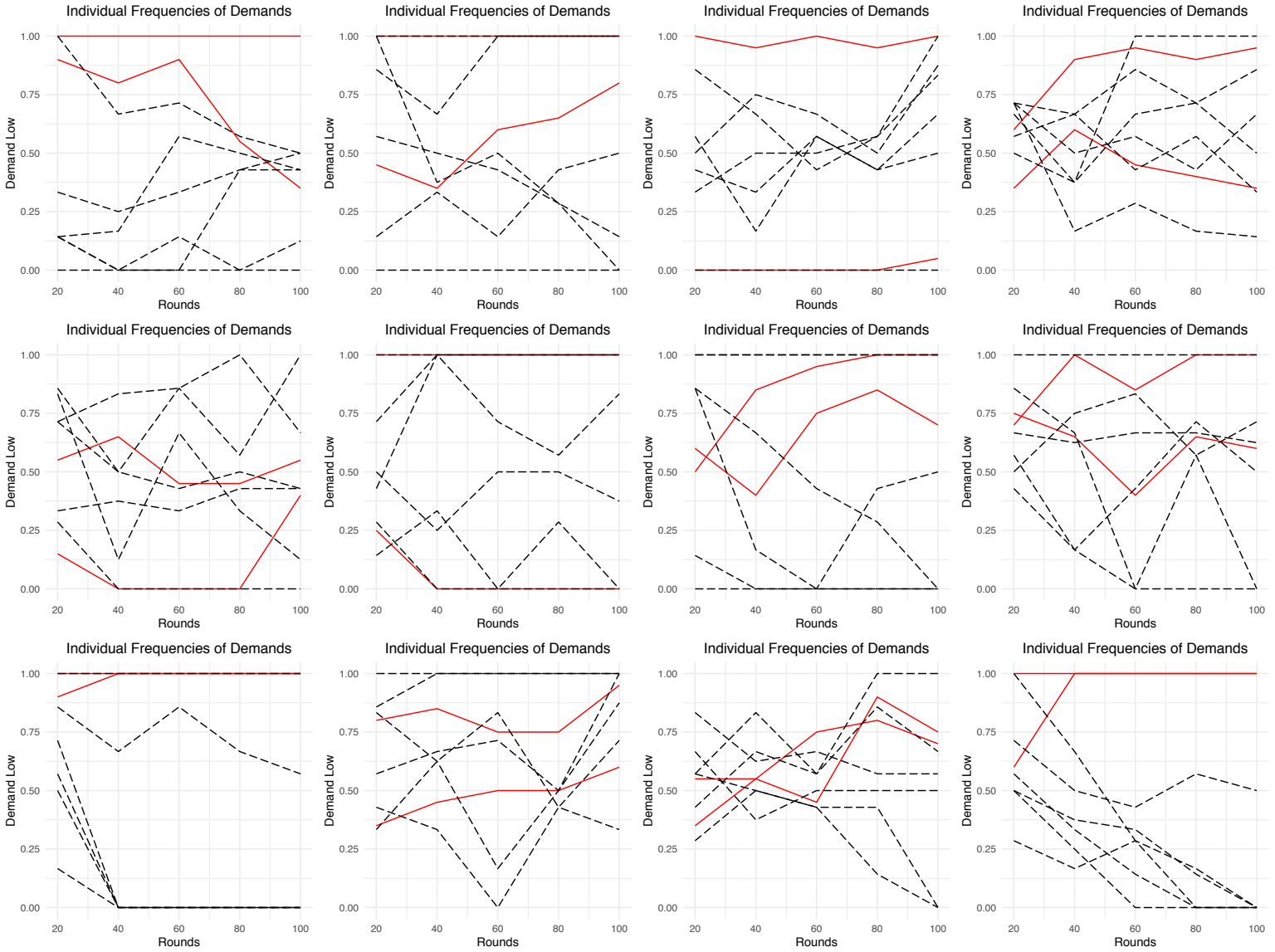
$$BF = 35.62$$

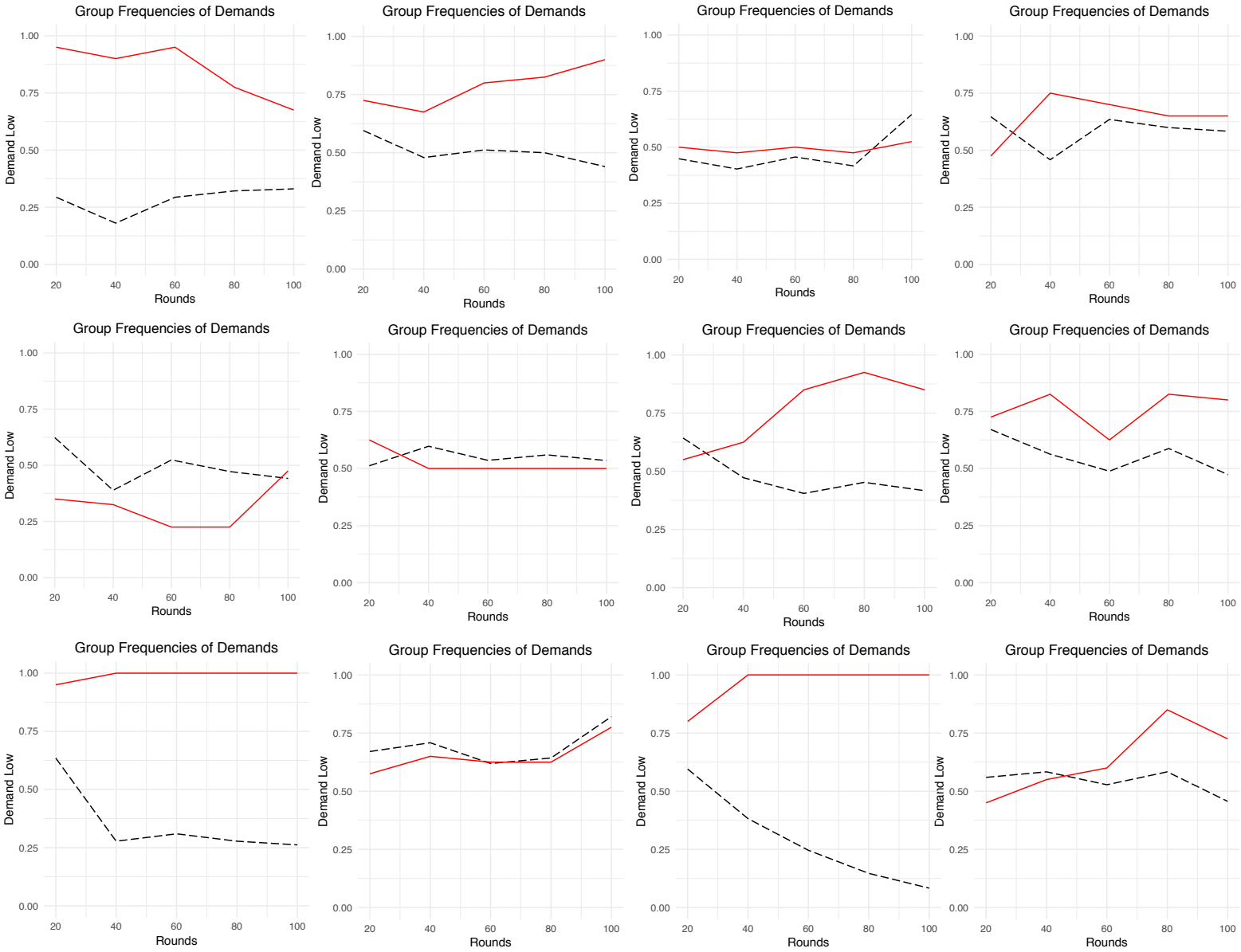


Minority group (——) Majority group (– – –)



Minority group (——) Majority group (– – –)


Individual Frequencies of Demands
Demand Low
Rounds
0.00
0.25
0.50
0.75
1.00
20
40
60
80
100

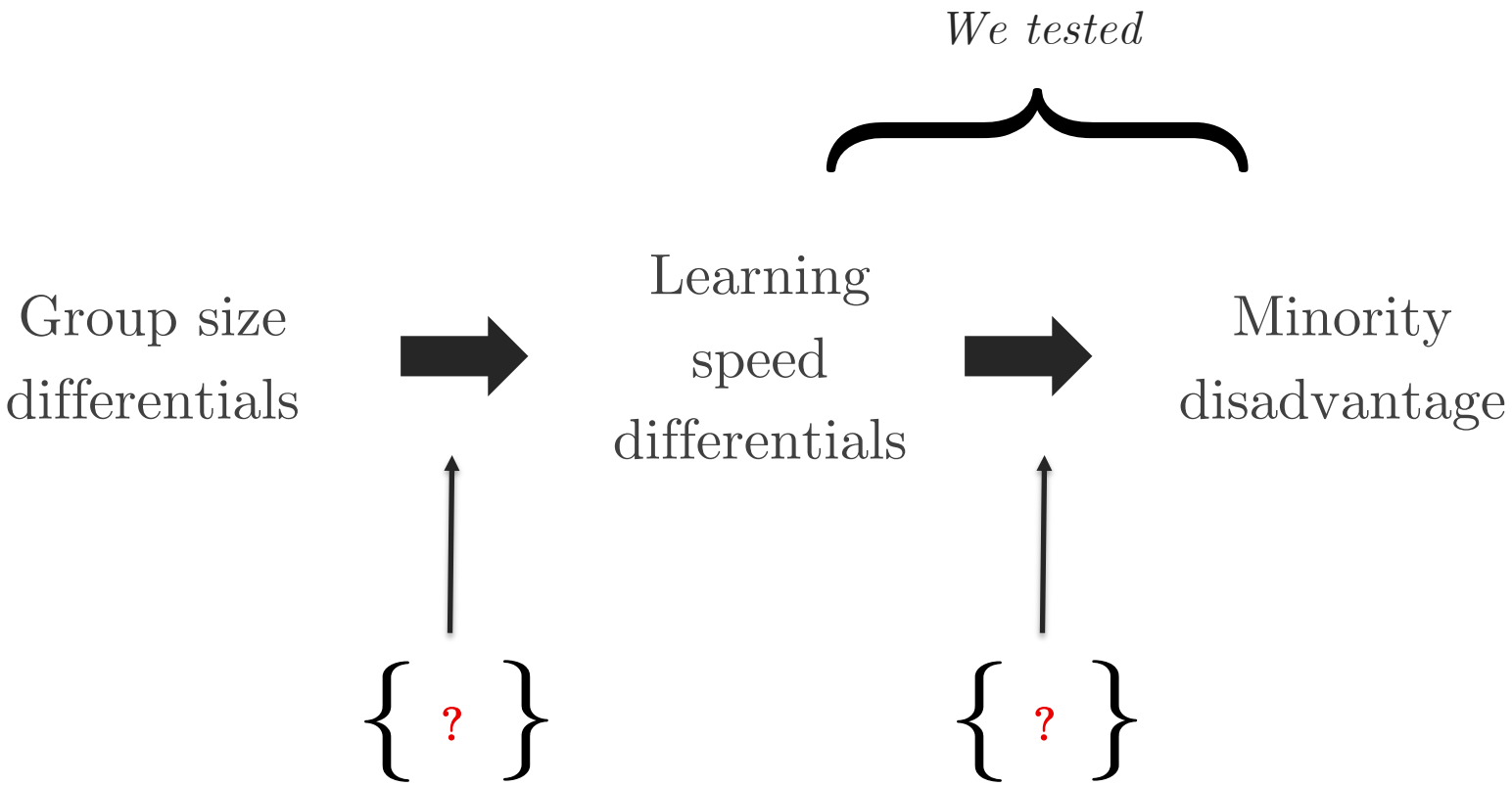

Group Frequencies of Demands
Demand Low
Rounds
0.00
0.25
0.50
0.75
1.00
20
40
60
80
100

6 Discussion

How to update one's credences given our results

(via Bayes', of course)

Cultural Red King Hypothesis



All of our data are available at:
`https://osf.io/mtc9f`

Thank you.

Award No. 1535139 for *Social Dynamics and Epistemic Communities*