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**Neuroeconomics of Social Decision-Making:
Insights into Contagion, Conformity, and
Behavioral Dynamics through Event-
Related Potentials Analysis**

Doctoral thesis



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Warsaw, April 2025

Acknowledgments

I am immensely grateful to the many extraordinary individuals who made this journey possible.

I extend my deepest thanks to **Professor Maciej Kamiński** for his steadfast guidance and unwavering support throughout my doctoral studies at the University of Warsaw. His intellectual rigor and kindness have profoundly shaped my academic path.

I am deeply grateful to **Professor Reza Khosrowabadi** for his mentorship and for providing access to laboratory facilities essential for EEG data collection. His expertise and generosity were indispensable to the success of this research.

I also wish to thank **Professor Vahabi** at the NBIC Institute in Tehran for his insightful mentorship and for deepening my understanding of the complexities of neuroscience.

Special thanks to **Mohammad Rabiee** for his invaluable assistance in coding the experimental tasks, and to **Fahimeh Parsaiee** for her expertise with ERP lab software—both of which significantly advanced the quality and precision of my work.

To my beloved family: thank you for your boundless love, unwavering faith, and endless support. You have been my constant source of inspiration and motivation.

This dissertation is not the product of solitary effort, but a testament to the collective encouragement, generosity, and wisdom of these remarkable individuals.

Finally, I am profoundly indebted to the music of **J.S. Bach, A. Vivaldi, F. Chopin, and P.I. Tchaikovsky**—along with many other great composers—whose Baroque clarity and Romantic expressiveness have sustained me with focus, comfort, and inspiration throughout my academic life, and especially during the writing of this work.

Author's Note on Revision

During the pre-defense review of my dissertation, the examiners correctly highlighted some errors and areas needing clarification. These have been addressed in the following published article. As the article itself is immutable in its published form, this note serves to officially acknowledge and correct these oversights. I thank the examiners for their meticulous review. It is important to emphasize that these issues are purely formal and do not affect the study's main findings, data interpretations, or conclusions.

For:

“Exploring the Neuropsychological Basis of Behavioral Contagion During Learning about Another Agent’s Social Preferences: Evidence from an ERP Study”

The following corrections should be noted:

1-In-text Citation: The in-text citation (Richardson & Marsh, 2014) is incorrect and should be changed to (Richardson et al., 2014).

2-Missing Reference: The reference list omits the full citation for Keynes (1936). The complete reference should be:

Keynes, J. M. (1936). *The General Theory of Employment, Interest and Money*. London: Macmillan.

3-Grammatical Error: The sentence “We conducted a paired t-test was performed” contains a grammatical error. It should be corrected to: “A paired t-test was performed.”

4- Some electrodes shown in Figure 5 (PO4, CP6, P6) are excluded from analysis.

PO4 is located near O2, CP6 is adjacent to CP4, and P6 is close to P8, with all these electrodes situated in the right posterior region of the scalp. Their pronounced activation in the topographical map (Figure 5) indicates that neural activity associated with social contagion extends beyond the core right posterior ROI (CP4, TP8, P4, P8, O2) to include neighboring areas such as PO4, CP6, and P6.

5-For:

“Behavioral and Biological Bases of Herding and Conformity. Basic and Clinical Neuroscience.”

The following correction should be noted:

Figure 1 presents publication trends for 'social conformity' based on a PubMed search conducted in August 2022.

6-For:

“The Role of Attention in Social Decision-Making: An Eye-Tracking Study in a Repeated Dictator Game.”

The variable RSV (Relative Self-View) is defined as follows:

The Relative Self-View (RSV) —a metric we used to quantify how much visual attention participants allocated to their own payoff option compared to the other person's option across all trials.

Specifically, RSV is defined as:

$$RSV = \frac{Time_{Self}}{Time_{Self} + Time_{Other} + Time_{Elsewhere}}$$

Time self: total time (or proportion of time) spent looking at the self option area of interest (AOI).

Time other: total time (or proportion) spent looking at the other option AOI.

Time Elsewhere: total time spent outside both AOIs (e.g., on blank screen regions).

This measure yields a value between 0 and 1, for example $RSV > 0.5$ bias toward self and $RSV < 0.5$ bias toward other.

By using this metric, we normalize the data such that the results are independent of total viewing time or trial duration, thereby focusing on the relative allocation of attention between the self and other options.

Data and Code Availability

This repository contains the high-quality figures and allocation lists detailing the binary choices for the paper:

Neuropsychological Basis of Behavioral Contagion During Learning about Another Agent's Social Preferences: Evidence from an ERP Study

<https://github.com/PedramPersian/Neuroeconomics-of-Social-Decision-Making.git>

All data and analysis code used in this dissertation are available from the author upon reasonable request.

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Research accomplishments

My thesis consists of three published articles, one under review, and a conference paper. Together these works provide a comprehensive picture of how people align their behaviors and attitudes with others, emphasizing the intricate dynamics of social influence in decision-making. These studies explore the interplay between biological, psychological, and social factors that shape individual choices and behaviors. The five studies are listed below, and document key steps in my research. They collectively represent the complete scientific journey, from defining the research questions to designing and performing original experiments, which form the foundation of this dissertation.

1. **Deldoost, M.** (2024). *Behavioral and Biological Bases of Herding and Conformity*. *Basic and Clinical Neuroscience*. Volume 15, Issue 4 (July & August 2024), <https://doi.org/10.32598/bcn.2022.4654.1> (IF 1.4, MEiN 70¹).
2. **Deldoost, M., Khosrwoabadi, R. & Kaminski, M.** (2024). *Exploring the Neuropsychological Basis of Behavioral Contagion During Learning about Another Agent's Social Preferences: Evidence from an ERP Study* (IF 2.244, MEiN 70). *Acta Neurobiol Exp* 2024, 84, <https://doi.org/10.55782/ane-2024-2500>
3. **Deldoost, M., Oloumi, E., Rabiei, M., Khosrowabadi, R., Vahabie, A.** *The Role of Attention in Social Decision-Making: An Eye-Tracking Study in a Repeated Dictator Game*. (Under review)
4. **Deldoost, M., Saeedi, M. T.** (2021). *Investigating Role of Social Value Orientation in Individual's Decision-Making: Evidence from the Ultimatum Game* (Conference paper published in *Eurasian Studies in Business and Economics*, Springer Nature), https://doi.org/10.1007/978-3-030-71869-5_4
5. **Roy, R. K., Deldoost, M. H. & Yonk, R.** (2025). *The confluence of humanomics and neuroeconomics on economic cooperation*. Accepted for presentation at the Menard Family Center for Economic Inquiry Summer Research Seminar on Humanomics: The Opportunities and Challenges of Modeling Humans with Moral Sentiments, Omaha, US, June 17-18, 2025.

¹ 1 IF refers to the impact factor of the journal, whereas MEiN refers to the number of points on the list of Polish Ministry of Education and Science (<https://www.gov.pl/web/edukacja-i-nauka/komunikat-ministra-edukacji-inauki-z-dnia-1-grudnia-2021-r-w-sprawie-wykazu-czasopism-naukowych-i-recenzowanych-materialow-zkonferencji-miedzynarodowych>).

Streszczenie

Zrozumienie dynamiki konformizmu i zarażania społecznego jest kluczowe dla współczesnych interakcji społecznych i ekonomicznych. Zjawiska te w istotny sposób wpływają na procesy decyzyjne, oddziałując zarówno na jednostki, jak i na zbiorowości. Niniejsza rozprawa doktorska analizuje te złożone relacje, aby rzucić światło na ich wpływ w ramach neuroekonomii – interdyscyplinarnego obszaru badawczego na styku psychologii, neuronauk i ekonomii.

Głównym zagadnieniem naukowym rozprawy jest kwestia, w jaki sposób zarażenie społeczne i konformizm kształtują decyzje społeczne i ekonomiczne na poziomie behawioralnym oraz neuropsychologicznym. Na wstępie badań zidentyfikowałem istotną lukę w literaturze przedmiotu: mimo że wiadomo, iż konformizm i zarażenie wpływają na podejmowanie decyzji, dotychczas nie podjęto dogłębnych prób zbadania mechanizmów neuronalnych leżących u podstaw tych zachowań społecznych w kontekście ekonomicznym – szczególnie w odniesieniu do preferencji altruistycznych (other-regarding preferences).

Rozprawa osadzona jest w dziedzinie behawioralnej mikroekonomii, której celem jest oparcie analizy ekonomicznej na rzeczywistych procesach decyzyjnych ludzi. Praca nie tylko wskazuje na istotną lukę w dotychczasowych badaniach, ale także proponuje nowatorskie podejście teoretyczne i eksperymentalne do jej wypełnienia.

Głównym celem jest zidentyfikowanie neuropsychologicznych sygnatur konformizmu i zarażania społecznego oraz wykazanie, w jaki sposób aktywność mózgową i procesy uwagi są modulowane podczas oddziaływań społecznych. W tym celu zastosowałem multimodalne podejście w ramach dwóch odrębnych, lecz uzupełniających się badań:

- eksperymentów z wykorzystaniem EEG, zapewniających wysoką rozdzielczość czasową dynamiki neuronalnej,
- badań z zastosowaniem eye-trackingu, dostarczających precyzyjnych miar uwagi wzrokowej i przetwarzania poznawczego.

Łącznie metody te umożliwiają głębsze zrozumienie tego, w jaki sposób wybory jednostek kształtowane są zarówno przez środowisko społeczne, jak i wewnętrzne procesy poznawcze.

W oparciu o tę lukę w literaturze sformułowałem następujące pytania badawcze:

- Jakie są neuronalne i poznawcze mechanizmy prowadzące jednostki do dostosowywania swojego zachowania do zachowań innych?

- W jaki sposób zarażenie społeczne i konformizm wpływają na procesy decyzyjne na poziomie mózgu?

W powiązonym badaniu z wykorzystaniem eye-trackingu zbadalem również procesy uwagi i fizjologiczne leżące u podstaw decyzji prospołecznych:

- W jaki sposób jednostki alokują uwagę wzrokową, gdy muszą dokonać wyboru między opcjami egoistycznymi a prospołecznymi?
- Czy alokacja uwagi różni się w zależności od rodzaju nierówności (korzystnej czy niekorzystnej dla decydenta)?

Mając te pytania na uwadze, zaprojektowałem rygorystyczną ramę eksperymentalną. Opracowałem serię eksperymentów wykorzystujących technologię EEG oraz eye-tracking w celu monitorowania aktywności mózgowej i wzorców spojrzenia podczas badania zarażenia społecznego i konformizmu, co umożliwiło szczegółową analizę leżących u ich podstaw procesów neuronalnych i behawioralnych. Dane EEG zostały zebrane w laboratorium Uniwersytetu Szahida Beheshti (SBU), natomiast dane z eye-trackingu – w laboratorium ... (NBIC). Ze względu na ograniczenia techniczne i organizacyjne laboratoriów, dane te zostały zebrane od dwóch odrębnych grup uczestników wykonujących to samo zadanie eksperymentalne. Choć idealnym scenariuszem byłoby jednoczesne przeprowadzenie obu pomiarów, ograniczenia praktyczne uczyniły to niemożliwym. Wyniki uzyskane każdą z metod zostały przedstawione w odrębnych publikacjach stanowiących podstawę niniejszej rozprawy.

Integrując perspektywy behawioralną i neuropsychologiczną, moje badanie ma na celu zakwestionowanie tradycyjnego pojęcia racjonalności dominującego w dyskursie ekonomicznym. Chciałbym w ten sposób przyczynić się do rozwoju neuroekonomii oraz pogłębić zrozumienie relacji ekonomicznych w coraz ściślej powiązanim świecie.

Ponadto, poprzez zastosowanie ram neuroekonomicznych, dążę do podkreślenia ich potencjału w badaniu decyzji ekonomicznych, także poza zakresem moich badań. Dziedzina ta stanowi pomost łączący funkcjonowanie mózgu z wynikami ekonomicznymi, co może w przyszłości prowadzić do stworzenia bardziej kompleksowych i realistycznych modeli ludzkiego podejmowania decyzji w różnorodnych kontekstach.

Na zakończenie przedstawiony zostanie zwięzły przegląd czterech kluczowych artykułów, które tworzą fundament niniejszej rozprawy doktorskiej.

Abstract

Understanding the dynamics of conformity and contagion is essential in today's social and economic interactions. These phenomena substantially influence decision-making processes, impacting both individuals and collectives. My dissertation explores these complex relationships to shed light on how they manifest within the framework of neuroeconomics—an interdisciplinary field emerging at the intersection of psychology, neuroscience, and economics.

The central scientific problem addressed in this thesis is how contagion and conformity shape social and economic decision-making at both behavioral and neuropsychological levels. At the outset of my research, I identified a critical gap in the literature: while conformity and contagion are known to affect decision-making, there has been insufficient exploration of the neural mechanisms underlying these social behaviors in an economic context—particularly in relation to other-regarding preferences.

This thesis is situated within the domain of behavioral microeconomics, which seeks to ground economic analysis in the actual decision-making processes of real people. It not only identifies a significant gap in the existing literature but also proposes a novel theoretical and experimental approach to address it.

The primary goal is to uncover the neuropsychological signatures of conformity and contagion and to demonstrate how brain activity and attentional processes are modulated during these social influence effects. To achieve this, I employed a multimodal approach across two distinct but complementary studies:

- EEG experiments, offering high temporal resolution of neural dynamics
- Eye-tracking studies, providing precise measures of visual attention and cognitive processing

Together, these methods allow for a deeper understanding of how individuals' choices are shaped by both their social environment and internal processes.

Based on this gap in the literature, I formulate the following research questions:

- What are the neural and cognitive mechanisms that drive individuals to align their behavior with that of others?

- How do social contagion and conformity influence decision-making processes at the level of the brain?

In a related study using eye-tracking, I explored attentional and physiological processes underlying prosocial decision-making:

- How do individuals allocate visual attention when deciding between self-serving and prosocial options?
- Does attentional allocation differ depending on the type of inequality (advantageous vs. disadvantageous)?

With these questions in mind, I designed a rigorous experimental framework. I developed a series of experiments using EEG technology and eye-tracking, to monitor brain activity and gaze patterns during instances of social contagion and conformity, enabling a precise examination of the underlying neural and behavioral processes. The EEG data were collected at the SBU laboratory, while the eye-tracking data were gathered at the NBIC laboratory. Due to laboratory constraints, these data were collected from two separate groups of participants performing the same experimental task¹. While the ideal scenario would have been to conduct both measurements simultaneously, practical limitations made this unfeasible. The findings from each method are presented in distinct publications within this thesis.

By integrating behavioral and neuropsychological perspectives, my study aims to challenge the conventional notion of rationality that dominates economic discourse. In doing so, I seek to contribute to the growing field of neuroeconomics and to advance our understanding of economic relationships in an increasingly interconnected world.

Furthermore, by applying the neuroeconomics framework, I aim to highlight its potential to investigate economic decision-making beyond the scope of my specific research. This field provides a powerful bridge between brain function and economic outcomes, which could ultimately lead to more comprehensive and realistic models of human decision-making across diverse contexts.

Finally, a summary of the four key articles that form the foundation of this thesis will be presented.

¹ To ensure transparency, the exact participant instructions are reproduced in Appendix D (Experiment Instruction).

1. Behavioral Economics and Neuroeconomics: Alternatives or Complementary Approaches to Conventional Economics?

*“The sciences have developed in an order the reverse of what might have been expected. What was most remote from ourselves was first brought under the domain of law, and then, gradually, what was nearer: first the heavens, next the earth, then animal and vegetable life, then the human body, and last of all (as yet very imperfectly) the human mind.” — Bertrand Russell, *Religion and Science* (1935)*

There has been an increasing attention towards behavioral economics as an alternative or complementary for conventional economic models, which presuppose that individual consistently make logical choices. The examination of economic decisions influenced by cognitive biases, emotions, and social factors forms a fundamental aspect of behavioral economics. By acknowledging that individuals don't always behave in a rational manner, behavioral economics offers a more realistic framework for comprehending economic phenomena. Behavioral economists are able to test their theories and policy suggestions by conducting experiments in a controlled laboratory setting (Earl, 2022). This approach enables them to observe actual human behavior instead of relying on assumptions about how people make decisions. Through these experiments, they can collect empirical data to evaluate the accuracy of their theoretical models and improve their policy advice.

Behavioral economics questions the assumption of flawless rationality (*Homo Economicus*) in economic frameworks, stressing the importance of incorporating cognitive biases, heuristics, and limited information processing into economic evaluations. This transformation has spurred the development of alternative models that better capture the complexities of decision-making. Experiments like the Ellsberg and Allais paradoxes have shown that people don't always make completely rational decisions. Later research by Tversky and Kahneman further demonstrated how various cognitive biases and mental shortcuts can influence our choices. These

findings indicate that no one is truly immune to the influence of irrationality (Montibeller & von Winterfeldt, 2024).

Of course, critics of behavioral economics have different opinions. For example, Levin (2012) in his book entitled "Is Behavioral Economics Doomed?" said:

“Unfortunately, psychology is no more perfect than economics. There is evidence, for example, that pigeons are more intelligent than psychologists.”

while such critiques highlight the limitations of behavioral economics, these perspectives also underscore the need for a more integrative approach—one that looks beyond observed behavior to the biological underpinnings of decision-making. Neuroeconomics takes a step further by integrating neuroscience methodologies and principles into examining economic decision-making. Its objective is to uncover the neural mechanisms underlying economic behaviors and explore how brain processes impact economic choices. Through an investigation of the neural basis of decision-making, neuroeconomics provides valuable insights into the biological foundations of economic behavior, thereby offering a finer-grained understanding of the fundamental cognitive processes involved. Introducing these interdisciplinary approaches has led to noteworthy ramifications for conventional economics.

Both behavioral economics and neuroeconomics highlight the impact of social context on decision-making. This realization has enhanced our comprehension of how external factors, including social norms, cultural influences, and environmental cues, influence economic choices.

Neuroeconomics investigation delves into how individuals apprehend, construe, and attribute meaning to economic stimuli and circumstances. This interaction between the objective realm and subjective experience profoundly shapes the decision-making process, ultimately reflecting in observable economic behaviors.

Behavioral economics offers valuable insights. Identifying how individuals deviate from rationality can help policymakers design interventions that promote better choices without restricting freedom. As a result, "nudge theory," which aims to influence behavior positively, has emerged.

Social sciences and neurosciences aim to understand human behavior, but their collaboration is often limited. Neuroeconomics has the potential to bridge this gap by addressing interdisciplinary research challenges, such as forming teams with diverse scientific backgrounds. This field can facilitate discussions and idea exchanges

between neuroscientists and economists (Levallois et al., 2012). Neuroeconomics has facilitated collaboration between economists, psychologists, neuroscientists, and other social scientists. This interdisciplinary approach promotes the fusion of various methodologies and viewpoints, resulting in a more thorough comprehension of economic behavior. Moreover, psychologists can also get benefits from this partnership. A neuroscientific approach contributes to the validity of psychological theories by providing an additional level of evidence (Wu et al., 2016).

Basically, in neuroeconomics, two types of views are commonly held, both ontologically (axiomatic core) and epistemologically. The first view is known as the "incremental" view, which seeks to enhance economic theories and decision-making models by incorporating findings from neuropsychology. This approach, described as behavioral economics in the scanner, aims to utilize brain data to substantiate behavioral models as well as improve economists' ability to predict behavior. "Behavior" refers to observed choices. The second perspective is the radical point of view, which not only aims to modify the foundations of traditional economics but also seeks to replace the core principles of mainstream economics. In other words, based on Kuhn's view, this viewpoint represents a shifting paradigm and a revolutionary approach to economics (Camerer, 2007; Fumagalli, 2010; Marchionni & Vromen, 2014; Sanfey et al., 2006).

Some challenges remain despite these efforts. Neuroscientists usually collaborate in large groups, while economists tend to work in smaller teams. Additionally, the peer review process in economics journals is typically longer than that in neuroscience journals (Levallois et al., 2012). To strengthen the integration of neurosciences and social sciences, ongoing efforts are needed to address the gaps in research practices, publication norms, and collaborative models. By cultivating greater mutual understanding and appreciation for the complementary strengths of these disciplines, the potential of interdisciplinary research in revealing the complexities of human behavior can be fully realized.

Despite behavioral and neuroeconomics' prominence, they have not entirely replaced traditional economic theories. Instead, they complement existing theories, offering a more nuanced comprehension of economic behavior. According to Loewenstein and Ubel (2010) as well as Levin (2012), behavioral economics should complement, not substitute for, more substantive economic interventions.

Incorporating these disciplines into mainstream economics signifies a continuous evolution and enhancement of economic analysis. Whether this evolution will culminate in a comprehensive scientific revolution in economics is uncertain, but it undeniably marks a significant departure in the discipline's paradigms and methodologies. Nevertheless, traditional economic models remain influential, and assimilating insights from behavioral and neuroscientific perspectives is an ongoing process.

Furthermore, Milton Friedman's influential essay on positive economics has significantly shaped the discipline. Friedman's work has encouraged economists to adopt a more instrumentalist and positive approach, prioritizing empirical testing and prediction as critical components of economic analysis. As a result, a significant number of economists maintain the belief that Samuelson's revealed preferences, utility function basis, and Friedman's instrumentalist methodology form a unified theoretical-methodological framework that underpins economic explanations. This perspective suggests that there is no need for additional scientific resources, as these components are considered sufficient. Furthermore, they hold the belief that economic hypotheses cannot be falsified through the use of neuropsychological and neurophysiologic data. (Davis, 2016; Gul & Pesendorfer, 2011; Koshovets & Varkhotov, 2019).

The dominance of mainstream economics is not merely a matter of theoretical prevalence but is deeply rooted in systems of prestige, institutional influence, and exclusionary practices (Dequech, 2007). As Fourcade et al.(2015) argue, mainstream economics is defined less by a fixed set of assumptions and more by its association with elite institutions—such as Harvard, MIT, and Chicago—where methodological conformity and hierarchical structures reinforce a narrow, neoclassical paradigm. This concentration of influence shapes both research agendas and curricula worldwide, privileging mathematical formalism and rational choice theory while marginalizing alternative approaches. The character of scientific discourse in economics thus diverges significantly from other social sciences, where theoretical pluralism is more readily accepted; instead, economics remains dominated by a single, hegemonic framework that shapes both teaching and research. This institutionalized uniformity has been widely critiqued, notably in the International Student Initiative for Pluralism in Economics (2014), where over 65 student

associations from 30 countries issued a joint call for curricular reform, decrying the exclusion of heterodox traditions and the lack of interdisciplinary and methodological diversity in economics education. Empirical evidence further supports this critique: citation pattern analyses reveal that heterodox economists publish in increasingly isolated networks, constituting only a small fraction of the discipline and often excluded from top journals and departments (Aistleitner et al., 2019). Indeed, as scholars have observed, despite growing efforts to institutionalize heterodox economics, their presence in academic departments often remains tokenistic—a symbolic gesture rather than a genuine integration into the mainstream (Lee, 2006). Whether this marginalization can be overcome is still subject to scholarly debate, but the persistent lack of pluralism suggests that the structural dominance of neoclassical economics remains largely unchallenged.

In recent years, scientists from statistical physics have also developed an interest in analyzing economic problems, forming a new discipline whose perspective we will briefly explore next.

2. The Econophysics of Human Social Behavior

Social connections play a vital role in human survival and overall well-being. An inherent and fundamental human need exists to form bonds and engage in social interactions, which is why individuals make efforts to nurture and maintain their relationships with others (Baumeister & Leary, 1995; Eisenberger, 2012; Wasylyshyn et al., 2018).

Within these intricate connections and interactions, social influence emerges as an essential factor in our daily lives and choices. It encompasses various forms, notably conformity, contagion, and herding, which contribute to the assimilation of beliefs, emotions, values, and actions with the viewpoints of others. Consequently, these mechanisms wield a substantial influence in shaping collective behaviors (Levy, 2008; Xie et al., 2016; Zheng et al., 2021) and we may be unaware of the importance these mechanisms hold in guiding our interactions within social and economic contexts (Young, 2015).

Other fields from natural science have also shown a rising interest in economics and social phenomena research. In recent years, physicists have increasingly turned their attention to studying economic phenomena and human crowd behavior, resulting in

the emergence of interdisciplinary fields like econophysics and sociophysics within the realm of orthodox economics. These disciplines aim to model complex human behavior on a large scale. This behavior can be characterized as non-linear and chaotic (Moscardini & Lawler, 2022). They employ techniques from statistical mechanics or statistical physics to study these systems.

Researchers in the fields of econophysics and sociophysics propose that human behavior at the micro level may resemble the random motion of molecules in gases, which is unpredictable. For example, Folmer (1974) recognized that incorporating social effects into microeconomic models could be achieved by utilizing Gibbs' probabilistic framework or equivalently Markov Random Fields. By incorporating random interdependent preferences, his paper examined the necessary conditions for the emergence of a price system within a pure exchange economy. Coincidentally, during the same period, scholars in the social sciences were investigating the impact of one's neighborhood on individual behavior and the tradeoff between micro and macro-level phenomena (Phan et al., 2004). Also, in other research, Mansky (1993) explores the "reflection problem," which emerges when researchers attempt to determine whether the collective behavior of a group impacts the individual behavior of its members due to an endogenous social effect. The Vicsek Model is a model that, originally proposed to explain the dynamics of bird flocking, serves as a framework for modeling collective behavior and self-organizing phenomena in complex systems.

Herd behavior can be modeled using the Ising model, which was originally developed in physics. The model demonstrates how local interactions among magnetic moments (spins) lead to collective alignment and a tendency to move toward a unified state. This model can be directly applied in economics to explain how the decisions of agents, such as consumers and investors, are influenced by the behavior of those around them.¹

Basically, scholars in the field of econophysics argue that collective human behavior, such as herding, can exhibit patterns and regularities akin to physical laws. Nevertheless, skeptics argue that humans are not lacking in intelligence like atoms or molecules, and their behavior is not fully predictable or governed by strict laws like

¹ For more information, please refer to the under-review paper *Beyond Aggregation: How Microeconomic Heterogeneity Shapes Macroeconomic Emergence* by Deldoost, M. H., & Gomes, O.

the motion of physical particles. Moreover, important factors like culture, history, and individual psychology are often overlooked in these models.

Despite these critiques, integrating insights from physics into economic behavior offers a fresh perspective on the dynamics of collective decision-making. Central to this analysis are the roles of social conformity, contagion, and herding, which we explore in greater depth in the following section.

3. Conformity, Contagion and Herding

From a contemporary economic perspective, the influence of sociological and psychological factors on individual behavior and decision-making has been largely disregarded by modern economists (Baddeley, 2010); therefore, in paper one, titled "Behavioral and Biological Bases of Herding and Conformity," I have undertaken a systematic and comprehensive review of the relevant literature from multiple databases and the reference lists of pertinent studies.

The focus of this paper has been on exploring the behavioral and biological foundations of herding and conformity. By considering various perspectives, including psychological, economic, neurobiological, and neurochemical aspects, I have sought to provide a comprehensive understanding of the underlying mechanisms involved in these social phenomena. The review encompasses a detailed definition and description of different forms of social influences, followed by an in-depth investigation of the psychological and economic evidence supporting the occurrence of social influence. Additionally, I have explored the neurobiological and neurochemical approaches employed in studying the intricate dynamics of social influence. Finally, in the conclusion, I have summarized the key findings and underscored three essential points that I believe are crucial for the future development of social neuroscience as an interdisciplinary and vibrant field.

Throughout the papers and this dissertation, we have utilized the terms 'conformity,' 'contagion,' and even 'herding' interchangeably. However, it is crucial to acknowledge the similarities and distinctions between these concepts. This interchangeable usage enables us to emphasize the overarching phenomenon of social influence, wherein the impact of others molds individuals' behaviors, beliefs, and attitudes.

VOSviewer network map (van Eck & Waltman, 2010) was employed to visualize the intellectual structure of research on social influence. Figure 1 depicts the results of the bibliometric analysis conducted on the keywords related to 'social influence' and the corresponding clusters within each of the studied topic areas. The map demonstrates that research on social influence is multidimensional, spanning structural (networks, norms), psychological (emotions, empathy), technological (social media), and situational (Covid-19) perspectives. The centrality of social networks and social influence indicates their role as bridging concepts that link different domains of study.

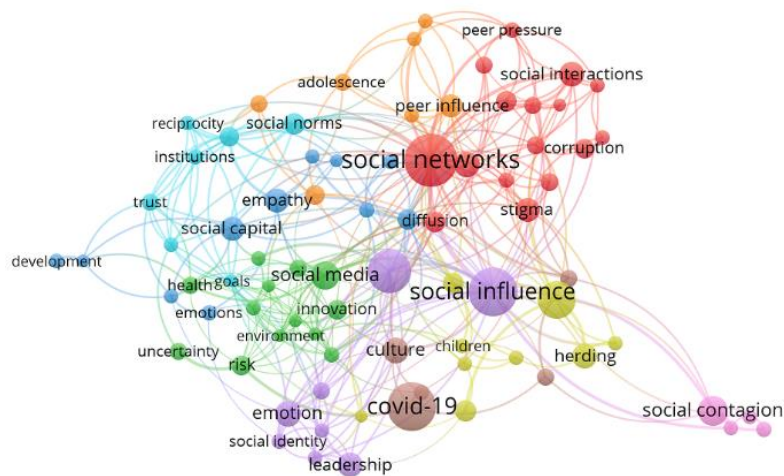


Figure 1 Mapping Clusters of Social Influence Keywords within Topic Areas

4. Neuropsychological Basis of Social Contagion and Conformity

Although the brain and nervous system have been studied for a long time, neuropsychology has grown significantly in the past century, driven by surgical breakthroughs (Sami & Camarata, 2019). This field examines how the brain interacts with the rest of the nervous system on the one hand, and how cognition—including perception, memory, emotion, and social cognition—interacts with behavior on the other (Cohen, 2014; Reddy, 2024).

Neuroscience includes many subdisciplines specialized for the investigation of the nervous system in terms of structure, biochemistry, pharmacology, and pathology. Some of these subdisciplines include neurochemistry, neurobiology, neurogenetics, computational neuroscience, neuroinformatic, and neuroethics, among others. Likewise, in the cognitive domain, there are subfields such as cognitive psychology,

perceptual psychology, cognitive linguistics, and social cognition. Situated in between these fields is cognitive neuroscience, which is a branch of both neuroscience and psychology.

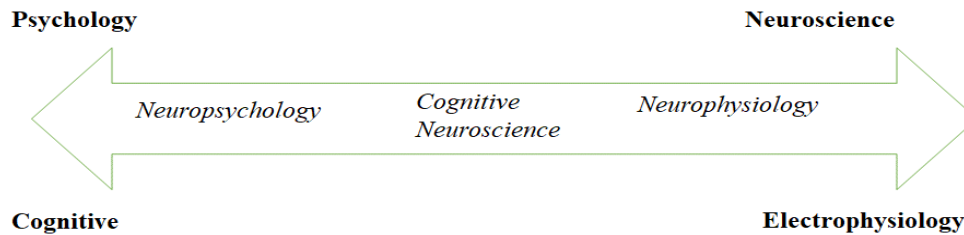


Figure 2 Cognitive - electrophysiology spectrum modified source: Cohen,2014

Social cognition is a complex and multifaceted field of study that explores the perception, processing, interpretation, and response to social information as well as social influence, with the overarching goal of understanding how individuals comprehend their social environments (Frith & Blakemore, 2006; Hunt et al., 2012; Parr, 2010; Pfeiffer et al., 2013; Rote & Smetana, 2011; Shany-Ur & Rankin, 2014).

Conformity and contagion are two types of social influence that are highly similar to each other (Wheeler, 1966). Both involve the adoption of beliefs, feelings, values, and behaviors that align with the opinions of others, and as a result, they have a profound impact on shaping various social behaviors (Levy, 2008; Xie et al., 2016; Zheng et al., 2021).

Despite some behavioral research on contagion and conformity, the current literature needs a comprehensive understanding of the neuropsychological mechanisms underlying these phenomena. In order to fill this gap, our second paper, "Exploring the Neuropsychological Basis of Behavioral Contagion During Learning about Another Agent's Social Preferences: Evidence from an ERP Study," aims to investigate the cognitive and neural basis of social influence. Specifically, in our study, we conducted an analysis of event-related potentials (ERPs) obtained from repeated mini dictator games.¹

We adopted the repeated mini dictator game for several key reasons.

First, its simplicity provides a clean paradigm for studying social decision-making, minimizing strategic complexity and isolating the core act of resource

¹ The full set of allocation schemes is provided in Appendix B (Allocation List).

allocation. This makes it well-suited for cognitive neuroscience research, where precise measurement of behavior and attention is essential.

Second, unlike the Ultimatum Game, the mini dictator game eliminates the possibility of rejection, removing strategic incentives. As a result, participants' choices directly reflect other-regarding preferences such as fairness and altruism—central to our investigation of non-strategic social influence and conformity.

Third, there is strong precedent in recent literature for using discrete-choice variants of the dictator game to study social decision-making. A growing body of research has adopted similar binary-choice formats to investigate fairness, altruism, and other-regarding preferences (e.g., Chen & Krajbich, 2018; Guala & Filippin, 2017; Krajbich et al., 2015; Panizza et al., 2021). These designs provide valid and tractable approximations of the classic dictator game while offering greater experimental control and compatibility with computational modeling.

Furthermore, they align closely with formal models of social preferences, such as the Fehr-Schmidt (1999) model of inequity aversion, allowing researchers to link observable choices to latent motivational parameters.

By repeating the binary-choice structure across multiple trials, the design allows us to analyze dynamic patterns of attention and choice. We refer to it throughout as the repeated mini dictator game to emphasize its distinct structure and its utility in studying the cognitive mechanisms underlying prosocial behavior.

Throughout this study, the terms conformity, contagion, and herding are occasionally used in an overlapping manner. Although each concept has distinct characteristics, they also share important commonalities. Using them in this flexible way helps to capture the broader construct of social influence, namely the processes through which people's behaviors and attitudes are shaped by the presence and actions of others.

Our aim was to gain valuable insights into the functions of imitative behavior in humans and to delve deeper into the underlying neuropsychological processes associated with social contagion. While we acknowledge the importance of neurophysiological properties, our focus was primarily on unraveling the intricate mechanisms and cognitive components involved in imitative behavior and its impact on social dynamics.

EEG is a powerful tool that allowed me to observe neural activity in real-time, giving me a high temporal resolution of brain processes as they occur. Its high temporal resolution was particularly advantageous for this research, as it enabled me to capture rapid changes in brain activity that corresponded with participants' decision-making processes in response to social influences.

EEG is relatively inexpensive brain imaging modality (Delorme, 2023) and offers several advantages that make it an excellent choice for neurophysiological investigations. Firstly, the voltage values measured by EEG directly reflect the biophysical phenomena (dendritic electrical activity) generated by populations of pyramidal neurons that are all oriented perpendicular to the cortical surface. This direct measurement (mesoscopic- to macroscopic-level) provides valuable insights into the electrical activity of the brain (Cohen, 2014). Secondly, EEG is a noninvasive technique, meaning it is a safe and well-tolerated method for studying brain activity. By employing this method, I was able to identify specific neural patterns that emerge during moments of social contagion, providing a clearer understanding of how conformity influences decision-making at a cognitive level.

By studying EEG/ERPs in the context of dictator games, this dissertation aimed to advance our understanding of how individuals are influenced by and imitate the actions of others, shedding light on the complex interplay between psychology and social interaction. Behavioral analyses revealed that a significant proportion of participants experienced shifts in their preferences as a result of contagion.

A key methodological question arises: why employ ERP analysis? ERP methods are particularly well-suited to detecting differential patterns of brain activity across conditions, such as before and after exposure to social influence. Their millisecond precision allows us to identify when and where conformity processes occur, offering a powerful tool to address these research questions.

Regarding the central questions proposed in this dissertation, I summarize the empirical answers as follows. The first question asked: What are the neural and cognitive mechanisms that drive individuals to align their behavior with that of others? Results showed that conformity is associated with an enhanced P300 response in the midline and right posterior brain regions during the 200–350 ms window following stimulus presentation. This neural signature reflects heightened attentional and evaluative processing of others' behavior among conformist

participants, thereby identifying a key mechanism of behavioral alignment. The second question asked: How do social contagion and conformity influence decision-making processes at the brain level? Scalp topography indicated maximal activity in temporoparietal and parieto-occipital regions—areas central to social cognition and the integration of external cues. Importantly, these effects were present in conformists but absent in non-conformists, underscoring individual differences in susceptibility to social contagion. Taken together, these findings provide clear evidence that the dissertation addressed its proposed research questions, identifying both the neural mechanisms and brain-level processes through which conformity shapes social decision-making.

While these findings shed light on the neural underpinnings of conformity and contagion, their direct application to policy remains an avenue for future work. Policymakers will not directly employ EEG/ERP markers such as P300 amplitudes in decision-making. Rather, these neural markers clarify the hidden mechanisms of social influence—such as when and why individuals become more sensitive to conformity pressures. This knowledge can inform policy in two ways: first, by identifying contexts and groups especially vulnerable to antisocial contagion, enabling targeted interventions; and second, by providing biomarkers to evaluate whether interventions (e.g., educational programs or prosocial campaigns) reduce the neural sensitivity associated with conformity. In this way, EEG/ERP findings complement behavioral economics by offering mechanistic insights and evaluation tools that can guide more precise policy-relevant research.

Neuropsychological insights deepen our understanding of social behavior, but individual differences also play a crucial role in social decision making. Next, we examine how social value orientation influences decision-making.

5. Attention, Response time and Decision Making

Another factor that traditional economists have often ignored is the role of attention and response time in decision making. In contrast, cognitive neuroscience emphasizes their significance in shaping decision-making processes (Konovalov & Krajbich, 2019; Krajbich et al., 2015b). Orthodox economic models typically assume the existence of a rational agent known as *Homo economicus*, who possesses unlimited cognitive resources and can instantaneously react to information.

Moreover, *Homo economicus* is typically depicted as a self-interested and greedy individual devoid of emotions and other-regarding preferences.

However, It has been widely acknowledged that individuals possess a natural inclination towards collaboration and a genuine interest in fairness, equality, and social welfare (Kranton et al., 2013). In simpler terms, individuals with social preferences prioritize considerations beyond their own material gain and demonstrate concern for others (Fehr et al., 2023). Additionally, (ironically), such assumptions in the classic economic paradigm, often fails to hold true in real-world situations and these things affect how the economy responds to the disruptions like wars and COVID-19 situations.

In our third paper, titled "The Role of Attention in Economic (Social) Decision-Making: An Investigation of Process Data in the Dictator Game," we utilized eye-tracking technology to explore the influence of attention on individuals' decision-making. It is a good idea to start with game theory when studying social decisions (D. Lee, 2008; von Neumann et al., 1944). There exist two distinct types of dictator games: giving and taking. These two variations yield different outcomes (Flage, 2024). In our study, we specifically focused on the repeated "Giving dictator game" instead of the "Taking dictator game" in which participants take money from recipients instead of giving.

While classic eye-tracking studies (e.g., Glaholt & Reingold, 2009 and Krajbich et al., 2010) have examined attention in asocial contexts—where choices affect only the self—we extend this framework to a social domain. Each decision in our task impacts both the participant and an anonymous other, shifting the role of attention from amplifying personal value to engaging with moral and interpersonal considerations

We obtained valuable insights into the interplay between attentional processes, decision-making behavior, and resource allocation by analyzing participants' visual attention and eye movements.

We found that individuals in advantageous situations (where the dictator earns more), attention to the self is highest. In disadvantageous situations (where the receiver earns more), attention to the self decreases. In mixed-inequality trials — where one option benefits the self and the other benefits the other — reaction time is longest and pupil dilation is greatest, indicating cognitive conflict and deliberation.

These findings suggest that attention is not simply amplifying value (as in the aDDM), but is actively involved in resolving moral trade-offs.

Additionally, we explored the role of the Behavioral Inhibition and Behavioral Activation Systems (BIS/BAS) in predicting process data. We discovered significant correlations between BIS/BAS scores, eye movements, and response time. We show that BAS-Drive — reflecting a persistent motivation to achieve goals — is positively associated with longer reaction times and greater pupil dilation, indicating heightened cognitive engagement during social decisions.

These results collectively indicate that incorporating response time and eye movement measures can provide a more comprehensive understanding of individuals' decision-making processes and preferences.

Our study, conducted in Iran—a non-WEIRD¹, collectivistic context—addresses the overrepresentation of Western samples in the literature and contributes to the broader cross-cultural validation of social decision-making models. Notably, while the expected $\alpha > \beta$ pattern in inequity aversion was replicated, the α coefficient in our sample (0.89) was substantially higher than typical Western estimates (~0.6). This suggests a culturally specific intensification of aversion to disadvantageous inequality and underscores the importance of contextualizing model parameters when interpreting social preferences across different cultural settings. Next, we examine how social value orientation influences decision-making.

6. Role of Social Value Orientation (SVO) in Individual's Decision-Making

In the article "*Investigating the Role of Social Value Orientation in Individual Decision-Making: Evidence from the Ultimatum Game*", we explore the behavioral factors that shape social decision-making. Using the triple-dominance method, we assessed participants' social value orientation in the Ultimatum Game under both hypothetical and real-incentive conditions.

Consistent with findings in behavioral economics, our results show that individuals do not act solely out of self-interest. Instead, they incorporate fairness

¹ Western, Educated, Industrialized, Rich, and Democratic

and other-regarding preferences into their decisions—challenging core assumptions of orthodox economics and the Nash equilibrium in classical game theory.

Furthermore, our findings contest the mainstream economic view that individual preferences are stable and context-independent. We observed significant differences in behavior between hypothetical and real-stakes conditions: proposers' offers varied markedly depending on whether the outcomes had real consequences. This highlights the critical role of context in shaping economic decisions and underscores how both situational factors and personality traits influence social preferences.

7. Bridging Mind and Brain: The Role of Humanomics and Neuroeconomics in Economic Cooperation

In the conference paper titled "The Confluence of Humanomics and Neuroeconomics on Economic Cooperation," we examine the interplay between human cognition, moral sentiments, and neurobiological mechanisms in shaping economic cooperation. The paper argues that social behaviors such as conformity and social contagion arise not merely from rational self-interest, but from the integrated influence of ideational, moral, and neurobiological processes. Grounded in the framework of Shared Mental Models (Denzau & North, 1994), this work bridges humanomics—which emphasizes meaning, values, and social norms—with neuroeconomics, which investigates the neural underpinnings of decision-making.

Building on this theoretical foundation, the present dissertation provides empirical investigation into these dynamics by analyzing neural responses during social decision-making. Using electroencephalography (EEG) and event-related potentials (ERP), we examine how social influence is reflected in brain activity, focusing on the cognitive and affective mechanisms underlying conformity and social contagion. By linking neurophysiological data to behavioral outcomes, this research offers mechanistic evidence for how social and moral factors shape economic choices. In doing so, it bridges high-level theoretical insights with experimental rigor, advancing a more holistic and human-centered understanding of economic behavior.

Conclusion

In this dissertation, I explored how people make decisions in social settings, focusing on conformity and contagion. These aren't just abstract ideas—our everyday choices, whether in classrooms, markets, or other social situations, are heavily influenced by what others do. That makes social decision-making a central part of understanding human behavior and economic interactions.

To study this, I combined behavioral and neurobiological approaches. On the behavioral side, I looked at experiments using the Ultimatum and Dictator Games and also employed eye-tracking to see where participants focused their attention and how social value orientations shaped their choices. On the neurobiological side, EEG and ERP measures revealed brain activity patterns, like the P300, which tell us when people are especially sensitive to social influence. So, the behavioral work shows us *what* people do, while the neural data help explain *why* and *how* these decisions happen.

Bringing these together, the findings suggest that conformity and contagion can be observed both in behavior and in the brain. More importantly, combining behavioral economics, neuroeconomics, and humanomics gives a richer, more realistic picture of decision-making as a social process. I hope this research provides a foundation for future studies that connect these insights to real-world challenges—like encouraging cooperation, reducing harmful contagion, or designing environments that support prosocial behavior.

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Papers included in the thesis

Review Paper



Behavioral and Biological Bases of Herding and Conformity

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Citation Deldoost, M. (2024). Behavioral and Biological Bases of Herding and Conformity. *Basic and Clinical Neuroscience*, 15(4), 433-442. <http://dx.doi.org/10.32598/bcn.2022.4654.1>
doi <http://dx.doi.org/10.32598/bcn.2022.4654.1>

Article info:

Received: 14 Sep 2022

First Revision: 29 Sep 2022

Accepted: 10 Oct 2022

Available Online: 01 Jul 2024

Keywords:

Conformity, Herding,
Neurobiology, Hormone,
Neurotransmitter, Mirror
neurons

ABSTRACT

Humans are inherently complex creatures, and this issue became even more complicated when they decided to construct social relationships. Research into human behavior is an interdisciplinary and multifaceted endeavor studied by various disciplines, such as psychology, economics, sociology, anthropology, and neurosciences. Today, with the cooperation of researchers in different fields, it is possible to link the cellular dynamic of neurons to brain function and human behavior. Cognitive science and neurosciences, along with other disciplines, can enrich our knowledge about mechanisms of social influence, which may assist policymakers in influencing public behaviors toward creating a better society. This review aims to describe previous research on social influence's behavioral, cognitive, and neural basis and provide more understanding of human behavior in society. I review and evaluate the relevant literature from multiple databases of peer-reviewed journals, books, and conferences and hand-searching reference lists of relevant studies that consider conformity from psychological, economic, neurobiological, and neurochemical aspects. This paper has been divided into four parts. First, I start by defining and describing two kinds of social influences. The second section focuses on psychological and economic evidence of social influence. It will then explore the neurobiological and neurochemical approaches to studying social influence. Finally, the conclusion summarizes and highlights three points I believe social neuroscience as an interdisciplinary and vibrant field should consider for future developments.

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Highlights

- Conformity can be influenced by factors like sex, age, and culture.
- Rostral cingulate zone (RCZ), ventral striatum, nucleus accumbens (NAc), and amygdala are the major parts of the brain that are involved in social influences.
- Serotonin and oxytocin promote conformity.

Plain Language Summary

Scholars from various fields, such as psychology, economics, anthropology, sociology and neuroscience, are collaborating to comprehend how our brains and behaviors influence one another. This paper reviews existing research on social influence—how people’s thoughts and actions are shaped by others—and aims to shed light on the biological and psychological mechanisms behind it. The review covers several key areas: First, it defines the two main types of social influence. Next, it discusses psychological and economic evidence that shows how our choices can be influenced by those around us. It then looks at the brain’s biology and chemistry to explore how these social influences manifest physically. Finally, the study highlights important points for future research in this interdisciplinary field.

1. Introduction

Highly social animals¹, especially our close primate cousins and indeed humans, are fundamentally motivated to establish social relationships (Cialdini & Goldstein, 2004) to get the benefits of a variety of social interactions such as protection, coordination, collaboration, gaining information (Rocha et al., 2021).

Societal bonds are crucial to human welfare; all humans thrive off social connections. Psychologists have cited this issue as one of the essential factors in human survival and believe that people have a basic "need to belong" or socialize with others (Baumeister & Leary, 1995; Eisenberger, 2012).

Therefore, individuals strive to maintain their linkage to others so that society does not ostracize them (Wasylyshyn et al., 2018), as it is considered a powerful form of social punishment.

These connections may be disrupted, such as when an individual is excluded from a group. People react differently to this social experience, and those who experience a strong need to belong might particularly adapt their behavior to fit in with others.

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1. Aristotle, the legendary Greek philosopher, said, "Man is by nature a social animal, he must satisfy certain natural basic needs in order to survive."

Conformity and obedience are two types of social influence that are inherent components of most social behaviors so that people under the influence of others' opinions are encouraged to align their own beliefs, feelings, values, and behaviors with someone else (Levy, 2008; Wang & Busemeyer, 2021; Xie et al., 2016; Zheng et al., 2021).

"Conformity is as old as humanity." It is not limited to a specific time and place (Sunstein, 2020). Before proceeding, it is necessary to clarify the difference between conformity and obedience. The main difference between obedience and conformity is that obedience is an act of following orders coming from someone with a higher status and relies on social power without any question. In contrast, conformity is a trait that allows human beings to follow social norms and go along with people with equal status, and it relies on the need to be socially accepted.

Conformity can be seen in our daily decisions, such as where to live, how to spend money, or changing lifestyles, such as going to the gym or having a healthy diet (Nook & Zaki, 2015).

In fact, not all types of conformity are identical. Traditionally, two distinct influences that drive conformity behavior have been distinguished (Deutsch & Gerard, 1955). The first is informational conformity, which is taking advantage of the information acquired by others. This kind usually occurs when people lack knowledge

and try to change their minds with someone else who has more accurate information because of the desire to be correct.

In this connection, self-confidence plays a significant role in informational conformity. People are prone to conform more because they are uncertain about the correctness of their beliefs and hold low self-confidence and self-doubt (Cross et al., 2017; Morgan et al., 2012; Zheng et al., 2021).

The second is normative conformity, which is often less conscious (Baddeley, 2018). It refers to fulfilling social norms to avoid sanction for deviating from norms (Carpenter, 2004) and to gain acceptance or maximize group cohesion (Mahmoodi et al., 2022). They copy others because they feel compelled by others around them. Also, they tend to look good in front of other people. Image-related concerns only occur if the individual's actions are observable to other people (Zafar, 2009).

Some studies have shown that self-esteem² can also influence social influence. People with low self-esteem may be more likely to be influenced by others (Kaplan, 1985; Stacy et al., 2016).

Tacit knowledge that we have gained from personal experience allows our brain to sometimes take cognitive shortcuts and follow rules of thumb in an uncertain situation; that is why people imitate. Gigerenzer and Goldstein (1996) described imitation as a kind of conformity that is "the fast and frugal heuristic in social situations."

Social influence: Psychological and economic evidence

Conformity behavior cannot be fully understood from a single perspective. This phenomenon has been widely studied by a plethora of previous researchers in different fields (Asch, 1955; Baumeister, 1982; Bond & Smith, 1996; Chein et al., 2019; Deutsch & Gerard, 1955; Duell et al., 2021; Goeree & Yariv, 2015; Janes & Olson, 2000; Klucharev et al., 2009; Muzafer Sherif, 1935; Xu et al., 2019) for several decades.

The overall summary of the research publication related to the social conformity topic is shown in Figure 1.

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2. The terms self-esteem and self-confidence are often used interchangeably. Self-confidence is about how a person has faith in their own capabilities and abilities, whereas self-esteem refers to how a person appraises overall their own value.

Psychology, behavioral economics, sociology, and biology attempt to tackle the topic of conformity from various angles and explain the different motivations for this phenomenon. For example, psychology studies stress the rewarding value of gaining social acceptance or "affiliation with others" (Cialdini & Goldstein, 2004). Meanwhile, in behavioral economics, attention is more on the effects of punishment for breaking or ignoring the norm (Klucharev et al., 2009). For instance, (Akerlof, 1980) assumed that the community sanctions factor may explain the tendency to conform, and deviations from social customs are punished by loss of social reputation.

The first serious discussion and analysis of such social phenomena emerged during the 1890s with crowds and mass psychologists like Gustave Le Bon and Gabriel Tarde. According to Tarde (1903), imitation was a collective hypnosis called "social somnambulism".

Modern economists have neglected psychological and sociological factors and solely focused on explaining conformity as the outcome of mathematical algorithm calculations like Bayesian updating in the Bayesian inference method (Baddeley, 2010).

The first studies in the literature on the impact of socio-psychological forces on economics, like sudden shifts in consumer behavior, were addressed by Veblen (1899) and Cox and Katona (1976).

Economic psychologist Cox and Katona (1976) conducted many studies using cognitive psychology to analyze how individuals learn from groups (Baddeley, 2010).

Also, Keynes, who famously spoke about "contagious animal spirits," draws our attention to sociological and psychological forces of herding behavior (bandwagon effect) that is often observed in stock markets, which affect investors in times of uncertainty (Baddeley, 2010; Chen & Chen, 2020) and crisis. It is necessary to clarify that herding behavior is a group phenomenon; in other words, many people emulate one person, and many emulate others with unconscious motivation (Baddeley, 2018).

Personality factors, such as age, gender, and cultural differences can influence conformity. According to a meta-analysis by Bond and Smith (1996), females are more likely to conform than males. This difference in conformity between sexes has been attributed to social explanation, which means women care more about others' desires. Still, the role of evolution in explaining this difference also should not be neglected (Griskevicius et al., 2006).

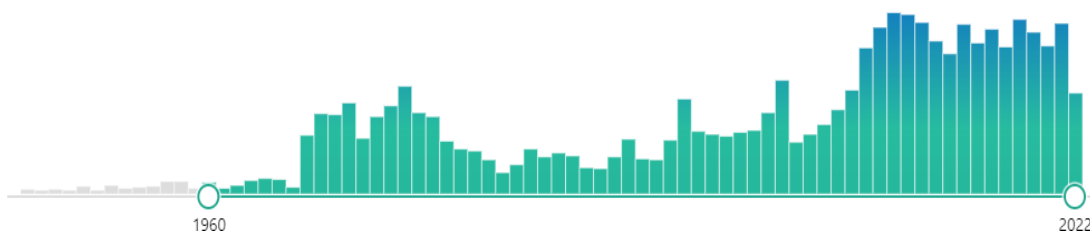


Figure 1. Social conformity research trends publication per year

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Moreover, the literature reveals that an individual's age also matters and significantly affects the rate of social conformity. Studies show that individuals in early and late adulthood are more easily influenced than individuals in middle age (Visser & Krosnick, 1998; Wijenayake et al., 2021).

In addition to personality factors, evidence suggests that cultural traits also significantly influence an individual's motivation to conform.

Bond and Smith (1996) reported a strong empirical relationship between collectivistic and individualistic cultures and conformity using Asch's line judgment task. People in collectivistic countries like the Middle East are more susceptible to conform than in individualistic countries. The questions that arise here are as follows: What are the implications of conformity and herding behavior for our everyday lives? Should we conform or act as a contrarian?

The answer to the above question lies in another question: Are crowds better at always making decisions?

Surowiecki (2004), in his book "The Wisdom of Crowds," claims that collective decisions are more likely accurate than individual ones if we put together a large enough diverse group of people. In the introduction, he tells the story of the great British scientist Sir Francis Galton (Charles Darwin's cousin), who was at a country fair in West England in 1906, where there was a wagering competition to guess the weight of an ox.

Seven hundred eighty-seven villagers' guesses were 1197 pounds, whereas the ox's actual weight was 1198. He expected the outcome to be unreliable. Instead, surprisingly, he found a small crowd error that contradicted his idea about the inferiority of the crowd.

However, under the right circumstances, collective decisions are more likely correct than individual decisions.

The first requirement is the independence of source information, meaning that people's decisions should be independent of one another. Second, the diversity of people's minds in a group plays a significant role in making more accurate predictions.

To answer the above questions, we can say that herding behavior and conformity are not inherently positive or negative. Agreement with others may lead to more positive and less negative outcomes (Fehr & Fischbacher, 2004); therefore, their goodness depends on the nature of the issue and the various situations.

If sameness leads to an adverse effect on self-identity or encourages dependencies, obviously, in that case, it is harmful to society. Still, it may be seen as a positive if it provides access to new information and learning from an expert.

Social influence: Neurobiological evidence

While a considerable amount of literature in psychology and economics has been published on social influence, its neurobiological basis is poorly understood and has received relatively little attention; nevertheless, the field of social neuroscience is rapidly evolving.

The neuroscientific approach extends our knowledge about the mechanism of social conformity and offers excellent information in extending and validating competing psychological theories of conformity. Neuroscience research, especially neuroimaging, may also help predict who is more likely to change their behavior and conform (Stallen & Sanfey, 2015; Wu et al., 2016).

Social neuroscience adds noninvasive neuroimaging techniques to study the neural underpinnings of social influence. In the past decade, neuroimaging methods such as functional magnetic resonance imaging (fMRI), which measure changes in blood oxygenation level-dependent, and electroencephalogram have dramatically

provided jaw-dropping insights into the brain's black box.

Berns et al. (2005) extended the Asch perceptual experiment by using fMRI and a mental rotation task to investigate the neural mechanism of conforming behavior in which confederate gave erroneous responses regarding the degree of rotation of a figure. The authors pointed out that conformity was associated with visual cortical and parietal activation. Due to the absence of activity in the frontal lobes, authors claimed that change in participants' initial judgments could be attributed to low-level perception, which does not necessarily require attentional processes compared to agreeing with others at an executive level.

Previous neuroimaging studies have shown that the amygdala, located in the medial temporal lobe, may also play a role in social decision-making and learning. An fMRI study (Baddeley et al., 2012) reports that the amygdala activates the herding task. Neuroimaging techniques also allow researchers to distinguish the type of conformity at two different levels of internalization. At the public level, people change their behavior just to be liked and avoid rejection, while the group's beliefs are not internalized privately in an individual's belief system. In other words, they conform without changing real behavior (Stallen & Sanfey, 2015). When a person publicly and privately conforms with others, this is the deepest level of conformity, and this alignment is permanent. Figure 2 refers to the term-based meta-analyses conducted by Neurosynth, which analyzed 84 studies utilizing the term "imitation."

Several researchers have suggested that conformity and reinforcement learning have similar neural mechanisms and responses to conflict with social opinions. A seminal study by Klucharev et al. (2009) reports that deviation from group norms leads to activation in the rostral cingulate zone and ventral striatum, which are parts of the posterior medial frontal cortex (pmMFC) and subcortical brain region, respectively. By using transcranial magnetic stimulation, which is a noninvasive technique

Klucharev et al. (2011) showed that the pmMFC region can mediate the reinforcement learning mechanism and play a causal role in social influence. Correspondingly, other fMRI studies (e.g. Burke et al., 2010; Campbell-Meiklejohn et al., 2010) have replicated a similar experimental paradigm to capture cognitive components of conformity. Their findings consistently supported the previous original findings. Furthermore, there is a large body of literature that demonstrates the link between

motor mimicry³ (imitation) and observational learning with mirror neurons (Catmur et al., 2009; Raafat et al., 2009; Rizzolatti & Craighero, 2004).

Mirror neurons are a class of neurons first observed by chance in the macaque monkey premotor cortex at the Università Degli Studi di Parma, Italy, in the 1990s. Mirror neurons are a group of neurons that fire without conscious control when an animal or individual performs a particular action (motor system), and when the individual watches (sensory system), another agent carries out a similar action. Researchers discovered mirror neurons are essential for imitation behavior and observational learning (Cross et al., 2009).

The following section will argue neurochemical contributions to a better understanding social influence.

Social influence: Neurochemical evidence

From the neurobiology perspective, a bidirectional relationship exists between hormones, neurotransmitters, and behavior. Hormonal and neurotransmitter mechanisms regulate the behavior of individuals, such as anger, stress, and conformity. Consequently, hormones and neurotransmitters can modulate individuals' behavior (Duell et al., 2021), and sometimes behavior can influence hormone concentrations. So far, however, there has been little discussion about possible neurobiological mechanisms underlying conformity.

A hormone is different from a neurotransmitter in many respects. The term hormone (e.g. oxytocin, cortisol) often refers to any substance, such as proteins, lipids, or cholesterol-based molecules, produced by an endocrine gland. They are released and transmitted into the bloodstream, whereas neurotransmitters (e.g. dopamine, serotonin, epinephrine) are proteins or amino acids released into the synaptic gap and diffuse across the synaptic cleft.

Neurotransmitters typically produce speedy physiological responses within milliseconds, while hormones take a few minutes to a few days.

Both are different types of chemical messenger molecules that regulate human and animal behavior.

3. In *The Theory of Moral Sentiments*, Adam Smith (1759) writes: "Though our brother is upon the rack . . . by the imagination we place ourselves in his situation, we conceive ourselves enduring all the same torments, we enter as it were into his body, and become in some measure the same person with him, and thence form some idea of his sensations, and even feel something which, though weaker in degree, is not altogether unlike them." In other words, people can imagine and feel themselves in another person's situation, technically they present "motor mimicry."

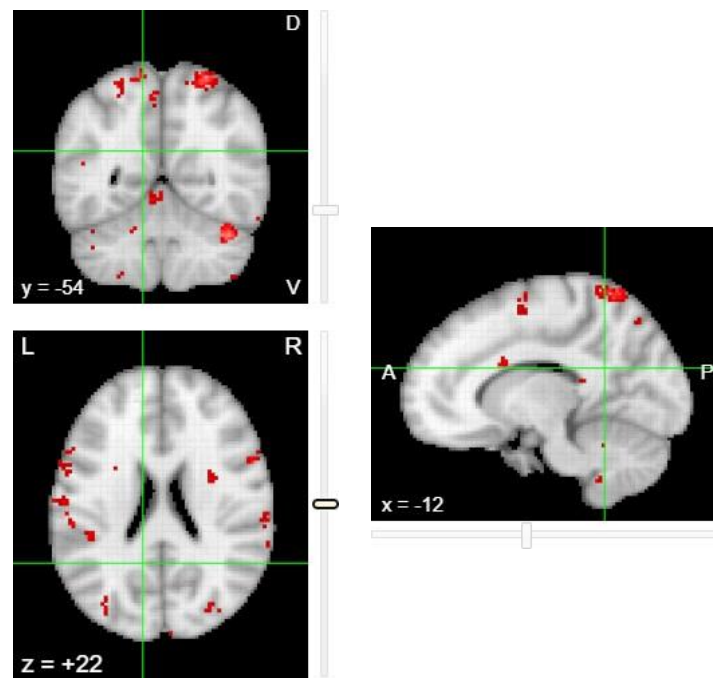


Figure 2. Neurosynth term-based meta-analyses of 84 studies used the word "imitation"

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Notes: The likelihood of each coordinate and functional activation is related to studies that examine imitation (Neurosynth, 2022).

To better understand the role of hormones and their effects on conformity, Duell et al. (2021) investigated the neural correlates of conformity with two major classes of steroid hormones: Testosterone and cortisol. Adolescent participants underwent fMRI scanning while they were asked to donate their time to different types of charities. They saw the peer confederate decision behavior for probable revision in post versus pre-peer observation. After observing highly prosocial behavior, the authors concluded that high testosterone and low cortisol lead to prosocial behavior but remained unchanged for peers with low-level prosocial behavior. Their results were in agreement with prior studies (Báez-Mendoza & Schultz, 2013; Do et al., 2019; Hoorn et al., 2016; Spaans et al., 2019) on social cognition, which indicated observing high prosocial behavior enhances greater activation in the pSTS/TPJ, insula, orbitofrontal cortex, and caudate regions.

Serotonin (5-HT) is an ancient phylogenetics molecule (Nardi et al., 2017) that is highly responsive to social influences (Hogenelst, 2016).

This neurotransmitter plays a crucial role in social choices (Rogers, 2010) and affects observational learning through social interactions.

Simonsen et al. (2014) examined the role of serotonin in the judgment's alteration of trustworthiness in a facial rating task. Half of the subjects, all females, received a single dose of the selective serotonin reuptake inhibitor citalopram, which increases serotonin levels in the brain; the rest (control subjects) took a placebo. After each rating, immediate feedback was shown on how a third party rated the same face. The authors concluded that compared with placebo-treated subjects, those receiving citalopram conformed more to the judgments of others.

In another study, Campbell-Meiklejohn et al. (2012) examined the role of catecholamines, a neurohormone that belongs to the monoamine neurotransmitter, on social influence. The conformity task was similar to that described earlier (Klucharev et al., 2009; Simonsen et al., 2013). In a double-blinded placebo-controlled procedure and before the task, the experimental group received a single oral dose of methylphenidate (i.e. Ritalin), which increased the level of catecholamine, while the control group received a placebo. Researchers found that subjects who received methylphenidate were more inclined to conform than those who received a placebo.

A possible explanation for this might be that methylphenidate can enhance reward saliency by increasing

extracellular dopamine concentrations in the striatum (van Dyck et al., 2021), with indirect consequences for modulating social conformity.

Oxytocin is another important natural hormone that can modulate human behaviors and social interactions, such as trust and empathy (Shamay-Tsoory & Abu-Akel, 2016). It is a neuropeptide made in the hypothalamus, a regulatory center in the brain.

Stallen et al. (2012) aimed to examine the role of oxytocin in the opinion of the in and out-group members. Hypotheses were tested using a double-blind, placebo-controlled design experiment to rate a series of visual stimuli and symbols on attractiveness when in-group and out-group members express preferences. Before the task, nasal oxytocin spray was self-administered in the experimenter's presence. The dose was three puffs per nostril. The authors demonstrated that oxytocin promotes conformity to the opinions of the in-group in contrast to out-group members.

Conclusion

In summary, I have argued how and why individuals are susceptible to social influence in this review. Furthermore, why our everyday actions often can be affected by the choices or opinions of others.

Most experiments testing the social influence on conformity have used mental rotation tasks or rating tasks like facial expressions. Social influence and conformity have not been extensively investigated using behavioral game experiments in neuroscience domains, and very few studies have been conducted.

Moreover, in future research, it is essential to distinguish the neural mechanism of conformity and its contagion in prosocial and antisocial activities.

Our brain is a complex system and interconnected network. Future research must examine how different brain parts structurally and functionally communicate in conformity tasks. It can allow researchers to identify causal relationships in brain networks when the opinion of others guides decisions.

Ethical Considerations

Compliance with ethical guidelines

This article is a review with no human or animal sample.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Conflict of interest

The author declared no conflict of interest.

Acknowledgments

The author would like to thank Michelle Baddeley for carefully reading the paper and providing valuable feedback. Additionally, this paper has greatly benefited from the suggestions of two anonymous referees.

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Exploring the neuropsychological basis of behavioral contagion during learning about another agent's social preferences: Evidence from an ERP study

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Social contagion is a pervasive phenomenon and an important social influence that involves the rapid dissemination (propagation) of behaviors, attitudes, emotions, or ideas from one person to another, often without conscious reflection or rational thought. This phenomenon is closely related to conformity, by which a person changes his/her original ideas and attitude and imitates certain behavior of others. Although some behavioral research has been carried out on contagion and conformity, there is very little neuropsychological understanding of these phenomena. Existing research on social influence and conformity has predominantly focused on tasks like mental rotation or rating tasks involving facial expressions, with fewer studies exploring risk preferences and temporal discounting. However, there is a notable gap in the literature when it comes to examining social influence and conformity using other-regarding preference models derived from heterodox economics. To address this research gap, the present study investigates the neuropsychological underpinnings of social contagion by utilizing event-related potentials (ERPs) recorded while subjects engage in mini-dictator games. The behavioral analysis revealed that contagion had an impact on the participants' preferences, leading to a change in their choices. We observed a P300 component in the midline and right posterior during the time window of 200-350 ms after stimulus onset, which showed a significant increase in mean amplitude when participants observed others' behavior, compared to when they made decisions based on their own preferences. Moreover, the lack of late positive potential in the time window of 500-650 ms suggests that the presence of P300 may indicate difficulty in making decisions. In summary, by analyzing both behavioral and ERP data, this study may provide a more comprehensive understanding of the cognitive and neural processes that drive conformity and contagion behavior. Our analysis has the potential to inform policymakers in developing effective interventions for promoting positive social behaviors and reducing negative ones.

Key words: contagion, Fehr-Schmidt model, dictator game, event-related potentials, decision difficulty, P300

INTRODUCTION

Gaining a comprehensive understanding of how people behave, and make decisions within a society is a highly complex process. The social phenomena emerging within human societies can be described as non-linear, dynamic, unpredictable, and multi-dimensional (Richardson & Marsh, 2014). The COVID-19 pandemic is a prime example of how human societies are embed-

ded within complex systems, and how individuals face complex situations. To identify appropriate solutions to such complex issues, interdisciplinary approaches, and collaboration among researchers from various disciplines are essential. Social influence is an example of such complexity as our decision-making processes are heavily shaped by social interaction, which is an integral part of our daily lives. Conformity and contagion are two types of social influence that promote the mim-

icry of beliefs, feelings, values, and behaviors with the opinions of others, and as such, they play a significant role in shaping most social behaviors (Levy, 2008; Xie et al., 2016; Wang & Busemeyer, 2021; Zheng et al., 2021). People often make these forms of decisions when unsure about their choices or having doubts about which alternative to choose as well as to avoid potential sanctions for deviating from established norms (Carpenter, 2004). In fact, imitation extends beyond human beings and animals; it also manifests in the realm of medical science. Recent studies have revealed a fascinating phenomenon in the context of brain cancer cells, specifically glioblastoma. These malignant cells have demonstrated an exceptional ability to mimic normal brain cells, thereby conferring resistance to conventional therapeutic interventions (Kim et al., 2024).

Although throughout this paper, we use the terms ‘conformity’ and ‘contagion’ and even ‘herding’ interchangeably, it is important to note that, there exist both similarities and differences between these concepts. This interchangeable usage enables us to highlight the broader phenomenon of social influence, where individuals’ behaviors and attitudes are shaped by the influence of others. Both conformity and contagion involve changes in a person’s behavior as a result of external influences and are characterized by conflict (Weiß et al., 2024). However, contagion differs from conformity in that individuals initially experience internal conflict, which is reduced or resolved through the influence of others. In contrast, conformity begins with harmony, and external influence creates conflict that must be resolved by the conformer (Wheeler, 1996).

In this paper, it is crucial to address two key points. Firstly, it is important to highlight that social contagion is a dynamic process that can manifest through both direct interaction and observational learning which is rooted in Bandura’s social learning theory. Secondly, a significant finding to consider is that individual differences have been consistently shown to predict the degree of social conformity, thereby shedding light on the heterogeneous nature of conformity among individuals (Klucharev et al., 2009; Campbell-Meiklejohn et al., 2010; Nook & Zaki, 2015; Nook et al., 2016; Kim et al., 2021). Overall, conformity and social contagion are interconnected social processes influencing human behavior and decision-making.

Various social and economic situations encountered in daily life can be classified as conformity behavior, such as engaging in healthy habits like going to the gym or having a healthy diet (Nook & Zaki, 2015), political voting, and fashion trends (Xie et al., 2016). Pro-social behavior, such as generosity, cooperation, and donation, is more likely to be emulated among peers

(Dimant, 2019; Yu et al., 2021). Similarly, individuals’ likelihood of performing antisocial behavior, such as stealing, dishonesty, and cheating, may increase if they observe their peers acting in such a manner (Gino et al., 2009; Falk & Ichino, 2015; Dimant, 2019; Yu et al., 2021).

In the section that follows, we will briefly discuss some of the most relevant studies that deal with conformity from different perspectives.

Literature review and hypotheses formulation

Given the complexity of social influence, it is impossible for a single perspective to fully explain conformity behavior. Thus, researchers from various fields including psychology, sociology, anthropology, economics, and more recently neuroscience, have studied this phenomenon over the years, resulting in a multitude of perspectives and approaches to understanding conformity (Asch, 1951; Baumeister, 1982; Bond & Smith, 1996; Chein, Jansen, Korbee & Bruijn, 2019; Deutsch & Gerard, 1955; Duell, Hoon, McCormick, Prinstein & Telzar, 2021; Goeree & Yariv, 2015; Janes & Olson, 2000; Klucharev, Hytonen, Rijpkema, Smidts & Fernandez, 2009; Muzafer Sherif, 1935; Xu, Becker, Kendrick, 2019).

The history of the study dates back to 1759. In his book “Theory of Moral Sentiments, “Adam Smith, proposed that conformity could be described as “herding” behavior, which is considered as a type of “mechanical imitation” and a form of “unconscious social contagion” (Song et al., 2022). Sociologists in the nineteenth century were aware that social pressures may influence opinions, beliefs, and actions (Packer, 2012). “Social somnambulism” is the term used by psychologists like Gustave Le Bon and Gabriel Tarde to explain imitation as a collective hypnosis (Rook, 2006). Conformity research was extensively investigated between the 1930s and 1950s, and many experiments were conducted to demonstrate its importance. Psychologist Sherif (1935) conducted a classic study on conformity based on perceptual processes. He utilized the autokinetic optical illusion by asking group members to judge the illusory movement of a stationary projected image and determined whether it could influence the opinions of others. He found that in an ambiguous situation, a naive person conformed to the opinion of the confederates (stooges). Asch’s (1952) ‘Line Judgment Task’ is another influential study that examines conformity. Participants were tasked with matching the length of a line segment to a comparison line. Asch’s measurements showed that, in many cases, subjects showed conformity to obviously incorrect answers and followed the overruling majority. American sociologist Phillips (1974) studied imitative suicides and claimed that sui-

cide rates generally increase when excessive suicidal behavior is observed only in the geographical region that receives media attention. This condition is known as the 'Werther effect'.

Early economists such as Thorstein Veblen, George Katona, and John Maynard Keynes pioneered the use of socio-psychological factors that drive human decision-making, especially in stock markets (Baddeley, 2017; Deldoost, 2022). Keynes used the term 'contagious animal spirits' to refer to the noneconomic motives of people's irrational behavior that can sway the markets. In his book 'The General Theory of Employment, Interest, and Money' (1936), he devoted substantial attention to the sociological and psychological forces of herding behavior that occur in times of uncertainty (Baddeley, 2010; Chen & Chen, 2020).

Traditionally, two types of conformity are recognized. The first is normative conformity, which is often less conscious (Baddeley, 2018). This type of conformity involves conforming to social norms in order to avoid sanctions for deviating from those norms (Carpenter, 2004).

The second type is informational conformity, which occurs when individuals leverage information acquired from others. This typically happens when a person lacks knowledge and seeks to align their beliefs with someone who possesses more accurate information, driven by the desire to be correct.

The rapid development of interdisciplinary research has led neuroscientists to focus on the neurobiological and neurochemical basis of social conformity. Neuroscience techniques such as EEG and ERP allow us to directly observe brain electrical activities and gain a more detailed understanding of the rapid changes in cognitive processes underlying conformity and contagion behavior. This provides a more objective and precise measurement, in contrast to traditional behavioral science methods that often rely on indirect measurements. For instance, Suzuki et al. (2016) used a model-based analysis of behavioral and fMRI data to demonstrate that contagion influences both behavioral and neural responses, and can alter individuals' risk preferences through observation and learning about another agent's behavior. Garvert et al. (2015) conducted an experiment to investigate the impact of learning about another agent's preferences on subjective intertemporal choice preferences. They found that, after observing and learning a partner's choices, subjects' own discount rate can be biased toward the partner's direction. The fMRI data showed that plasticity is caused by learning another's value in the medial prefrontal cortex. Additionally, plasticity predicts the extent to which one's preferences shift toward the behavior of others.

Time-locked EEG activity or ERP is an excellent method for observing sensory and cognitive processes by capturing the brain's electrical activities on the order of milliseconds. (Fabiani et al., 2000; Amodio et al., 2014; Xie et al., 2016). The most famous and commonly studied ERP waveforms that are associated with social and higher cognitive processes are the N200, P300 and LPP waveforms. In response to repetitive stimuli, the N200 deflection typically peaks around 200-350 ms after the stimulus onset (Folstein & Petten, 2008; Luck, 2012; Zhang et al., 2019). Some scholars have argued that the N200 is sensitive to effects related to cognitive conflict, error monitoring, and response inhibition, which are generated in the anterior cingulate cortex. Additionally, the amplitude of the N200 is positively correlated with levels of response conflict (Folstein & Petten, 2008; Nieuwenhuis & Yeung, 2003; Zhang et al., 2019). When we make decisions, the P300 waveform is induced. It is thought to reflect how we evaluate and categorize stimuli, and its amplitude is negatively correlated with the difficulty of decision-making (Cutmore & Muckert, 1998; Vallesi & Stuss, 2010). Chen et al. (2010a) used ERP to investigate how consumer herding behavior in online book buying is related to neural and psychological factors. Behavioral data showed that there is greater herding of decisions when customer reviews are consistent. A positive correlation was found between the herding rate and the amplitude of the LPP component, which is sensitive to the detection of categorical differences. Zhang et al. (2019) found that, compared to herding choices, anti-conformity choices caused an increased N2 amplitude (i.e., more negative), indicating that participants might have been experiencing more decision conflict. In contrast, herding choices enhanced the amplitude of the LPP component. This suggests that when subjects stay with the majority, they may have a greater sense of decision confidence and better evaluation categorization before making final decisions.

To the best of our knowledge, little is known about the comprehensive understanding of the neuropsychological mechanisms that underlie contagion and conformity in the existing literature. This research gap highlights the need to investigate the cognitive and neural processes involved. To date, the majority of experiments exploring into social influence and conformity have predominantly focused on tasks such as mental rotation or rating tasks (Berns et al., 2005; Shestakova et al., 2013; Simonsen et al., 2014; Chen et al., 2023) involving facial expressions, as well as on behavioral economics tasks like risk preferences or intertemporal choice (Garvert et al., 2015; Suzuki et al., 2016). However, there has been limited investigation into the effects of social influence and conformity us-

ing behavioral game experiments within neuroscience domains. Moreover, only a few studies have explored the application of other-regarding preference models derived from heterodox economics, where individuals' decisions not only impact their own payoffs but also influence the payoffs of others. Consequently, there is a notable gap in the literature regarding the examination of social influence and conformity through the lens of these heterodox economic models, which provide a more comprehensive understanding of social decision-making dynamics.

Additionally, a neuropsychological measure, event-related potentials (ERPs), is also employed to investigate the neural and cognitive bases of social influence and the role of imitation in humans. The findings of this study will fill a crucial gap in the literature, by shedding light on how individuals align their attitudes, and behaviors with others. Furthermore, this paper opens several avenues for future research, providing insights for designing effective strategies and interventions in fostering desirable social outcomes.

Hypotheses regarding behavior and event-related potentials

In this study, we explore both behavioral and neural mechanisms underpinning imitation and conformity, focusing on two extensively researched ERP components within the context of decision-making: the P300 and LPP. As manipulation may influence decision-making when subjects observe others' behavior, we hypothesize that when subjects observe the behavior of others, the degree of similarity between the subjects' behavior and the behavior of the observed will be greater after manipulation than before manipulation, indicating the occurrence of contagion (H1).

From an electrophysiological point of view, the presence of the P300 and LPP components may support decision-making theories such as categorization theory, while the absence of LPP may provide evidence for the conflict theory hypothesis. Previous research (Chen et al., 2010a) has shown that category similarities can enhance the amplitude of both the P300 and LPP components. Building on this finding, we propose the following hypothesis:

H2: Individuals who conform, similar to the effects of category similarities, will show higher LPP and P300 amplitudes compared to those who do not conform. This hypothesis is based on the theory that social conformity is associated with increased attention to social cues and heightened cognitive processing, which may be similar to the effects of category similarities on these brain components. If confirmed, this finding

could provide further evidence for the notion that social conformity and category similarities may share similar neural mechanisms.

The amplitude of LPP or P300 is inversely related to the difficulty of decisions (Azizian et al., 2006; Chen et al., 2010a). This means that as the difficulty of a decision increases, the amplitude of LPP or P300 decreases. We can formulate the following hypothesis:

H3: Individuals who exhibit conformist behavior, similar to the effects of decision difficulty, will exhibit greater amplitudes of either P300 or LPP compared to those who do not conform.

This hypothesis is based on the theory that social conformity is associated with reduced decision-making effort and cognitive load. If confirmed, this finding would provide further evidence for the relationship between decision difficulty and brain activity, and extend our understanding of the neural mechanisms underlying social conformity.

METHODS

Participants

An a-priori power analysis was conducted using G*Power to determine the necessary sample size (Faul et al., 2009). In accordance with the literature (Clayton et al., 2019), which is commonly used in similar research designs to determine sample size, statistical power, and effect size, a minimum of 26 participants was required for a power of 0.80, with α set at 0.05, and an effect size of 0.6.

Thirty healthy students from SBU University voluntarily participated in this ERP experiment in a single one-hour session for a compensation of 100 K toman (approximately 5 dollars). The subjects ranged in age from 18 to 30 years (M age=25 years, SD=4.71). The informed consent forms were signed by all participants before the study began. They were all right-handed, had no history of nervous or mental diseases/psychiatric illness, and had no history of brain injuries. Additionally, they had normal vision and hearing. Due to excessive head and ocular movements during data acquisition, two participants were excluded from the analysis. As a result, the final sample comprised 28 participants (8 female). The experiment was carried out following the guidelines of Helsinki Declaration. The ethical aspects of the experiment were evaluated and approved by the ethical review board of the Institute for Cognitive Science Studies, with a reference number of IR.UT.IRICSS.REC.1400.34.

Prior to conducting the main experiment, a series of trial tests were performed to ensure a smooth and

effective research process. These trial tests focused on clarifying instructions, refining buttons and questions, and ensuring their clarity for participants.

Materials

The entire experimental task consisted of three sessions or phases and was conducted under no time pressure conditions (Fig. 1A, 1B). The 66 trials of the binary mini-dictator games are displayed in Fig. 1C. The list of all mini-dictator games can be found in supplementary materials. In the first session, the subject acted as a dictator and was repeatedly asked to decide how to allocate a finite set of experimental currency (ECUs) between themselves and other person (Fig. 1D). This session is referred to as the self-trials session and is represented by orange. In the second session, participants only observed the proposals made by the confederates (observe session) which is depicted with blue. As in previous studies (Klucharev et al., 2009; Campbell-Meiklejohn et al., 2010; Zaki et al., 2011; Garvert et al., 2015; Suzuki et al., 2016), participants were told that the choices they observed were made by a subject in a previous experiment. In actuality, however, computer algorithms were designed to generate observer's choices. Subsequently, participants were asked to estimate and rate their confidence level between 0 and 100% regarding which options the previous participant had chosen, and then were given correct response feed-

back. Prediction trials were used to confirm that participants learned the observer's behavioral preferences and tendencies. Session 3 involved both self-trials and observe trials, and the order of presentation for the trials in each game was randomized. The purpose of the experiment and the manipulation approach were initially not explained to the participants. However, to ensure transparency and ethical conduct, a debriefing session was conducted as an integral part of the research process. During this session, the researchers provided a comprehensive explanation of the goal and purpose of the study to the participants.

We conducted a repeated mini-dictator game as a means of measuring the social preferences of subjects, using the Fehr-Schmidt (FS) model, which is a widely-used in heterodox economics. The model can be formally represented as follows:

$$U_i = M_i - \alpha_i \max[(M_j - M_i), 0] - \beta_i \max[(M_i - M_j), 0] \quad i \neq j$$

In this model, U_i represents the individual's own utility, M_i denotes their own monetary payoff, and M_j represents the monetary payoff of another individual. The model includes two parameters that reflect the subject's feelings of envy (disutility from being behind) and guilt (disutility from being ahead). We estimated the regression described by equation (1) in order to extract these parameters from the task data. Using the calculated parameters of the FS model from phase one, the algorithm will present participants with appropriate op-

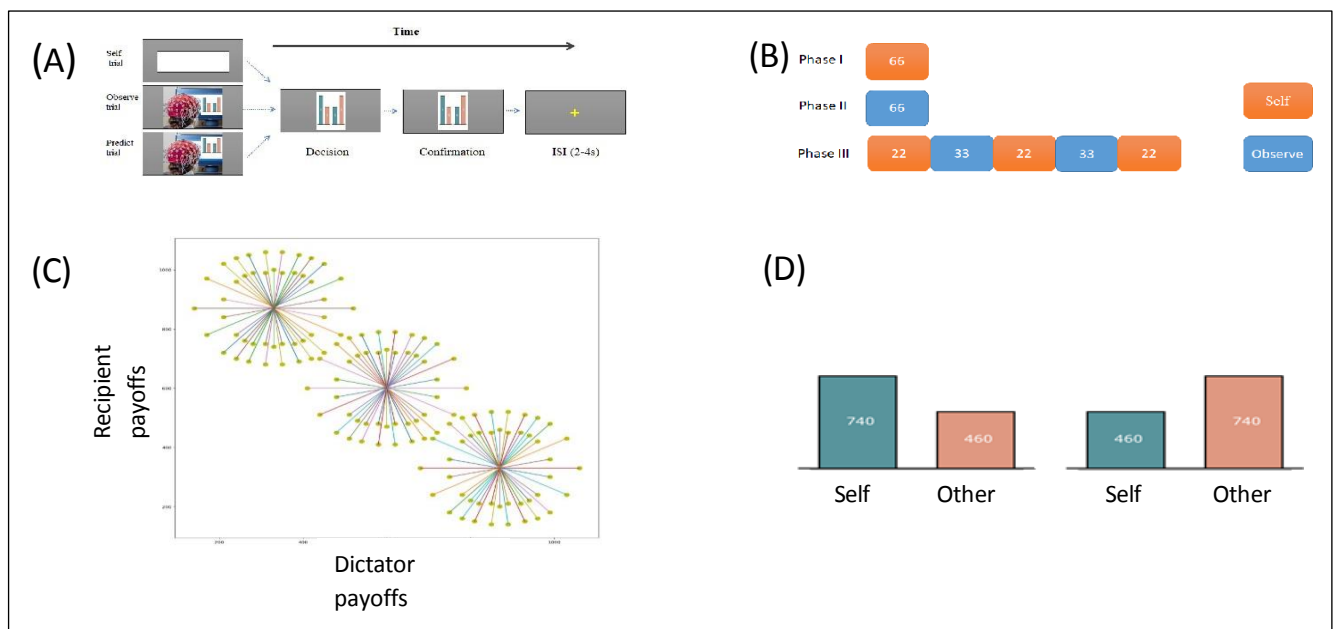


Fig. 1. Schematic illustration of the time course of stimulus presentation in the games task (A). Overall schedule in a block-wise manner. Trials in each block are indicated by white digits (B). All allocations in different inequality space (C). An example of dictator's decision. A binary allocation menu (D).

tions based on the choices of others during phase two, with the intention of manipulating their decisions. For a comprehensive understanding of the behavioral model, please refer to the supplemental experimental procedures, which contains additional details in the form of MATLAB code.

Procedure

To minimize distraction, the experiment was conducted in a shielded room with low lighting levels. Participants were seated on comfortable couches in front of 19-inch computer monitor. Prior to experiment, a brief explanation of the experiment instructions was given to the subjects. They were instructed to avoid blinking or moving their body as much as possible while keeping their eyes fixed on monitor approximately 75 cm away from them.

At the start of the experiment, participants were asked to carefully read a set of instructions displayed on the computer screen, which were previously explained by the experimenter. They were then instructed to compare the two options and choose one of them using the mouse buttons (left or right), while the EEG signals were recorded simultaneously. As mentioned earlier, the stimuli were displayed on the monitor screen without any time pressure, and the interstimulus interval was approximately 2000 ms. The stimulus sequence is shown in Fig. 1A. To avoid becoming fatigued, participants were given the option to rest or press the space button to continue.

Electroencephalogram recording and analysis

For this experiment, continuous EEG data was recorded from the scalp using a 64-channel Ag/AgCl electrode cap. The recording was performed using the amplifier designed by Liv Intelligent Technology Ltd Co., (website: www.livivv.com/). The EEG data recording was performed by sampling frequency of 250 Hz and the impedance of all recording sites was less than 5 k Ω throughout the experiment. Prior to the stimuli presentation, 4 min of resting state EEG data (2 min in eyes-closed and two minutes in eyes-open conditions) were recorded as well. The electrodes placed behind the ears were used to measure the average activities, and the presentation and recording systems were synchronized by sending trigger markers on the parallel port. The open-source software EEGlab, ERPlab in MATLAB (Version 2019b; MathWorks Inc., Natick, MA) is used for the pre-processing of the collected data. The cutoff frequency of the bandpass

filter was 1-40 Hz to reduce residual high-frequency artifacts in the waveforms. Signals are often corrupted by eye-related artifact like blinking and eye movement or muscle potentials that generate large amplitude peaks that need to be eliminated. Independent component analysis (ICA) which is a general and practical tool for removing oculomotor artifacts. For each EEG channel, ERP signals were segmented at intervals of 200 ms before stimuli onset to 600 ms after onset. ERPs were averaged separately for each channel and experimental condition.

Behavioral results

The conformity rate is the proportion of subjects who made conformity decisions according to observed choices. Fig. 2 (left panel) displays the similarity of subjects' decisions in session 1 and session 3 with confederate.

The horizontal axis represents the number of similarities between the subject's decisions and the confederate in session 1, while the vertical axis represents the number of decision similarities in session 3. If contagion occurred, we would expect to see more trials located above the 45-degree line. The graph and statistical test indicate that the phenomenon of contagion occurred for a significant number of participants. We conducted a paired t-test was performed to analyze the similarity of subjects' decisions in phase 1 and phase 3 with those of the confederate. The results revealed a significant difference between the two phases: participants exhibited higher similarity with the confederate in phase 3 compared to phase 1 ($t=-4.35$, $p<0.001$). These findings provide support for H1, which predicted that the phenomenon of contagion would occur.

Table 1 displays the mean response times (RTs) for the behavioral data, which represent the time it took participants to make decisions from the moment each stimulus was presented in the experiment.

As Table 1 shows, the response times (RTs) were significantly shorter in phase 3 compared to phase 1 ($t=3.83$, $p<0.001$). Moreover, the mean RTs for the contagion group in phase 3 (2.75 ms) were slightly shorter than for non-contagion (2.77 ms). However, a t-test revealed no significant difference between RTs for contagion and not contagion ($t=-0.04$, $p=0.9$).

Table 1. Phase 1 / phase 3 mean response times.

Condition	RTs	SD
Phase1	4.16	2.06
Phase 3	2.76	0.96

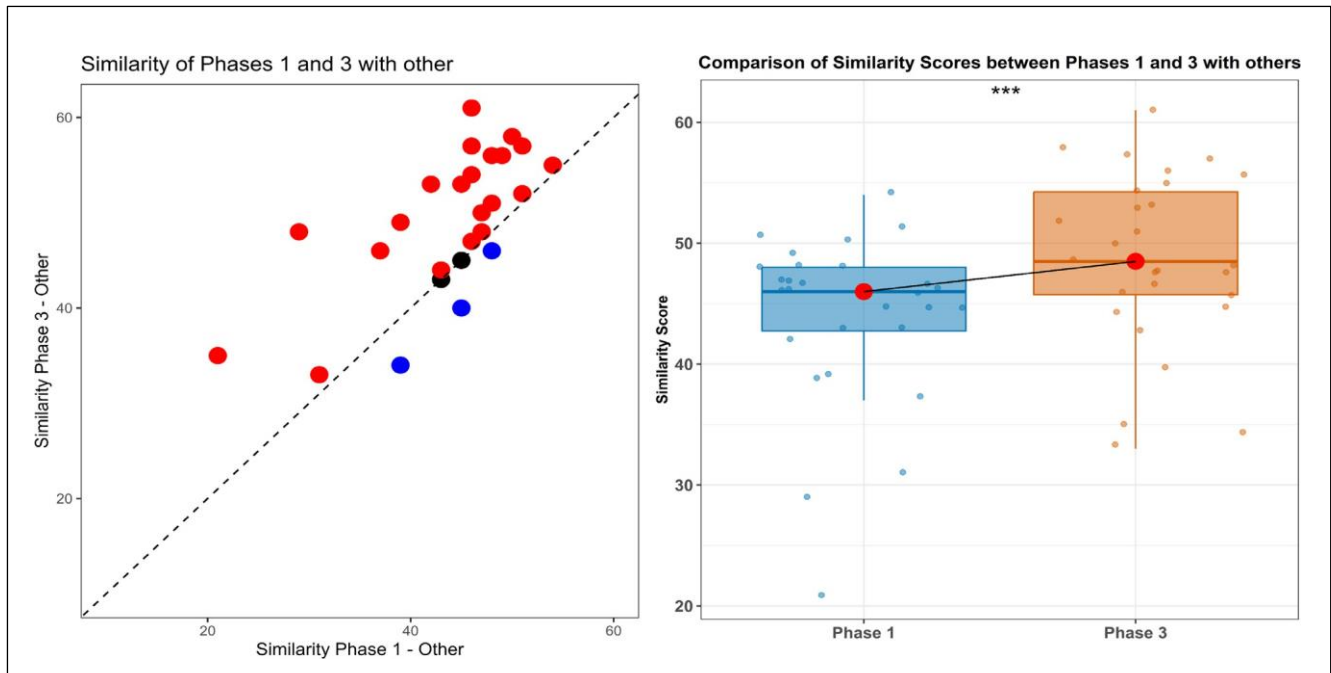


Fig. 2. Similarity of subjects' decisions in phase 1 and phase 3 with the confederate.

RESULTS

ERP results

The effects of three factors (predictors) were analyzed – 64 channels \times 2 (phases: phase 1 and phase 3) and \times 2 (contagion: exposed to contagion and non-exposed to contagion) – on the amplitude of a dependent variable in two different windows: 200-350, and 500-650 within subjects in R software.

P300

For the time window of 200 to 350 ms, within participants repeated measure three-way ANOVA revealed significant effects of three factors (Contagion, Phase, and Channel) on ERP amplitudes, as well as significant interactions between the factors. The ANOVA results reported in Table 2 revealed a significant contagion effect ($F_{(1,27)}=32.258$, $p<0.001$). This suggests that mean P300 amplitudes vary between conditions with and without contagion. Meanwhile, we also found a significant phase effect ($F_{(1,27)}=75.978$, $p<0.001$), indicating that ERP amplitudes differed across phases.

Table 2. Three-way ANOVA results.

Source	d.f	Sum Sq	Mean Sq	F value	Pr(>F)
Contagion	1	0.158	0.1583	32.258	1.47e-08 ***
Phase	1	0.373	0.3729	75.978	< 2e-16 ***
Channel	63	4.549	0.0722	14.711	< 2e-16 ***
Contagion: Phase	1	0.288	0.2885	58.771	2.31e-14 ***
Contagion: Channel	63	0.066	0.0011	0.215	1
Phase: Channel	63	0.109	0.0017	0.351	1
Contagion: Phase: Channel	63	0.062	0.0010	0.200	1

Also, the main effect of the channel was significant ($F_{(63,1727)}=14.711$, $p<0.001$). This implies that ERP amplitudes differ across various electrode locations. The data also revealed significant interaction effects between contagion and phase ($F_{(1,27)}=58.771$, $p<0.001$), suggesting that the effect of contagion on ERP amplitudes depends on the phase of the experiment. However, the interaction effect between contagion and channel showed not significant ($F_{(63,1727)}=0.215$, $p=1$), indicating that the effect of contagion on ERP amplitudes does not depend on the electrode location. Similarly, the interaction between phase and channel was not significant ($F_{(63,1727)}=0.351$, $p=1$), indicating that the effect of phase on ERP amplitudes does not depend on the electrode location. Finally, the interaction effect between contagion, phase, and channel was insignificant ($F_{(63,1727)}=0.200$, $p=1$). In summary, the results suggest that phase, contagion, and channel all have significant effects on ERP amplitudes. In addition, contagion's effect on ERP amplitudes depends on the experiment phase.

LPP

The ANOVA results showed that the 'channel' variable was not significant ($F_{(63,3328)}=1.27$, $p=0.077$) in the time windows of 500 to 650 ms. As a result, we did not observe LPP (late positive potential) components in this time window. As mentioned earlier, the P300 and LPP components of the ERP are sensitive to various cognitive processes, including category similarity and decision difficulty. Therefore, if only one of these components is observed (e.g., only P300 or only LPP), it's possible that its amplitude may be more closely related to decision difficulty rather than category similarity.

Differences waves from not contagion minus contagion in different phases

From the 200 to 350 ms time window, we segmented the brain into nine regions of interest (ROIs) following the approach used in previous research (Chen et al., 2010b). ERP differences between the two experimental conditions were then analyzed and compared for each ROI and electrode separately.

Table 3 shows the results of the statistical analysis. Three regions were found to be significant; however, after conducting *post hoc* analyses, two regions of interest (ROIs) – midline posterior and right posterior – withstood the false discovery rate (FDR) correction test, indicating that these differences were statistically significant at the adjusted alpha level. Specifically, the p -value for the right posterior ROI was less than 0.01. There are moderates to large effect sizes for Cohen's d and Hedges' g in the regions with significant p -values, suggesting that these differences are meaningful and not simply by chance. The effect sizes are generally smaller for the non-significant regions, indicating that the groups do not differ as much. Fig. 3, 4 show the grand averaged difference ERP waveforms for contagion and not-contagion in different phases in midline posterior and right posterior respectively. The scalp map distribution of the grand average difference potential between contagion and non-contagion differences is presented in Fig. 5, along with the corresponding p -values.

This topo plot supports the notion that the temporoparietal and parieto-occipital regions of the brain play a crucial role in processing information, particularly with respect to conformity and other regarding information.

Table 3. Results of statistical analysis for ROI differences.

ROI	t-value	p-value	Cohen's d	Hedges' g
Left frontal (FP1, F3, F7, FC3, FT7)	1.56	0.128	0.33	Small
Midline frontal (FPZ, FZ, FCZ)	1.58	0.125	0.33	Small
Right frontal (FP2, F4, F8, FC4, FT8)	2.02	0.052	0.61	Medium
Left central (C3, T7)	0.96	0.345	0.20	Small
Midline central (CZ)	1.10	0.280	0.24	Small
Right central (C4, T8)	1.28	0.211	0.30	Small
Left posterior (CP3, TP7, P3, P7, O1)	2.37	0.025*	0.66	Medium
Midline posterior (CPZ, PZ, OZ)	2.43	0.0219*	0.67	Medium
Right posterior (CP4, TP8, P4, P8, O2)	2.95	0.006**	0.87	Large

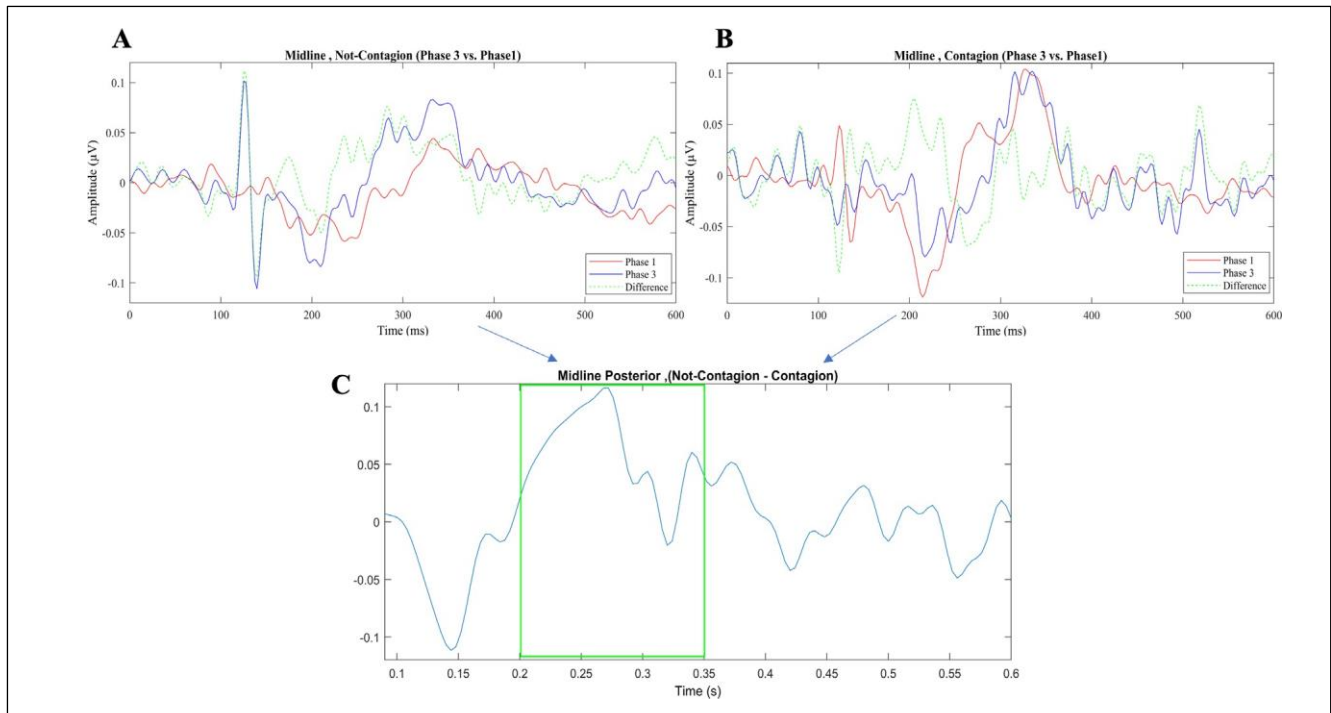


Fig. 3. Grand-averaged waveform of P300 in the midline posterior region for contagion and not contagion in phase 1 and phase 3 (panels A and B, respectively). Panel C shows the difference waveform of not-contagion and contagion in the midline poster.

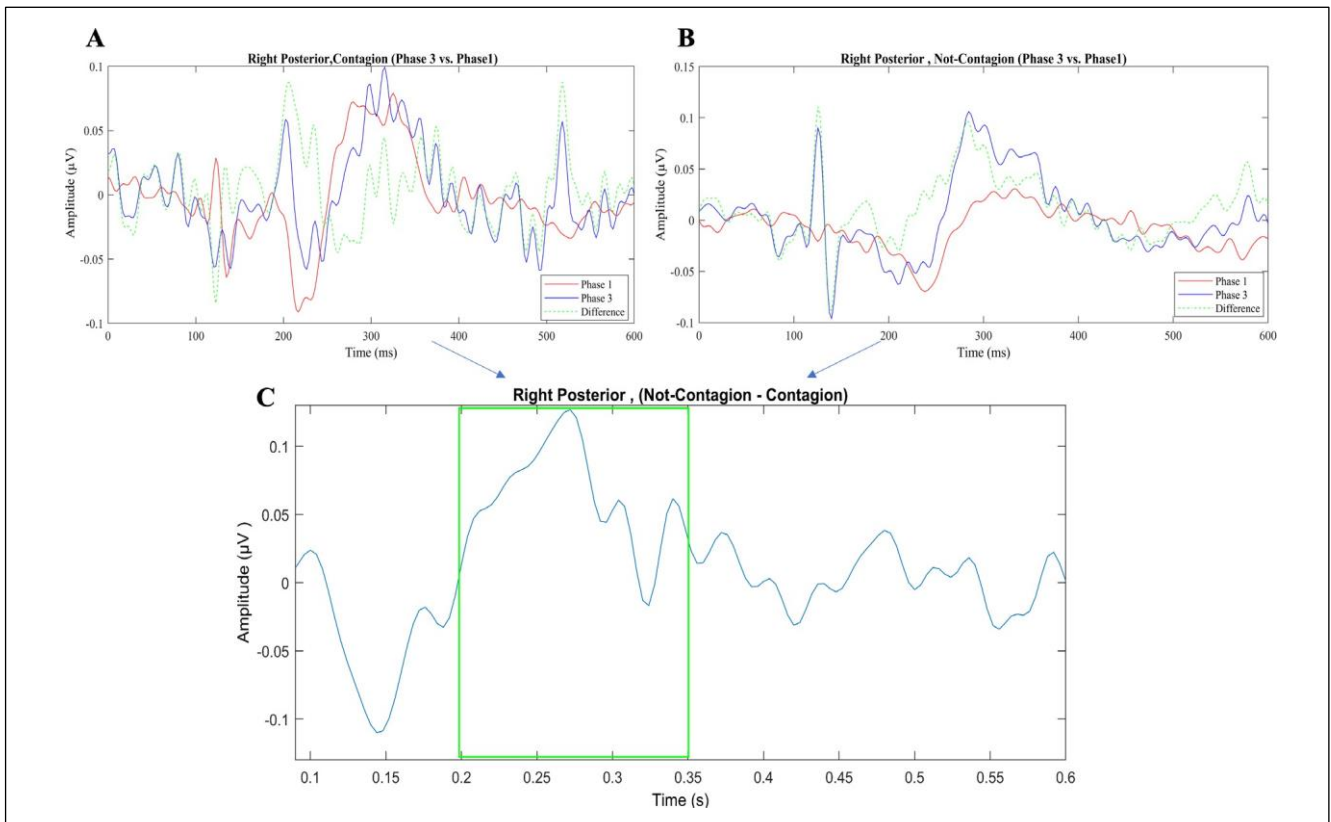


Fig. 4. Grand-averaged waveform of P300 in the right posterior region contagion and not contagion in phase 1 and phase 3 (panels A and B, respectively). Panel C shows the difference in the waveform of not-contagion and contagion in the right posterior.

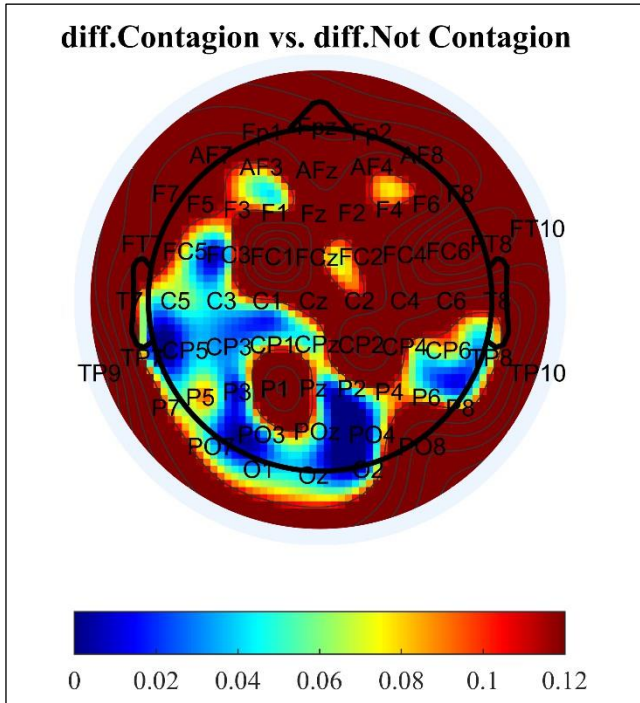


Fig. 5. The *p*-value topographic distribution of grand average difference potentials between 200 and 350 ms.

At the same time, the differences in ERP between the left hemisphere (FP1, F3, F7, FC3, FT7, C3, T7, CP3, TP7, P3, P7, O1), and right hemispheres (FP2, F4, F8, FC4, FT8, C4, T8, CP4, TP8, P4, P8, O2) were analyzed. The results showed that the P300 response in the right hemisphere was significantly larger than in the left hemisphere, with a *t*-value of 2.20 and a *p*-value of 0.03.

Also, as seen in Fig. 6 the mean amplitude across the all subjects and electrodes in right, left and mid-line posterior between 200 and 350 ms for phase 3 (Mphase3=0.03, SD=0.042) was larger than phase 1 (Mphase1= 0.01, SD=0.044).

Overall, the contagion and conformity conditions elicited a P300 that was distributed in the midline posterior and right posterior regions, with a significantly larger amplitude observed over the right hemisphere electrode sites. These results provide support for hypothesis 3, which pertains to the effect of decision difficulty on amplitude, rather than to the effect of category similarity, since both components (i.e., P300 and LPP) must be observed to address this issue.

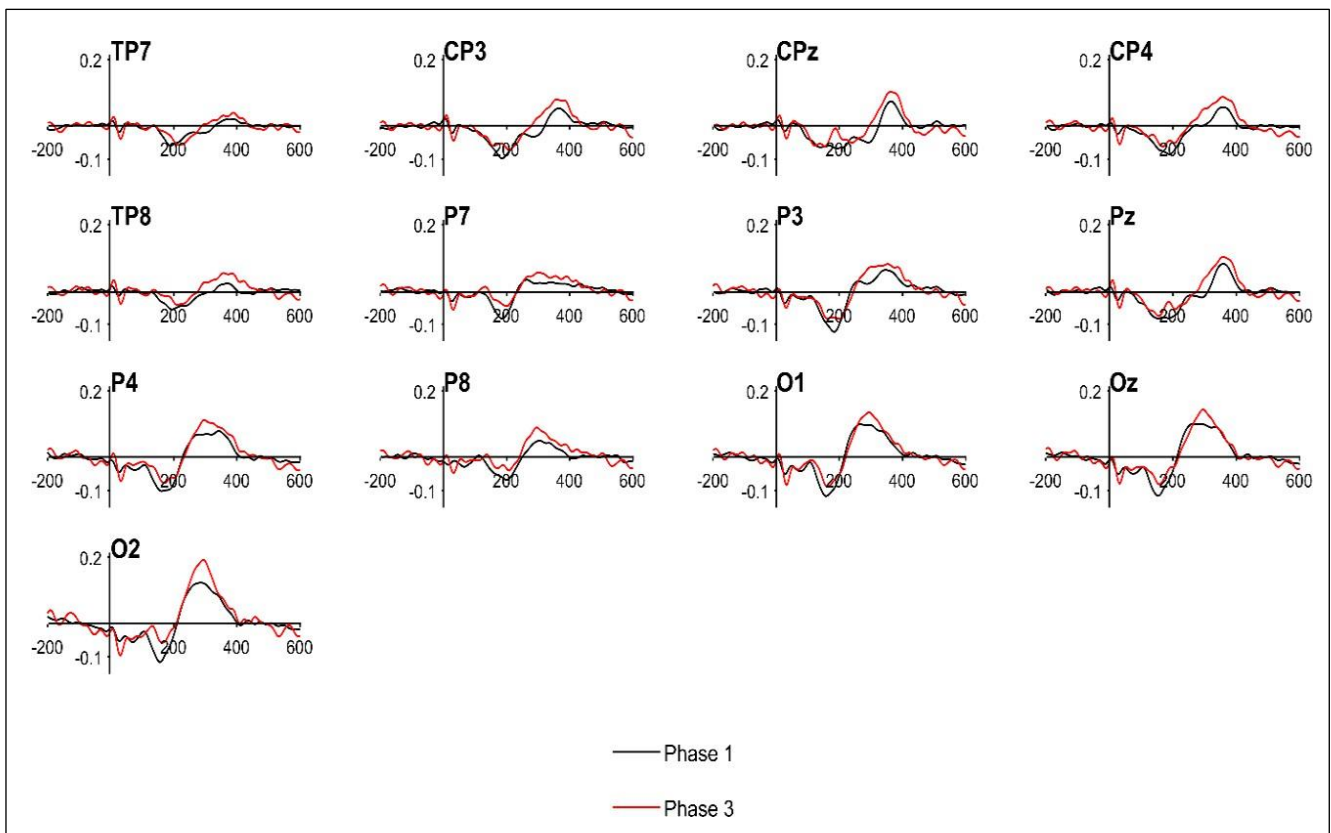


Fig. 6. ERP waveform across all subjects in selected electrodes.

Group differences in neuropsychological measures

To determine whether individuals' behavioral changes are manifested in brain activity, we conducted a Spearman correlation between amplitude and reaction time in ERP data, both across all subjects and among those who experienced contagion. Mean event-related potential (ERP) amplitude differences were calculated between phase 3 and phase 1 within the significant regions of interest (ROIs) during the time interval of 200-350 ms. Additionally, differences in reaction time between phase 3 and phase 1 were also computed. As we can see from Fig. 7A a significant inverse relationship was observed between the two variables, suggesting that as amplitude increase, reaction time decrease. This negative correlation was stronger among individuals who conformed ($\rho = -0.58$, $p = 0.02$) than the correlation coefficient for all subjects ($\rho = -0.35$, $p = 0.03$). Thus, the correlation between amplitude and reaction time is more pronounced in individuals who had higher levels of conformity (Fig. 7B). However, an inverse relationship between the two variables was not observed in the not conformed subject ($\rho = -0.15$, $p = 0.3$) (Fig. 7C).

Fig. 7. Scatterplots showing the correlation between difference in RT and the difference in mean ERP amplitude. The fitting regression line is shown in black, and the 95% confidence interval for the line is shown in gray shading.

DISCUSSION

The current study aimed to investigate how individuals are influenced by the decisions of others and to investigate the neural and behavioral mechanisms underlying this contagion effect.

The outcomes of our behavior experiment have replicated the classical behavioral pattern commonly seen in social conformity studies; individuals' initial decisions can be modified as a result of observation of others' behavior (Chen et al., 2010a, 2010b; Zhang et al., 2019). Our first hypothesis, which proposed that individuals would be affected by behavioral contagion, was supported. The reasons for this behavioral change could include factors such as limited information, low self-confidence, and social pressure to conform. In essence, people have the propensity to believe in and maintain consistent with the majority of others' beliefs (Deutsch & Gerard, 1955; Chen et al., 2010a; Gao et al., 2017; Zhang et al., 2019).

Behaviorally, in line with previous studies (Chen et al., 2010a, 2010b), we found that the mean RTs in phase 3 were significantly shorter than in the initial phase. The fact is that, the reduced reaction time observed in phase 3 can be attributed to various factors, including familiarity with the environment, and / or learning from observing the choices of others. As participants became more familiar with the task and learned from the behavior of others, they likely developed a faster decision-making process, leading to a decrease in reaction times.

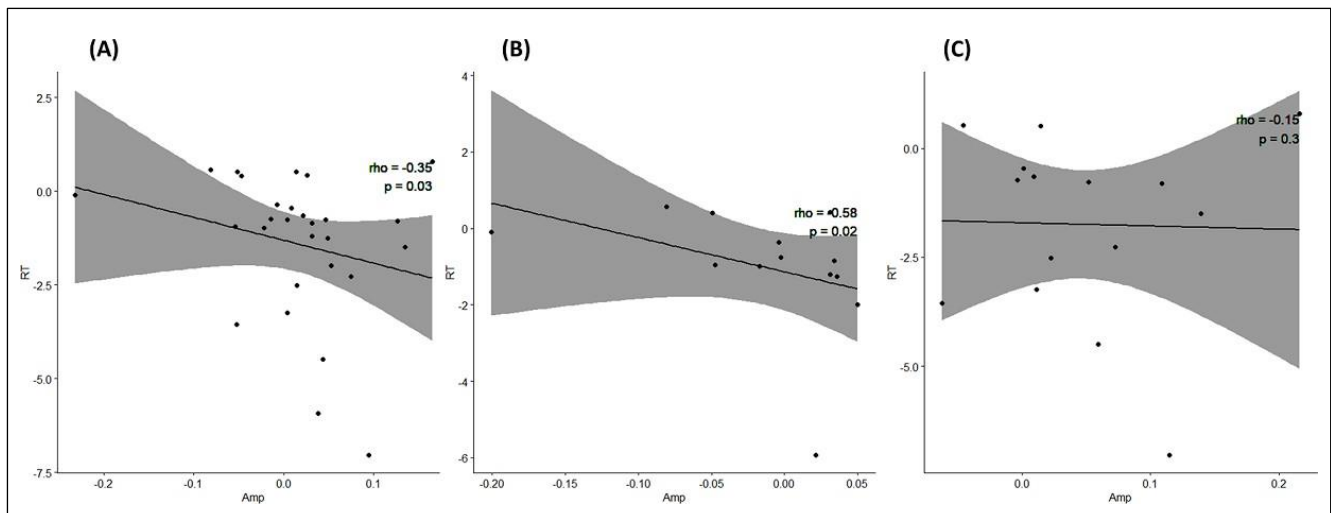


Fig. 7. Scatterplots showing the correlation between difference in RT and the difference in mean ERP amplitude. The fitting regression line is shown in black, and the 95% confidence interval for the line is shown in gray shading. Results for (A) all subjects; (B) conformed subjects; (C) subjects who did not conform.

In addition, the results of the analysis revealed that participants who exhibited higher levels of conformity demonstrated significantly smaller differences in reaction time between phases 1 and 3, compared to those who did not conform. This suggests that participants who aligned their decisions with the observees may have had less difficulty in making decisions and did not require more time to process decision-making conflicts.

The ERP results indicated that in phase 3, participants who shifted their choices toward the observees' choices exhibited a larger P300 amplitude compared to other participants. P300 is an established neural marker of core information processing in the brain (Palmer et al., 1994; Pierguidi et al., 2019; Xie et al., 2016) and its amplitude has been shown to be negatively related to the difficulty of decision-making tasks (Vallesi, 2011) so in phase 3, participants who aligned their decisions with the observees they had less difficulty in making decisions compared to those who did not align their decisions.

The third hypothesis posited that individuals who aligned the behavior to match others, will exhibit either larger LPP or P300 amplitude like the effect of decision difficulty reported in previous studies (Palmer et al., 1994; Cutmore & Muckert, 1998; Finnigan et al., 2002). This finding suggests that the absence of LPP response may be more closely related to decision difficulty rather than category similarity. However, the absence of a significant LPP component in the time windows 500-650 ms could potentially be attributed to the experimental design or influenced by the relatively small sample size and insufficient number of trials.

We divided the brain into nine regions of interest (ROIs) and calculated amplitude differences between phase 1 and phase 3 in the time window of 200-350 ms for participants who displayed higher conformity *versus* those who did not. We found that two out of the nine ROIs showed significant amplitude differences, suggesting neural activation patterns associated with behavioral contagion.

Moreover, our findings indicate a significant difference in P300 amplitude between right hemisphere and left hemisphere. Specifically, the P300 amplitude was found significant in the right hemisphere. There may be a differential involvement of hemispheric processing in behavioral contagion. The topo plot offers compelling evidence regarding the functional importance of the temporo-parietal and parieto-occipital brain regions in the processing of information associated with conformity and other regarding information. The parieto-occipital region has been implicated in processing both self-relevant and other-relevant information (Padmanabhan et al., 2017). The right temporoparietal

junction (rTPJ) has been identified as having a distinct role in understanding the beliefs of others (Spreng & Andrews-Hanna, 2015). It is actively involved in processing social information, such as making inferences about the intentions and beliefs of individuals (Tso et al., 2018). Furthermore, studies (Peng et al., 2021) have indicated that the rTPJ also influences emotional mimicry based on group membership.

Although some researchers have reported the activation of the frontal lobe in conformity tasks, the results of our research are in line with the findings of Berns et al. (2005). They reported that conformity is associated with activation in visual cortical and parietal regions, while the frontal lobes showed no significant activity. This discrepancy may be attributed to differences in the experimental paradigms and stimuli employed across studies. They suggested that changes in participants' initial judgments during conformity tasks could be attributed to low-level perception rather than higher-level attentional processes. Our findings support this notion and highlight the importance of visual and parietal regions in the neural mechanisms of conformity. The involvement of these regions suggests that participants may rely on visual information processing and basic perceptual mechanisms to align their judgments with those of others, rather than engaging executive processes associated with the frontal lobes.

We also found a correlation between the difference in RT values and the difference in mean ERP amplitudes before and after the manipulation for a significant ROI within the time windows of 200-350 ms. We can interpret the results as follows: when subjects conform or experience a contagious effect, they tend to have lower reaction time and higher amplitude in their ERP data (Chen et al., 2010a, 2010b). The negative correlation between amplitude and reaction time differences could be attributed to the neural mechanisms involved in the cognitive processes of conforming or experiencing a contagious effect. This interpretation is supported by the finding that ERP amplitude, which serves as a neural measure, exhibits a significantly larger magnitude within the significant ROI for the group displaying higher conformity compared to the group displaying lower conformity. Conversely, reaction time differences, a behavioral measure, is shorter in the higher conformity group, suggesting a potential inverse relationship between the two variables and indicating the presence of a shared underlying neural process.

Our study is subject to several limitations that may impact the generalizability of our findings. Firstly, the relatively small sample size and unequal gender distribution could potentially influence the statistical

power analysis. Additionally, the imbalanced gender distribution introduces the possibility of biased results. To enhance the reliability and robustness of our findings, we recommend conducting future studies with a larger sample size and ensuring equal gender representation.

Experimental research on social preferences has commonly involved student participants. However, it is important to consider the limitations associated with this sample. Recent research by Epper et al. (2024) has demonstrated differences in the distribution of social preferences between students and the general population. These differences are likely influenced by factors such as age and education. Additionally, conformity tendencies can be influenced by various personality factors, including age, gender, and cultural differences (Deldoost, 2022). Studies have indicated that an individual's age significantly affects their susceptibility to social conformity. In particular, individuals in early and late adulthood tend to be more easily influenced compared to those in middle age (Visser & Krosnick, 1998; Wijenayake et al., 2021). Considering these factors, it is important to acknowledge that our study's sample consisted solely of students, which may limit the generalizability of our findings. Future research should aim to include participants from diverse backgrounds to gain a more comprehensive understanding of social preferences and decision-making behavior.

While our study applied EEG to measure neural activity, future investigations could incorporate other neuroimaging techniques, such as fMRI, allowing for a more detailed examination of the brain region-specific and providing insight to deepen our understanding of the neural processes underlying contagion and social influence.

ACKNOWLEDGMENT

This work benefited from discussions with Abdolhossein Vahabie, Mohammad Rabie, and Fahimeh Parsaiee.

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The Role of Attention in Social Decision-Making: An Eye-Tracking Study in a Repeated Dictator Game

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Credit authorship contribution statement

All authors contributed to the study conception and design. Methodology and data acquisition were done by: SMHD, EO, and MRG. Formal analysis was done by: SMHD, EO, MRG, and AHV. SMHD drafted the manuscript. All authors contributed in editing the draft.

Funding:

AHV and RKH would like to acknowledge the supports of cognitive science and technologies council.

Data Availability: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Abstract

For more than a century, predicting human decisions has been a key topic of interest in psychology, economics, and recently, neurosciences. Attention is a fundamental cognitive process essential for effective decision-making, and research often examines how attention to individual objects impacts this process. The present eye tracking study (N=42) aims to explore the association between social decision-making in a repeated dictator game, based on the Fehr-Schmidt inequity aversion model, and process data, including response time and pupil dilation. Specifically, we investigate the potential relationship between these process-level measures and social decision-making in the context of the repeated dictator game. By measuring participants' visual attention during the task, we can gain insights into how attentional processes relate to individuals' choice behavior and resource allocation. We found that individuals tend to allocate more attention to their self-option compared to other options, regardless of the context. Furthermore, they exhibited an even greater level of attention to the self-option for chosen items compared to unchosen items. We also examined the Behavioral Inhibition and Behavioral Activation Systems (BIS/BAS) as a predictor of process data. We found significant correlations between the BIS/BAS scores, pupil size and response time. Taken together, these results suggest that the information obtained from response time and eye movement measures can offer a more comprehensive perspective on individuals' decision-making processes and preferences.

Keywords: Attention, eye movements, repeated dictator game, response time, Fehr-Schmidt model

Introduction

"Focus is the gateway to all thinking: perception, memory, learning, reasoning, problem-solving, and decision making." Daniel Goleman

People make a wide variety of decisions in their daily lives, and a part of these decisions typically involve complexity, multiple attributes, and uncertainties. (Banks & Gamblin, 2022). These decisions encompass a wide range of aspects including, what to eat, where to travel, browsing for products on the web or shelves, decisions about charitable donations, and even determining who to vote for. In essence, all of these decisions involve search as well as choice which are influenced by various social and economic factors. Decisions often involve trade-offs between self-interest and social outcomes, such as allocating resources to others in economic games (Krajbich, Bartling, et al., 2015).

The value associated with different options is a crucial factor that influences our decision-making process when choosing among alternatives (Rangel et al., 2008). In other words, value impacts how someone interprets information (Meglino & Ravlin, 1998). Thus, value-based decisions are driven by subjective preferences and personal judgments (Padoa-schioppa & Schoenbaum, 2015). Modeling value-based decision-making can be approached in two primary ways. The first approach, commonly employed in economics, involves representing an individual's preference relation through a utility function that is aimed at maximizing their desired outcome. Mathematically: $\text{argmax}_{a \in A} [U_i]$. That is, individuals want to choose the option a in the set of possible options A which maximizes the utility (U).

Another perspective, frequently used in psychology and neuroscience, suggests that individuals participate in information sampling and evaluation processes. To better grasp these processes and uncover people's preferences from choices, various models, such as sequential sampling models (SSM), pupil size, eye movement, mouse tracking and neural activity, have been introduced and developed. These models provide valuable insights into how individuals gather and assess relevant information during decision-making. Eye-tracking as a non-invasive technology, in particular, has allowed researchers to study the impact of attention on choice

behaviors and quantify the relative significance of different factors in decision-making (Chen & Fischbacher, 2016; He & Bhatia, 2023; Mormann & Russo, 2021). Attention is not just about what is seen, but how information is processed within an option. Traditional models like the Drift-Diffusion Model (DDM) assume evidence accumulates based on overall option value, while the attentional DDM (aDDM) proposes that attention amplifies the value of attended options. However, He and Bhatia (2023) shows that attention can be "interactive"—a high-value attribute (e.g., a large payoff) biases attention toward other attributes within the same option branch (e.g., its probability), shaping decisions through internal attribute dynamics rather than simple option-level weighting. Recent reviews (Mormann & Russo, 2021) have questioned whether visual attention causally increases the subjective value of options, as assumed in models like aDDM. As they argue, we need to more carefully examine whether "looking causes liking" or whether "liking causes looking" — a distinction that has profound implications for how we interpret fixation patterns in decision-making. Their critique highlights the need for empirical studies that examine attention in more socially grounded contexts. Our study contributes to this debate by analyzing how gaze patterns, pupil dilation, and personality traits reflect the dynamics of value-based decisions involving self–other trade-offs in a repeated dictator game.

This growing focus on the cognitive and attentional underpinnings of choice highlights a fundamental gap in traditional economic models, which often treat decisions as instantaneous and context-free, ignoring the very processes that shape real-world behavior.

While cognitive neuroscience emphasizes the importance of attention and reaction time in shaping decision-making processes, traditional economic models ignore them (Konovalov & Krajbich, 2019; Krajbich, Hare, et al., 2015). These models typically assume that individuals have boundless cognitive resources and can react to information immediately, which is often not the case in real-world situations.

In most value-based decision-making problems, at least two factors are competing for the subject's interest. These competing factors are particularly evident in social decision-making, where the benefits to self and others can influence the decision process differently. In the dictator game, the choice between different options is determined by the competition between self-interest or envious and altruistic

motivations. The difficulty in decision-making stems from the close contest between these competing drives. In other words, a greater difference between the competing factors leads to simpler decisions, whereas a smaller difference complicates the decision-making process.

Prior studies have examined attention in asocial contexts, where decisions affect only the self (Fiedler & Glöckner, 2012; Glaholt & Reingold, 2009; Krajbich et al., 2010), and gaze reflects self-referential value. These paradigms overlook how attention operates when others are impacted. Our study fills this gap by examining attention in a repeated dictator game, where choices affect both self and other. We aim to determine the relative importance of self- versus other-regarding benefits in shaping both attention and final decisions.

To achieve this, we have utilized eye tracker data to analyze participants' attention patterns and gather insights into their decision-making strategies. Furthermore, we measure the relative difficulty of decision problems that arise from the perceived benefits of self and others by analyzing participants' reaction time and pupil size, which is an appropriate proxy for value-based decision making (Slooten et al., 2018). Moreover, we also recognize that the significance of these factors depends on the personality and traits of the subjects. Understanding how individuals allocate their attention to these factors and how they influence their final decisions is a crucial aspect that we aim to uncover in this study.

Our study builds upon previous research by confirming that response time and eye movements are reliable indicators of individuals' preferences and can reveal important aspect of decision process. The three metrics we investigated pupil size, reaction time, and relative self-view (RSV) can be crucial in determining resource allocation and social interactions and may be influenced by personality traits. Our analysis revealed that these indicators offer complementary perspectives on individuals' decision-making processes, which can lead to a more comprehensive understanding of their preferences.

Based on this framework, our study examines the following research questions:

- **RQ1:** How do individuals allocate visual attention when choosing between self-serving and prosocial options?
- **RQ2:** Does attentional allocation differ depending on the type of inequality (advantageous versus disadvantageous)?

- **RQ3:** Can physiological markers such as pupil dilation and response time indicate decision conflict in morally ambiguous choices?
- **RQ4:** How strongly do personality (e.g., BAS and BIS) predict patterns of attentions and decision outcomes in a repeated dictator game?

To explore these questions in details, we applied a multimodal approach that connects attentional dynamics and personality traits to decision outcomes in a repeated dictator game.

Additionally, our study offers a valuable cross-cultural perspective to the social decision-making field. The majority of prior researches have been conducted in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies, where individualism and certain social norms prevail. In contrast, Iran represents a non-Western cultural context that emphasizes collectivism and different value systems. Conducting our experiment in Iran allows us to test the generalizability of theories of attention, inequality aversion, and personality-driven decision-making beyond the WEIRD paradigm, offering a culturally inclusive understanding of social preferences.

Methods

The study included 46 healthy volunteers (20 females), predominantly undergraduate and graduate students from the University of Tehran, who participated in a single session for a compensation of 100,000 toman (approximately 5 dollars). Additionally, to incentivize participants, two of their chosen options were randomly selected, and the average of their outcomes was paid as a bonus immediately after the experiment.

An a-priori power analysis was conducted using G*Power to determine the necessary sample size (Faul et al., 2009). For an effect size of 0.50, a power of 0.8, with α set at 0.05, a minimum of 42 participants was required. One person was removed from the study because the eye-tracking system unexpectedly crashed, and three others were excluded due to problems with system calibration. Consequently, the total number of participants in the final sample was 42. The informed consent forms were signed by all participants before the study began. They were all right-handed, had no history of nervous or mental diseases/psychiatric illness, and had no history of brain injuries.

Additionally, they had normal vision and hearing. The experiment was carried out following the guidelines of Helsinki Declaration. The ethical aspects of the experiment were evaluated and approved by the ethical review board of the Institute for Cognitive Science Studies, with a reference number of IR.UT.IRICSS.REC.1400.34.

This article deals with the simplest kind of distributive choice, which involves the allocation of resources between two individuals. We conducted repeated dictator game where two players are involved and the second player (referred to as the "other"), assumes an entirely passive role and has no influence on the outcome. In a dictator game the decision maker acted as a dictator, repeatedly, will be asked to decide how to allocate a finite set of experimental currency units (ECUs) which were exchange into Iranian toman (1ECU=10 toman) between self and other. The sequence in which the trials were presented in each game was randomized.

We explicitly refer to our design as a binary-choice version of the repeated dictator game throughout the manuscript to avoid confusion with the classical version and to reflect its specific methodological advantages.

To better understand the trade-offs related to the selection position, we have shown the choices numerically and graphically. Figure 1. A shows the presented options in a sample trial and Figure. 1. B shows the options at all trials in the space of self-other payoffs The representation of a dictator game is depicted by a solid line, where the two options are at each end of the line.

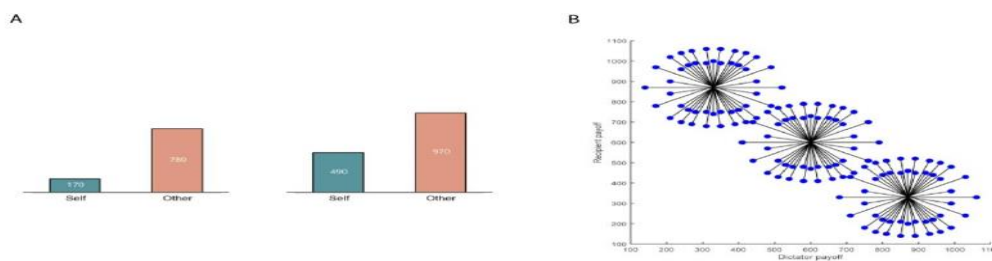


Figure 1 An example of a dictator's decision, A binary allocation menu (A). All allocations in different inequality space (B)

Each of the three circles contains 22 binary dictator games (Figure. 1.B). Two payoffs self/other allocations are connected by a line and the slope of the line specifies the dictator's cost of altering the other payoff, more precisely, represents the relative price of giving. In the top left (bottom-right) and above (below) the

degree line is called disadvantageous (advantageous) inequality, which is the payoff of the dictator is always smaller (higher) than the receivers. A vertical line means that the payoff of the other can be increased or decreased at no cost to the dictator (in this situation, not giving may be interpreted as envy). A positive slope indicates that giving is beneficial both to oneself and to the other (not giving maybe evidence of spitefulness). Thus, in an advantageous (disadvantageous) space, we are able to estimate the value of Beta (Alpha) parameters. The options in the middle (mixed) payoff space specify both alpha and beta parameters depending on the chosen option. Our measurement of subjects' other-regarding preferences was based on the Fehr and Schmidt (hereafter FS) model, which is one of the most important and widely cited theories for studying inequity aversion. The FS model provides a utility function for two players, which is as follows:

$$(1) \quad U_i = M_i - \alpha_i \max[(M_j - M_i), 0] - \beta_i \max[(M_i - M_j), 0] \quad i \neq j$$

Where U_i is the individual's own utility, M_i is the self-monetary payoff, and M_j depicts another monetary payoff. his model has two parameters that capture feelings of the subject's enviousness (disutility from being behind) and guilt (disutility from being ahead). We estimated the regression described by equation (1) to elicit those parameters in the task (for estimation details, see the appendix C). In their original paper, Fehr and Schmidt (1999) assume that two disutility parameters are $\alpha \geq \beta \geq 0$. In terms of alpha and beta, no consensus exists on what are plausible values or what is their distribution (Nunnari & Pozzi, 2022).

In addition to examining decision-making behavior, we also sought to understand each subject's visual attention and decision-making dynamics. To this end, we recorded eye movement data while participants were choosing among 66 binary dictator games, in which they selected one of two offers. Participants were seated in a chair with a chin rest in front of a 144-Hz frequency monitor with a screen resolution of 1920x1080 (BenQ Zowie XL2411P), at a viewing distance of approximately 55 cm. Eye movements were monitored and recorded using a 500-Hz eye-tracking system (Farmed Tajhiz, Iran), with a sampling rate of one observation every two millisecond.

The experiment was implemented with Psychtoolbox package (Clavien & Klein, 2010) in MATLAB (Version 2019b; MathWorks inc, Natick, MA) and lasted approximately 45 minutes. We investigated the degree to which participants'

attention on their self-option relative to others' option in three conditions: all options, chosen options, and unchosen options. Additionally, we analyzed the effects of advantageous and disadvantageous inequality, as well as absolute utility as a measure of choice difficulty, alpha, and beta parameters in FS model, pupil dilation, reaction time on the RSV variable.

RSV was calculated as the proportion of total fixation time directed toward the self-option relative to both options combined. This measure provides a normalized index of attentional focus, ranging from 0 (exclusive focus on the other option) to 1 (exclusive focus on the self-option). Similar metrics have been used in prior studies to quantify gaze bias and its relationship with choice behavior (e.g., Chen & Fischbacher, 2016; Shimojo et al., 2003).

To assess the amount of attention directed towards the subject's own option compared to other option, we calculated the ROI (Region of Interest) or areas of interest for each option based on the midpoint. The total view was measured by counting the number of samples of eye positions within each ROI. To determine the relative view in relation to oneself for each option, we normalized the number of samples at each ROI based on the total view time. Statistical analyses were conducted using a mixed-effects generalized linear model with the subject as a random effect on the intercept (table 1). This analysis was performed using the "fitglme" function in MATLAB.

Table 1 Equations used in Generalized Linear Mixed-effects Model (GLMM)

$$(2) \text{ RelSelf-}y = \beta_0 + \beta_1 * \text{beta} + \beta_2 * \text{alpha} + \beta_3 * \text{absutility} + \beta_4 * \text{advantage} + \beta_5 * \text{disadvantage} + (I|\text{SubID}) + \varepsilon$$

$y = \text{other, chosen, un-chosen}$

$$(3) \text{ Pupil} = \beta_0 + \beta_1 * \text{BIS} + \beta_2 * \text{BASD} + \beta_3 * \text{BASR} + \beta_4 * \text{BASF} + \beta_5 * \text{absutility} + \beta_6 * \text{advantages} + \beta_7 * \text{disadvantages} + (I|\text{SubID}) + \varepsilon$$

Additionally, after completing the game, participants were asked to complete a post-experimental questionnaire that included measures of the Behavioral Inhibition System/Behavioral Activation System BIS/BAS (Carver & White, 1994). The BIS/BAS scales are self-assessment questionnaires comprising 24 items. The questionnaire includes a certain number of BIS items and a certain number of BAS items. Each item provides respondents with four response choices, ranging from 1

(strongly agree) to 4 (strongly disagree). The BAS scale consists of three subscales: BAS-Reward Responsiveness (BASR) relates to the positive reactions and anticipation of rewards, BAS-Drive (BASD) refers to the tendency to persistently pursue desired goals, and BAS-Fun seeking (BASf) reflects the inclination to seek out novel and exciting rewards spontaneously, craving excitement and new sensations. The BIS is highly responsive to signals of punishment, leading to the inhibition of behaviors that may result in bad or painful occurrence (Jorm et al., 1998).

Results

Our findings revealed that participants displayed a significantly higher level of attention towards their self-option compared to the other option ($t(40) = 6.49$, $p < 0.0001$, $SD = 78.62$), as illustrated in Figure 2A. Furthermore, as depicted in Figure 2B, we observed a notable increase in attentiveness towards the self-option in both chosen ($t(40) = 7.27$, $p < 0.0001$, $SD = 0.09$) and unchosen situations ($t(40) = 7.42$, $p < 0.0001$, $SD = 0.05$)

compared to the other option. Additionally, our results indicate that the chosen option was viewed more frequently than the unchosen option ($t(40) = 14.82$, $p < 0.0001$, $SD = 0.06$).

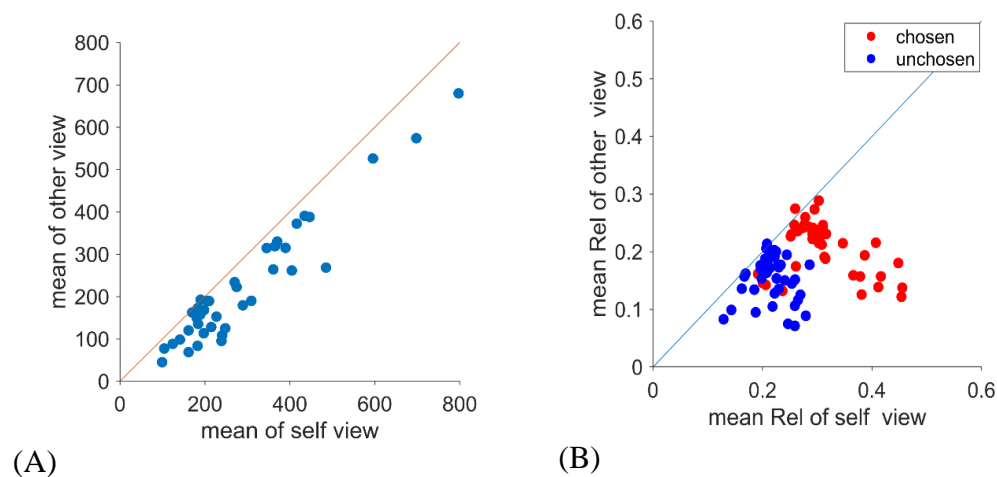


Figure 2 Comparison of attention to self-option and other-option (A). Comparison of attention to self-option in for chosen and unchosen items (B).

Generalized Linear Mixed-effects Model (GLMM)

To rigorously investigate these observations, we conducted a mixed-effects regression analysis, which is summarized in Table 2. In specification (1), the dependent variable is the RSV, and we included beta, alpha, advantages and disadvantages, as well as absolute utility, as covariates (see Equation 2).

Our findings reveal that both the alpha and beta parameters exert a negative influence on the RSV. In simpler terms, as these parameters increase, the amount of relative attention devoted to the self-option decreases. Furthermore, we observed relationship between the difficulty of the decision does not reach to the significance level, as measured by the absolute utility variable, and the RSV. In advantageous situations, individuals tend to exhibit a higher RSV, whereas in disadvantageous situations, this relative amount decreases.

Table 2 Results of Mixed-Effect Regression Analysis RVS as Dependent Variables with Covariates

	(1)RSV: Across both options		(2) RSV: In chosen options		(3): RSV in Unchosen options		(4) RT	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Constant ¹	-0.014	0.182	-0.65***	0.15	-0.91***	0.13	5.428***	0.400
Beta	-0.47**	0.028	-0.38**	0.17	-0.39**	0.15	-0.781	0.432
Alpha	-0.89***	0.25	-0.74***	0.21	-0.64***	0.18	1.299**	0.532
Abs.utiliy	-0.000	-0.000	0.000	4.08	-	0.000	-	0.0003
Advantage	0.04**	0.01	0.02	0.01	0.01	0.02	-0.443**	0.169
Disadvantage	-0.12***	0.01	-0.09***	0.01	-0.08***	-0.02	-0.223	0.170

*** p< 0.001, ** p< 0.01, * p<=0.5

In specification (2) and (3), We conducted the same analysis for RSV within chosen option and unchosen option separately (see Equation 2).

The findings indicated that the absolute value of utility only has an impact on the relative self-view on unchosen options. In other words, the more difficult the options (i.e., the lower the absolute utility value), the greater the effect on the unchosen options.

¹ The intercept (constant term) is included as part of standard regression modeling practice to anchor the model when all predictors are zero. It is not interpreted directly in this context but ensures correct estimation of other coefficients.

Furthermore, we conducted a comparison to determine if there is a discrepancy in attention towards the self-option based on whether participants were in an advantageous or disadvantageous condition. Our findings demonstrate that participants exhibited a higher level of attentiveness towards the self-option in advantageous situations compared to disadvantageous situations, as depicted in Figure 3.

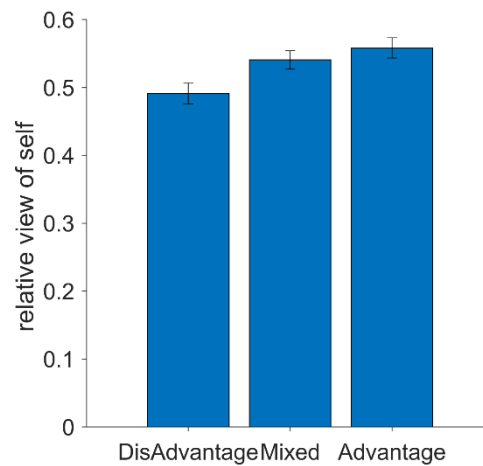


Figure 3 Comparison of attention to self-option in advantageous and disadvantageous areas

In other words, the pay-off associated with each option can be a decisive factor in determining the level of focus on one's self-option versus the other option. To clarify, our findings indicate that when the subject's payoff exceeds that of the other person, they tend to allocate more attention to the self-option. Conversely, when the other person's payoff is higher, individuals tend to direct their attention towards the other option. In essence, attention appears to be influenced by the relative payoff, with a greater focus on options associated with higher payoffs.

With respect to reaction time (specification (4)), the positive effect of "Alpha" suggests that higher values of this variable lead to longer response times. On the other hand, "Beta" does not appear to have a significant impact on the response time. The coefficient for "Advantage" is estimated at -0.443 ($p < 0.01$), indicating a significant negative relationship with the response time. This suggests that when the dictator's payoff is greater than the receiver's, the response time tends to decrease. On the other hand, the coefficient for "Disadvantage" is estimated at -0.223 ($p > 0.05$), indicating a non-significant relationship with the response time. This suggests that

when the receiver's payoff is greater than the dictator's, it does not significantly impact the response time.

Additionally, our findings suggest that in the mixed situation, the reaction time is longer compared to both the advantageous and disadvantageous situations as illustrated in Figure 4.

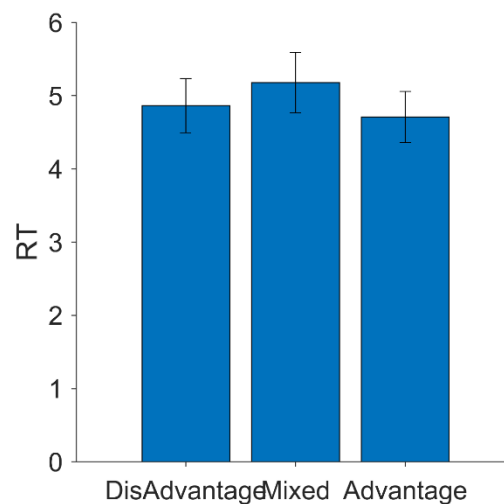


Figure 4. Reaction time in different inequality spaces

This indicates that advantageous and disadvantageous conditions are relatively easier than mixed one and higher reaction time depends on the task difficulty.

Roles of BIS/ BAS as a predictor of Reaction time and Pupil dilation

The BIS is conceptualized as an attentional system which is sensitive to the fear of punishment. The BAS is understood as a motivational system which explores whether people behavior are motivated by the desire for signals of rewards (Amodio et al., 2007). There is evidence that individual differences in BIS/BAS can affect the way options are evaluated in decision-making (D. Y. Kim & Lee, 2011; Li et al., 2021).. It is also possible to link the BIS / BAS system to the eye movements (Rauthmann et al., 2012).

To scrutinize the relationship between RT, Pupil size and BIS / BAS scales in greater detail, we employed a comprehensive mixed-effects regression analysis. The results of this analysis are presented in Table 3, which offers a concise summary of our findings. In specification (5), the dependent variable is the RT, and we included BIS/

BAS items , advantages and disadvantages, as well as absolute utility, as covariates (see Equation 3).

Table 3 Results of Mixed-Effects Regression Analysis: RT and pupil size as Dependent Variables with Covariates

	RT (5)		Pupil (6)	
	Coef.	Std. Err.	Coef.	Std. Err.
Constant	-0.804	5.42	-19.85	184.79
BIS	0.3014	0.259	6.909	8.802
BASD	0.770**	0.268	21.867*	9.933
BASR	-0.190	0.199	1.125	6.635
BASF	-0.384	0.218	-9.485	7.471
Abs.utiliy	-0.003***	0.0003	-0.009***	0.0025
Advantage	-0.516**	0.1747	0.003	1.195
Disadvantage	-0.411**	0.1748	-1.262	1.1962

The BAS- Drive variable showed a positive association with both RT and pupil size. The BAS- Reward and BAS Fun Seeking variables did not have a significant impact on RT or pupil size. Additionally, the absolute utility variable demonstrated a negative relationship with both RT and pupil size. The advantage variable was negatively associated with pupil size, while the disadvantage variable did not significantly affect either RT or pupil size. These findings suggest that individual differences in BIS/BAS systems, as well as the consideration of absolute utility and advantage, may influence both cognitive and physiological responses.

Discussion

This study advances the field of social decision-making in several significant ways. First, by integrating eye-tracking data, physiological measures (pupil dilation and response time), and the Fehr-Schmidt model of inequity aversion, we provide novel evidence on the cognitive mechanisms underlying distributive choices. Second, our cross-cultural design, conducted in Iran—a collectivist society—extends the generalizability of attention and fairness theories beyond Western contexts. Third, we demonstrate meaningful links between personality traits (BIS/BAS), gaze allocation, and decision outcomes, offering new insights into how individual

differences shape social preference formation. Collectively, these findings enrich current process models of decision-making and underscore the importance of cultural and personality factors in shaping attentional dynamics and fairness considerations.

Attention Allocation and Self-Option Bias

We analyzed participants' visual attention toward their own option relative to the other option across various conditions: all options, chosen options, and unchosen options. Our results revealed a consistent self-option bias, where participants allocated significantly more attention to their own payoff than to the other's, regardless of context. This aligns with prior research showing that individuals tend to focus more on attributes of greater utility or personal relevance (Glöckner & Herbold, 2011; B. E. Kim et al., 2012; Su et al., 2012). The fact that this bias was present even for unchosen options suggests that the self-option held intrinsic salience for participants, potentially due to its direct impact on personal outcomes.

Furthermore, as previously observed (Glaholt & Reingold, 2009; Shimojo et al., 2003), participants also looked longer at the chosen option compared to the unchosen one. This supports the idea that gaze reflects not only value but also post-choice evaluation and justification processes.

The Influence of Relative Payoff on Attention

Our analysis of attention allocation under different inequality conditions yielded novel insights. Participants exhibited a higher level of attention to the self-option in advantageous situations (where their payoff was higher) compared to disadvantageous ones (where the other person earned more). This pattern is consistent with earlier studies (Fiedler & Glöckner, 2012; Towal et al., 2013), which suggest that relative payoff influences attention allocation. This finding fits with value-based attention frameworks, which propose that attention is not uniformly distributed across options but is instead guided by their subjective value. Options with higher relative payoffs are likely to be perceived as more rewarding, increasing their attentional salience and drawing cognitive focus. From an adaptive standpoint, allocating more attention to higher-payoff options may optimize decision accuracy and efficiency by prioritizing relevant information in value computation. This mechanism aligns with the aDDM, where value-driven attention accelerates evidence accumulation toward a choice. Thus, the link between relative payoff and gaze duration reflects not just preference, but an instrumental cognitive strategy.

In contrast, when the other's payoff was higher, attention to the self decreased. This shift may reflect downward social comparison or relative deprivation, triggering a monitoring process of the other's outcome. In contrast, when the other's payoff was higher, attention to the self decreased. This shift may reflect downward social comparison or relative deprivation, triggering a monitoring process of the other's outcome. According to Festinger's (1954) theory of social comparison, individuals assess their own standing by referencing others. In disadvantageous contexts, increased attention to the other may serve to evaluate fairness, monitor inequity, or consider redistributive actions. Importantly, this does not necessarily reflect prosocial motivation, but rather a cognitive-emotional response rooted in envy, loss aversion, or normative evaluation.

These patterns support a broader view of attention's role: rather than merely amplifying subjective value (as in the aDDM), attention serves an evaluative function, especially in morally complex or socially embedded decisions. This interpretation is reinforced by the concurrent increases in response time and pupil dilation during mixed and disadvantageous conditions—both established indicators of heightened cognitive load and emotional arousal.

Pupil Dilation and Response Time as Indicators of Cognitive Load

In line with foundational work by Hess and Pollett (1960), who demonstrated a positive correlation between pupil size and task difficulty, and later corroborated by Ahern & Beatty (1979) and Kahneman & Beatty (1966), we found that pupil dilation increased with decision complexity, as measured by absolute utility. Similarly, longer response times were associated with more difficult decisions, particularly in mixed and disadvantageous inequality scenarios (Arsalidou et al., 2013; Bachurina et al., 2022).

Together, these physiological signals confirm that participants engaged in deeper cognitive processing when faced with trade-offs involving fairness, self-interest, and social norms. The integration of these metrics allows us to move beyond behavioral data alone, revealing the hidden dynamics of moral deliberation.

Personality Traits and Decision Dynamics

We also explored how individual differences in BIS/BAS scores predicted attention and decision outcomes. Individuals with higher BAS-Drive scores showed increased

pupil dilation and longer response times, indicating heightened cognitive engagement and arousal. These individuals may be more responsive to rewarding stimuli and exhibit a broader evaluation of potential gains, leading to more deliberate decision-making.

Moreover, the BAS system is linked to a dopaminergic neural network involved in goal pursuit and reward sensitivity (Depue & Collins, 1999). Activation of this system could explain the observed greater attentional focus and slower responses among high-BAS individuals. In contrast, BIS scores did not significantly affect attention or reaction time, suggesting that punishment sensitivity plays a lesser role in this particular decision context.

Cross-Cultural Insights and Fairness Sensitivity

Our cross-cultural contribution is particularly noteworthy. Most existing eye-tracking and decision-making studies have been conducted in WEIRD (Western, Educated, Industrialized, Rich, Democratic) societies, limiting the generalizability of findings. By conducting this research in Iran, a collectivist culture, we extend the applicability of attention and fairness models to non-Western populations.

Our estimated α parameter (aversion to being behind) was 42% higher than Western averages (Nunnari & Pozzi, 2022), suggesting a heightened sensitivity to disadvantageous inequality. This aligns with cultural values emphasizing relative standing and social harmony (Ghorbani et al., 2003). Conversely, the β parameter (aversion to being ahead) fell within Western ranges, possibly reflecting universal guilt constraints when receiving more than others.

Given the collectivist orientation of Iranian society, participants may be more attuned to normative concerns for equity, even in anonymous settings. Greater attention to the other's payoff may reflect a desire to avoid appearing selfish or to maintain group cohesion, reinforcing the idea that attention is shaped not only by individual preferences but also by cultural scripts.

Implications for Process Models of Decision-Making

By linking eye-tracking data, physiological signals, and personality traits, our study challenges traditional economic models that ignore attention and cognitive limitations. It also contributes to ongoing debates about the causal role of attention in decision-making. While some models assume that gaze amplifies value, our findings

support the view that attention serves an evaluative function, especially in contexts involving trade-offs between fairness and self-interest.

Moreover, combining the Fehr-Schmidt model with process-level data (e.g., fixation patterns, pupil dilation, and RT) provides a richer interpretation of how fairness considerations unfold in real-time. These findings highlight the need to refine current process models so they more accurately reflect how cognitive, emotional, and cultural elements interact during value-based decision-making.

Conclusion

In summary, our findings illuminate the mechanisms through which individuals process trade-offs between self and other interests, and how these processes are shaped by internal traits and external structures. We show that visual attention is not merely a passive indicator of preference, but an active component of moral evaluation and conflict resolution. Furthermore, we demonstrate that cognitive load markers like pupil dilation and response time offer valuable insights into the hidden dynamics of decision-making.

By incorporating cross-cultural and personality-based perspectives, we contribute to a more nuanced and inclusive model of attention in social decision-making. These results highlight the need to move beyond WEIRD-centric paradigms and integrate multimodal, culturally sensitive approaches in future research.

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Investigating Role of Social Value Orientation in Individual's Decision-Making Evidence from the Ultimatum Game



Mostafa Hosseini Deldoost and Mohammad Taghi Saeedi

Abstract In the conventional literature of economics, human preferences are defined based on self-interest and independence from social contexts and norms. In practice, however, human behaviors and actions are seriously influenced by social norms (such as fairness and beliefs) individual's and the mutual behavior of others. Given that people's social values influence the decision-making process, this study aims to investigate individual's social value orientations in hypothetical and real conditions. Therefore, the triple-dominance measure and the ultimatum game were used to determine the social orientation of individuals in hypothetical and real conditions, respectively. In total, 64 students were randomly selected from the faculty of Economics, University of Tabriz, and the required data were collected within two weeks in January 2019. Since the data were not normally distributed, the non-parametric techniques of Chi-square and Wilcoxon were employed to explain the correlation between the research variables. The results showed that the assumptions were very simplistic and misleading in the neoclassical economic paradigm. Individual's personality traits and social value orientations affected their decisions, so that about 75% of people chose the equality strategy, instead of maximizing their self-interest. The results also indicated a significant difference in the strategies and decisions of the proposers in both hypothetical and real conditions. In other words, in addition to self-interest, the behavior and action of the dividers in the ultimatum game were a function of personality and environmental factors.

Keywords Behavioral economics · Ultimatum game · Social value orientation · Hypothetical bias · Real conditions

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M. H. Bilgin et al. (eds.), *Eurasian Business and Economics Perspectives*, Eurasian Studies in Business and Economics 18,

https://doi.org/10.1007/978-3-030-71869-5_4

1 Introduction

Many economic theories are based on the concept of rational choice, which is manifested as the economic man. The main characteristic of a *Homo economicus* is to maximize pleasure and minimize pain. Based on these theories, it is assumed that the economic man is isolated from the society, like Robinson Crusoe; it does not matter what the source of his/her preferences and choices is or how valuable they are, the important point is to maximize his/her self-interests (Robbins 1935). Considering this concept and according to the rational choice theory, Individuals in any situation choose the option that best suits them based on their self-interests (Green 2002). Accordingly, neoclassical economic theories define themselves as anti-behavioral, so that in most of these theories, cognitive studies and social psychology have no place and human beings always act in such a way that suits best to them in all circumstances (Mullainathan and Thaler 2000).

Since simplifications such as frictionless over ground or neglecting air resistance in the exact sciences, like physics, have sometimes led to dramatic progress in natural sciences, conventional economics has also sought to simplify and present an ideal type by introducing the rational man in accordance with natural sciences. Therefore, it has led scholars of the classical school, especially the neoclassical school, to build abstract economic models independent from values and unrelated to other social sciences, such as psychology; in these models, only the relationship between human and goods, and not the relationship between human and human, is considered.

In the neoclassical economic paradigm, assumptions are very simplistic and too far from reality. For example, the assumption of the *Homo economicus* rational behavior is a simple one. Among various definitions and justifications, this assumption provides a powerful analytical framework for analyzing human behaviors. According to psychological studies, not only self-interests, but also social conditions and beliefs, affect one's decisions. Keynes argued that in order to find a complete solution to economic problems, one cannot rely entirely on economic considerations, but also on ethical and social considerations that go beyond economics. Interdisciplinary studies such as economics, cognitive science, and psychology using laboratory methods confirm the effect of cognitive and emotional variables on people's decision-making process (Sanfey et al. 2003). In this regard, behavioral economics uses the theories of economics, psychology, and cognitive sciences to investigate how people make decisions in the real world. Decision-making in risky situations and behavioral games such as the ultimatum game or Allais paradox indicates a violation of the selection mechanism based on the von Neumann-Morgenstern expected utility and, in general, human rational behavior is defined in the neoclassical school and

game theory.

The impact of various factors (other than self-interest) on individual's behaviors has been studied in different frameworks (Balliet et al. 2009; Bieleke et al. 2016; Bogaert et al. 2008; Fiedler et al. 2013; Gärling et al. 2003; Gong and Sanfey 2017; Joireman et al. 2003; Mavrodiev et al. 2013; McClintock and Allison 1989; van Dolen et al. 2012). The theory of social value orientation (SVO) is one of the frameworks proposed in these studies. According to this theory, people do not make decisions only based on the same criteria such as self-interests when evaluating resource allocation between themselves and others, but also on different motivations, goals, and values (Murphy et al. 2011).

SVO is defined as a personal trait, reflecting how people deal with social I liked this word. In this regard, researchers define SVO in three ways (prosocial orientation, individualistic orientation, and competitive orientation). Prosocialists or egalitarian are those who try to maximize their own and others' self-interests in dealing with social issues; individualists are those who simply seek to maximize their own achievements when facing social issues, regardless of the achievements of others, they neither assist nor interfere; ultimately, competitive people are those who always seek to maximize the difference in achievement between themselves and others in their favor (Wei et al. 2016). Individual's social values are considered to be the strongest social element influencing human behaviors due to their effect on human orientations, actions, and interactions. The concept of justice has an important and prominent role among social values that affect individual and social actions. This important and challenging concept in economic exchanges is usually defined as the proper distribution of different types of goods between two people (Tabibnia et al. 2008).

In this regard, behavioral games prove that players care not only about self-interest, but also about fair treatment mutually (Akerlof and Kranton 2010). In bargaining games, people behave differently in sharing interests. Theoretically, these behaviors can be classified into two categories: In the first perspective, researchers believe that people behave rationally and act in their own self-interests (utility is merely a function of self-interest). According to the second perspective, people's evaluation of utility is not only a function of self-interest, but also the concept of fairness and social considerations affect the utility resulting from distribution (Karagonlar and Kuhlman 2013).

According to the proposed theory, people have different orientations based on their personal values. The existence or effect of these orientations on human behaviors has been investigated by researchers in various studies. In this regard, new studies in the field of laboratory economics show that not only social values affect people's behavior, but also the impact of these values on people's behavior is different in hypothetical and real conditions

(FeldmanHall et al. 2012; Grebitus et al. 2013; Vlaev 2012). Neuroscientists have also differentiated between behavior and the brain when making actual and hypothetical choices, depending on the intensity of neural activation (Camerer and Mobbs 2017). According to the results, people generally do not behave in the same way when dealing with social issues in real and hypothetical situations. Previous studies have focused on contingent valuation and questioning individuals about their willingness to pay deal with environmental issues (Diamond and Hausman 1994; Loomes 2006), which have generally been exaggerated. This dual behavior in hypothetical and real conditions is called hypothetical bias, which can be objectively reflected in social psychology in the social orientation of individuals in terms of exposing their preferences and sharing interests between themselves and others (Van Vugt et al. 1995).

Behavioral economics researchers such as (Kahneman et al. 1982), (Thaler 1980), and (Camerer and Loewenstein 2004) have criticized the ideas of conventional economics as psychologically unrealistic principles. These researchers use laboratory and experimental methods to directly observe and test economic phenomena and behaviors in a controlled setting. These experiments make it possible to draw clear inferences about human behaviors, most of which are not possible outside the laboratory. However, laboratory economics has limitations for its validity. The most important critique of the artificial behavior of participants and even their incorrect answers to the questions posed was made by (Wallis and Friedman 1942). Therefore, it is necessary for researchers to use appropriate tools to gain the trust of the participants regarding the occurrence of real behaviors.

In recent decades, a relatively large number of experimental studies have been conducted on behavioral games such as ultimatum and dictator games. Some of these studies have examined players' behavioral changes as the total stake increases. In general, some have found that increasing the total stake can be effective in changing the behavior of at least one group of players, while a number of studies have not provided acceptable evidence for the relationship between these two variables. (Cameron 1999) reviewed several economic experiments. By reviewing the sections of bargaining games, such as the ultimatum game, they examined the relationship between increasing the total stake and the behavior of players. They found that increasing the total stake in the ultimatum game had a slight effect on the behavioral change of the players; however, this change in the dictator game led to a decrease in the fairness¹ of the proposers.

(Hoffman et al. 1996) examined the relationship between players' behavior and increased total stake from \$10 to \$100 by conducting the ultimatum game involving 98 pairs of players. They found that increasing the total stake had no significant effect on the share

¹. The term "fairness" and "justice" are used interchangeably in this paper.

of offers. They also reported that as the total stake increased, the rate of rejected offers by responders decreased significantly, representing those responders were willing to accept more unfair offers for higher amounts of money. These results were somewhat similar to the results obtained by (Cameron 1999) in Indonesia, (Munier and Zaharia 2002) in France and Romania, and (Slonim and Ruth 1998) in Slovakia. Cameron (1999) increased the total amount of money by about three times of the average monthly expenses of the participants. Their findings showed no correlation between the total amount of money and the offered amount. Similarly, Munier and Zaharia played the game for \$7 and \$360 with students from France and Romania. Their findings also demonstrated no correlation between the offered amount and the increase in the total amount of money. Slonim and Ruth played this game for about \$50 with students from the Slovak Republic. Despite the differences in the total amount of money, the offered amounts were almost at the same level: 42% in Indonesia, 43% in France, 37% in Romania, and 43% in Slovakia.

One possible explanation for the relatively fair behavior of proposers could be that they are aware of the responders' sensitivity to unfair offers and, considering the risk of rejecting such offers, they behave more cautiously (Holt and Laury 2002; Prasnikar and Roth 1992). According to Robbins (1935), the number of responders who wanted to punish a player with unfair offers or to lose a game's payoff decreased as the total amount of money increased.

Andersen et al. (2011) found a significant relationship between the increase in the total stake and the change in the behavior of both groups of proposers and responders in the northeastern region of India. Bechler et al. (2015) also reported the same relationship in the ultimatum and dictator games.

The main focus of the present study is on analyzing the behavior of the proposers, but the behavior of the responders in a particular condition is also examined. This study aims to investigate people's SVOs in real and hypothetical conditions. Therefore, laboratory economics techniques were used to explain the differences in decision-making under the influence of SVO in real and hypothetical conditions. Accordingly, the triple-dominance measure (Van Lange et al. 2007), and the ultimatum game were employed to determine SVOs in hypothetical and real conditions, respectively. The difference between this study and previous works is that, in this study, people's SVO was first determined in hypothetical conditions, and then, to determine the behavior of players in real conditions, the ultimatum game was performed in two states, whether the divided amount of money was already specified or not specified. To achieve the objectives of the research, the following questions are raised:

1. Does the proposer adopt the same behavior and strategy in the ultimatum game in

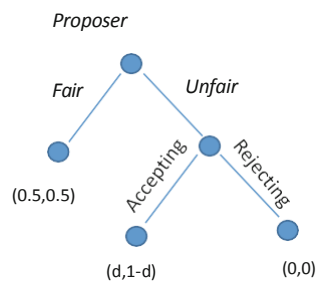
hypothetical and real conditions, whether the total amount of money is specified or not? In other words, do people have different SVOs in hypothetical and real conditions, whether the total amount of money is specified or not?

2. Does the proposer in the ultimatum game make the same offers when they are aware of the total amount of money or not? In other words, can the total amount of money that should be divided lead to different decisions by the proposer?

And final question addressed in this research is does proposer's SVO predict the decisions one makes in an ultimatum game?

The paper is structured as follows; in the first section, the theoretical foundations is presented. In the following methodology and data collection are presented in the next section results of the experiments are discussed. The paper ends with a discussion and conclusion.

Fig. 1 Schematics of the ultimatum game.
(Source: Authors own study)



2 Theoretical Foundations

The ultimatum game is a well-known one-shot anonymous sequential bargaining game introduced by Güth et al. (1982), in which there is an amount of money and two players. In this game, the first player, called the “proposer,” divides an amount of money between him/herself and the other person $d \in [0, 1]$ (who is usually unknown to the divider). Then, the proposer makes an offer to the second player, called the “responder,” who has the right to either reject or accept it. If the responder accepts the offer, the amount of money specified by the proposer will be divided; but if the responder rejects the offer, neither player receives any money (Güth et al. 1982). In the literature of laboratory economics, there is another game similar to the ultimatum called dictator game; the main difference between these two games is in giving the responder the right to choose. In the dictator game, unlike the ultimatum game, the responder should accept the division offer, which can be either fair or unfair, without any right to choose. The schematics of the ultimatum game can be shown as Fig. 1.

A concept called “Nash equilibrium” is used to predict the behavior of players in the game theory. This equilibrium reflects the best response to the opponent’s strategy, so that none of the players are motivated to deviate from this point. The proposer divides the money as $(1-d, d)$. Accordingly, different modes of the ultimatum game based on Nash Equilibria are as follows:

1. The proposer makes a fair offer; the responder only accepts fair offers.
2. The proposer makes an unfair offer; the responder would only accept that unfair offer.
3. The proposer makes an unfair offer; the responder can accept any unfair offer.

Backward induction technique determines the optimal strategy of the player who the make last move in the game. Following the prediction of the perfect sub game Nash equilibrium (PSNE), And according to the rational solution, the proposer should offer the least amount to the responder and he accepts it, because based on the economics literature, more delete is preferred to less. The experience of empirical research and facts observed in different societies has shown that people’s behaviors are different from the behaviors of a player described in the game theory. In other words, based on the utility function, people consider not only their self-interests, but also the influence of choices on the utility of other people. According to the above

studies, the Nash equilibrium is not established, and the strategy of the players is a function of their individual and social conditions in different conditions of the ultimatum game. Generally, the proposer offers about 35–50% of the total amount and the responder rejects offers which are less than 30%. The reason for this can be explained by the concept of sensitivity to equality between the two players.

3 Methodology and Data Collection

Prior to commencing the study, ethical clearance was sought from the local ethics committee. Participants were asked to fill out and sign the consent form before the experiment. Sixty-four students were recruited from the pool of economics undergraduate students at the University of Tabriz and the interactions were anonymous. It should be noted that none of the students were familiar with the ultimatum game and the rules governing it, as well as the social orientation questionnaire. This study was conducted in two stages. In the first stage, after explaining the triple-dominance measure, the participants were asked to answer the questions to find out their SVO in the hypothetical conditions and their information was then recorded. They were also asked to cooperate in the second stage of the study two weeks later. The reason for conducting the study in two stages was to avoid letting players remember their social orientation choices in the first stage, i.e., for example, if a

person introduced him/herself as a proponent of equality, she/he was more likely to follow his/her past choice when she/he wanted to make a real choice.

In the second stage, the proposers and responders were randomly assigned, the rules of the game were explained to both groups separately, and their questions were answered. The proposers were first asked to divide an uncertain amount of money between themselves and the responders who did not know them; then, their division offers were recorded. Next, they were given IRR 200,000 (approximately 5 dollars) and asked to allocate a share of it to another person sitting in the next room. That division offer was calculated in percentage and stated to the responders. At the end of the experiment, eligible participants were compensated for their time and they received a gift card for lab visit as well as the payoff from the bargaining game. All data were entered into SPSS (version 25.0) and the normality test was performed for response variables of the percentage of the total amount divided by the proposer in cases of being either aware or not aware of the total amount. Since the normal distribution was rejected, Wilcoxon and Chi-square non-parametric tests were inevitably used.

4 Results

The Fig. 2 shows the proposers' offers in two real conditions of being aware and not aware of the amount of money.

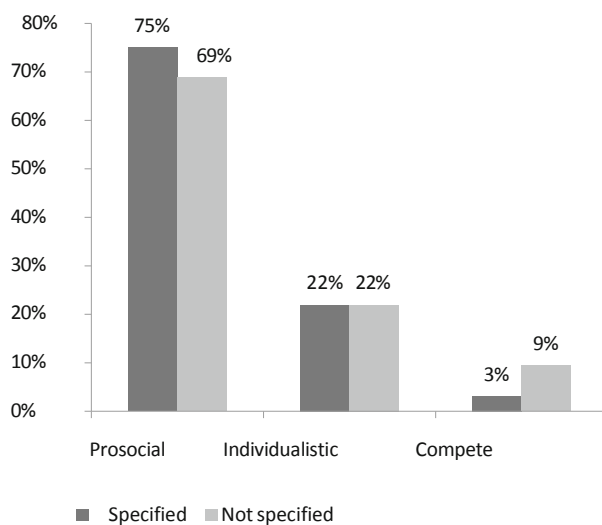


Fig. 2 Proposers social value orientations in real conditions. (Source: Authors own study)

As can be seen in Fig. 2, most of the proposers chose the equality strategy, indicating the significance of fairness among the students of the Faculty of Economics, University of

Tabriz. This is in line with previous findings on the fair division offers by the majority of the proposers. The following analyses were done to answer the research questions.

To answer the first question, the hypothesis of the difference in the proposer's behavior was examined. For this purpose, the proposer's strategy was first investigated in hypothetical and real conditions when she/he was not aware of the total amount of money. Results of Chi-square test with $\chi^2 = 10.028$, $df = 4$, $p_{\text{value}} = 0.040 < 0.05$ indicated that the null hypothesis was rejected, assuming that when the proposer was not aware of the total amount, there was no significant difference between division offers in the real and hypothetical conditions at the significance level of 0.05. In other words, the proposer's strategy differed in the hypothetical and real conditions when she/he was not aware of the total amount.

Then, the proposer's strategy was investigated in hypothetical and real conditions when she/he was aware of the total amount of money. Results of Chi-square test with $\chi^2 = 32.886$, $df = 4$, $p_{\text{value}} = 0.000 < 0.05$ indicated that the null hypothesis was rejected, assuming that when the proposer was aware of the total amount, there was no significant difference between division offers in the real and hypothetical conditions at the significance level of 0.05. In other words, the proposer's strategy differed in the hypothetical and real conditions when she/he was aware of the total amount. The results represented that their SVOs and actions in real and hypothetical conditions were different and can lead to different decisions by them.

The next question of the study examined the proposer's strategy in real condition whether she/he was aware or unaware of the total amount, for which the Wilcoxon test was used. According to the results of the Wilcoxon test with $Z = -2.090$ and $P_{\text{value}} = 0.037 < 0.05$, the null hypothesis was rejected at the significance level of 0.05, indicating that the proposer's strategy was different whether she/he was

Table 1 Results obtained from testing the hypotheses

Conditions for testing the hypothesis	Statistics	df	p-value
Hypothetical and real conditions—Unaware of the total amount	$\chi^2 = 10.028$	4	0.040
Hypothetical and real conditions—Aware of the total amount	$\chi^2 = 32.886$	4	0.000
Real condition—Aware and unaware of the total amount	Wilcoxon $Z = -2.090$	-	0.037

Source: Authors' own study

aware or unaware of the total amount. In other words, the proposer's strategy and social

behavior were a function of the total amount of money.

The responders' behavior and strategy of accepting or not accepting the offered amount was another question that was examined using Fisher's exact test.

According to the test results ($P_{\text{value}} = 0.625 > 0.05$), the null hypothesis was not rejected at the significance level of 0.05, indicating that the responder's strategy when she/he was aware of the total amount was not different from his/her strategy when she/he was not aware of that, and the criterion for their decision on whether or not to accept was a function of the amount allocated by the proposers. The summary of the test results of the hypotheses is shown in Table 1.

5 Discussion and Conclusion

Perfect rationality is one of the most important and fundamental principles of classical and neoclassical economic theories. According to this principle, people in any situation choose the option that best suits them based on their self-interests, regardless of environmental factors. However, based on new findings in the field of laboratory economics, human decisions make sense in the social structure and these decisions are the result of not only economic components, but also social considerations and individual characteristics that have received less attention in Orthodox economics.

In this study, the participants' decisions were examined in hypothetical and real conditions using the ultimatum game. To the best of our knowledge, this study was conducted for the first time in Iran, because the researchers did not find any relevant literature in this regard. Also, according to the participants, none of them had the experience of participating in such a test.

The first research question was about the compatibility of the proposer's behavior and strategy on how to divide the money into hypothetical and real conditions. This question was tested in two states of whether the amount of money was specified or not. The test results showed that people behaved differently based on their SVOs in hypothetical and real conditions. In other words, people had hypothetical bias.

Regarding the second research question that whether the proposers' offers under real conditions can be a function of the total amount of money or not, the results of data analysis showed that this variable was important and effective. In other words, the proposer's behavior and SVO were a function of the total amount of money divided.

The behavior of responders, whether being aware or not of the total amount of money, was not significant. The criterion for accepting or rejecting the offers was the amount of money offered by the proposers. In general, it can be concluded that the decision-making process is very complex and factors such as personality traits as well as environmental

variables play a significant role in this process.

It should be noted that, in addition to the advantages of experimental and laboratory economics, such as direct testing of economic behavior, economic efficiency of instruments, and reliability of tests, some of the limitations of this method should also be considered. For example, people who are tested know that they are being monitored and all their actions are being recorded, so they may exhibit false behaviors or even answer the questions incorrectly.

Therefore, researchers in this field should be careful in generalizing the laboratory results to real conditions. In other words, those who participate in the study may not show their real behavior according to some considerations, so the researcher should ask the participants to express their real and desired behaviors by creating the necessary grounds for them.

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The confluence of humanomics and neuroeconomics on economic cooperation

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I. Conceptual foundations: Synthesizing humanomics & neuroeconomics through Shared Mental Models

Douglass North asserted that “The process of sustained economic growth that historians believe began between 1750 and 1830 radically altered the manner and standard of living of Western men and women.” And Deirdre McCloskey (2016, 2021) claims that all of this was caused by the spread of bourgeois ideas and free markets. Indeed, entrepreneurial thought and free markets continue to drive economic development worldwide. While traditional neoclassical economic models are highly useful for describing and analyzing what markets *do* and *how* they function, they lack a causal explanation of *why* they operate as they do. Human beings cause markets to work. Entrepreneurial drive and initiative originate in the human head. Human beings formulate ideas and muster the ingenuity to bring them to fruition, often by cooperating and collaborating (co-laboring) with others.⁴

The purpose of this paper is to investigate the interrelationship of the 1) ideational, 2) moral and 3) neurobiological foundations of economic cooperation. We proceed on the basis that the mind and the *brain* are distinct, but inextricably connected, phenomena. Although they are different, they coexist in the human head. Therefore, when studied, these phenomena should be conceptualized accordingly. In the words of Caroline Leaf (2021), the human *mind* and *brain* are “characterized by a triad of thinking, feeling, and choosing. When you think, you will feel, and when you think and feel, you will choose. These three aspects always work together.”⁵ We suggest that human cooperation and collaboration involve 1) “shared intentionality” (sometimes known as *we* intentionality), 2) “shared learning and knowledge,” 3) empathy (fellow feeling), and 4) “social contagion.” Accordingly, we synthesize insights from the emerging areas of *humanomics* and *neuroeconomics* to explore the philosophical and cognitive causes underlying economic cooperation. Centering on the human mind, humanomics incorporates aspects of moral philosophy, social learning, and experimental analysis to examine the causes of human behavior. Centering on the brain, *neuroeconomics* studies the neurobiology underpinning human behavior. We employ Arthur T. Denzau and Douglass C. North's (1994) “shared mental Models” (SMM) framework as a conceptual bridge between the two areas of humanomics and

neuroeconomics to analyze the ideational, moral and neurobiological foundations of human cooperation. (See Figure 1.)

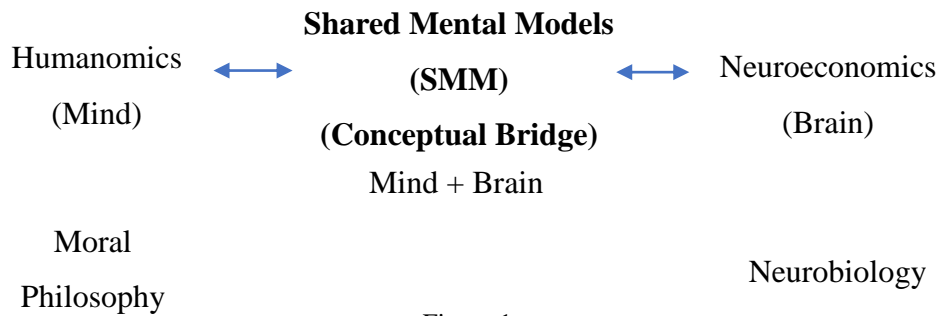


Figure 1

Let us continue with a brief conceptual explanation of the ideational, moral, and neurobiological foundations of human behavior. *Ideational foundations*: The ideas we hold in our heads inform our conceptions of what is rational and what is not. Our ideas are not formed in a vacuum, but rather, reflect the cultural and environmental social contexts in which we live and operate. We never see the world as it *is* objectively. Instead, we perceive it through cognitive filters or what Denzau and North (1994) refer to as *mental models*. In its 2015 *World Development Report* entitled *Mind, Society, & Behavior*, The World Bank Group reveals that: “Mental models include categories, concepts, identities, prototypes, stereotypes, causal narratives, and worldviews. Without mental models of the world, it would be impossible for people to make most decisions in daily life. And without shared mental models, it would be impossible in many cases for people to develop institutions, solve collective action problems, feel a sense of belonging and solidarity, or even understand one another” (pp. 63-4.) The mental models that human beings use to interpret reality are neither axiomatic nor universal as traditional neoclassical MAX-U approaches often assume. Instead, mental models are cognitive constructions that reflect our highly varied human experiences. Human behavior is, in part, a reflection of the moment and environment in which it occurs, reflecting the current temporal, spatial, and environmental context. Human conduct, on the other hand, comprise past actions that have helped shape one’s character (Wilson 2025). When examining the reasons why particular social systems develop, operate and evolve—especially questions centered on why markets work— one must consider both human behavior and human conduct.

2) *Moral foundations*: Human beings share ideas, experiences, and feelings with others. They often demonstrate feelings of respect and empathy towards one another. In his 1759 masterpiece, *The Theory of Moral Sentiments*, Adam Smith suggested that human beings

possess *dual natures*. The first is self-love and the other is fellow feeling. Self-love manifests when it advances and protects *one's parochial interests*. Fellow-feeling (often operationalized as empathy) manifests when one demonstrates concern for the interests of family members, neighbors, and even strangers. Those “dual sentiments,” which exist simultaneously in our heads, underlie our desire to cooperate and indeed, collaborate (co-labor) with one another. The emerging field of humanomics emphasizes the importance of ideas, moral sentiments, cultural norms, and cooperative behavior in driving productivity, wealth, prosperity, and overall well-being. The writings of Adam Smith, Vernon Smith and Bart Wilson have been advancing the study of humanomics to redirect the focus of economic inquiry on ideas, emotions, norms, values, and social phenomena that motivate human behavior. According to Bart Wilson (2024), “[t]he origins of our actions—ideas—do indeed matter. They make us human. Moreover, they make the principles of economics—trade, the division of labor, and property—possible.” Wilson continues, “As a positive science, the study of economics can classify the moral sentiments that prompt human beings to act, the meaningful actions that human beings take, their values, and the purpose of their actions” (p. 36). Accordingly, Wilson suggests that “[w]e can [and indeed should] be twenty-first century students of Adam Smith who study economic activity in both its origins and consequences. Meaningful economics is a science of economics that retains the human mind” (p. 37). According to Wilson, the humanomics framework “puts human feeling on an equal footing with knowing, thinking and wanting, which makes economics all at once ethical, psychological, sociological, and anthropological” (p. 41). Wilson (2024) emphasizes that if economics is to remain relevant to our lives, it must rediscover the whole human being.

3) *Neurobiological foundations*: Neuroeconomics is a multi-disciplinary area of research that draws on insights from psychology, neuroscience, economics, and anthropology to explore the neurobiological causes of human cooperation and collaboration. Research by Van Bavel, Pärnamets, Reiner, Packer (2022) explores “How neurons, norms, and institutions shape group cooperation”; Houser and McCabe (2009) study experimental neuroeconomics and cooperative behavior in a game-theory setting; Paul Zak studies the role of the oxytocin on morality, trust and cooperation in the lab and the real world; Deldoost, Khosrowabadi, Kamiński (2024) explore the underlying neuropsychological processes associated with social contagion and how it influences economic cooperation. By drawing together concepts from humanomics and neuroeconomics using Denzau and North’s conceptual SMM framework, we hope to gain improved understanding of why human beings cooperate in free market systems to the extent that they do.

This paper builds upon three related research projects published by Denzau, Roy, and Minassians (2016) and Roy and Denzau (2020, 2024), which examine the connections between humanomics, mental models, and social cooperation. Earlier work conducted by work Deldoost (2024) and Yonk (2024) independently supplements Roy's research. The authors' collective contributions are synthesized to provide fresh conceptual insights on *why* markets work. In section II we examine the limitations of MAX-U by exploring markets as cognitive constructions that stem from our human nature as social creatures; section III explores the "The confluence of the humanomics of 'the mind' and the neuroeconomics of 'the brain' on social cooperation in the market"; section IV explores the neuropsychological influence on social contagion and conformity and trust on social cooperation. We conclude by examining how humanomics is making a transformative contribution to the field of public choice.

II. Markets are cognitive constructions that driven by human sentiments

Until the 1930s, the economic study of human behavior encompassed moral and normative dimensions. The rise of positivist thought in economics, which was solidified by Lionel Robbins, Paul Samuelson, and Gary Becker, among others, marginalized the study of ideational and moral causes of human behavior (McCloskey 2021; Wilson 2024). Consequently, modern economics largely ignores the fundamental "human" element in its causal analysis by reducing the study of human behavior to utility functions that measure our preferences and choices in relation to resource scarcity. Bart Wilson (2024) lucidly explains that "Lionel Robbins shifted the focus of economics from the study of wealth or economic welfare to examining how individuals make choices under conditions of scarcity. It was a long road from 1932 until his definition of economics achieved near universal acceptance among economists. But by the bicentennial of the publication of Adam Smith's *An Inquiry into the Nature and Causes of The Wealth of Nations*, scarcity had clearly supplanted the nature and causes of the wealth of nations as the fundamental problem of economics" (p. 29).

Contrary to the assumptions of MAX-U, humans are not robotic utility maximizers. The concept of MAX-U, so revered in traditional economics, is "erected upon the granite of self-interest" (Stigler 1975, p. 237). Contrary to popular myth, the concept of "self-interest" itself was not promulgated by Adam Smith (Wilson 2024). Adam Smith astutely observed that human beings are social creatures who seek meaning in their lives by making connections and building bonds with others. Traditional neoclassical economic models tend to understate the complexities shaped by cultural and moral influences on human behavior. Smith and Wilson's humanomics approach suggests that human beings engage in a process of self-

reflection and cognition that evaluates not just whether their utility was maximized but whether their behavior was deemed, in Smithian terms, to be “praiseworthy” by others. Such social approval-seeking behavior, as we shall see, is embedded in social *conformity* and *contagion*. Smith describes that process of cognition as “the man within the breast,” “The Impartial Spectator.” Vernon Smith and Bart Wilson’s laboratory experiments reveal that what individuals view as appropriate ways of behaving are both context-dependent and often constrained by the bounds of propriety.

Through their experimental analysis, Smith and Wilson (2019) came to realize that “human feeling, thinking, and knowing about what a good action is also maps outcomes onto actions.” (p. 63). Moreover, MAX-U’s one-size-fits-all notion of universal rationality does not account for wide variations in human norms and cultures. Culture, a phenomenon that is a characteristic of human societies, encapsulates norms, notions of fairness, familial and societal obligations and shapes group identities (Tomasello 2009). All those concepts affect human behavior and must be accounted for in meaningful and relevant economic analysis. Smith and Wilson (2019) conclude that the assumptions economists hold regarding the predictive power of Max-U models are insufficient and suggest that something more is needed. While traditional neoclassical, positivist-based approaches have furnished us with an abundance of models in the MAX-U vein, they have offered little in the way of meaningful theory-building, resulting in the advancement of economics as an observational *human science* (Wilson 2024).

At its core, MAX-U models often misconstrue what markets are ontologically. Markets are much more than revealers of relative scarcity and instruments of price signaling. Although among the important roles they serve, markets are fundamental builders of social capital. They bring people together and, in doing so, act as a societal glue. Without them, democracies and even other systems would collapse. At their core, markets are cognitive constructions shared (mental models) that extend from human propensities that are internal to the mind and the brain. Successful voluntary market transactions reflect cooperative social behavior that is embedded in *shared intentionalities* aimed at positive-sum outcomes.

Legitimate and sustainable economic agreements (market equilibriums) are reached through a “meeting of the minds” between buyers and sellers, producers and consumers, entrepreneurs and investors— humans in any case. Markets are complex social processes that promote social learning, discovery, and innovation in ways that best facilitate human flourishing and prosperity. They are dynamic systems of an emergent order that reflect

properties of both human rationality and sociality. Woven into market processes, therefore, are elements of both predictability and spontaneity. While exhibiting periods of stability, they are frequently characterized by ubiquitous novelty and uncertainty that are sometimes punctuated by periods of great instability and even devastating crises. Innovations and breakthroughs in human knowledge and understanding about the world, therefore, cannot be planned with any reliable precision. And yet, making practical use of such knowledge is impossible without intentional thought and deliberate action. Learning and knowledge creation are advanced most effectively when humans interact and, indeed, transact with other human beings. Through social engagement and market transactions, human beings often (though not always) arrive at positive-sum outcomes. Indeed, failure (which can be painful and costly) on both the personal and collective levels is essential for social learning. The experience of pain and suffering often causes humans to fundamentally change or alter their beliefs and patterns of thought, leading to new ways of doing things— behavioral change. The desire to avoid further pain and suffering often cause people to learn from past mistakes, resulting in mental model shifts and scientific revolutions— paradigm shifts. Again, all of this happens in the human head.

Ideas, McCloskey (2016), argues, are what drive human beings to prosper. The ideas espoused by enlightenment thinkers helped transform people’s understandings of the meaning and purpose of what human beings ought to do with their lives. The so-called Great Enrichment (McCloskey 2016) was characterized by a radical shift in shared mental models. That said, meaningful economic inquiry should be devoted to understanding *why* that shift occurred and *why* the spread of bourgeois ideals has continued to transform the human condition across the continents, most notably in places like India and China over the last four decades. During the Scottish Enlightenment, scholars like Adam Smith understood correctly that successful market arrangements were the result of human capacity for moral agency, forming complex thoughts and ideas, and developing sophisticated ways of communicating them to others. Accordingly, they focused on the values, thoughts, and feelings that motivate human action. Economies exist because human beings think and communicate with one another in unique ways. Frank Knight (1997 [1924]) asserts that: “the relationships between people differ greatly from the relationships between inanimate objects, and thus a different approach to their study is necessary” (p. 483.)

MAX-U models ignore much of this. Therefore, it is hardly surprising that they are unable to account for much of human cooperative behavior in the real world. According to Wilson (2024), “[w]e need meaning-making feelings, as against the screw-you machinery of

noncooperative game theory, to understand the economics of human intercourse” (p. 41). Indeed, Kevin McCabe, Stephen Rassenti, and Vernon Smith (1998) reveal that cooperation occurs with much greater frequency than the standard models tend to predict. When exploring why markets work, researchers must accurately conceptualize our dual natures. In his essay on “The Two Faces of Adam Smith”, Vernon Smith (1998) explains that: “[t]hese views are not contradictory if we distinguish impersonal market exchange and personal exchange” (p. 2). Vernon Smith’s (1998) experiments found that behaviors in both settings stem “from a self-interested propensity for exchange in markets and friendships” (p. 2). Accordingly, Vernon Smith and Bart Wilson (2019) suggest that “while neo-classical analysis works well for studying impersonal exchange in markets, it fails to explain why people conduct themselves the way they do in their personal relationships with family, neighbors, and friends”⁶ Moreover, Smith and Wilson (2019) found that we often exhibit feelings of empathy and engage in cooperative behavior in many impersonal (anonymous) interactions, including financial ones. Feelings of empathy cause humans to connect emotionally with one another and help forge social bonds between them. The bonds are forged through contagion, conformity, and interpersonal trust, which, as we will explain, are the foundations of cooperation and what *enables* markets to function and operate effectively. Smith and Wilson’s work is compelling because it provides us with an epistemological foundation for testing Adam Smith’s belief that human cooperation stems from our ability to reveal concern for ourselves and others simultaneously. Therefore, social cooperation appears to be a function of both rational self-interest and human empathy. While other species exhibit social connections and behavior, human beings appear to be rather unique in their ability to exhibit fully evolved moral sentiments. The sentiments that underlie human cooperative behavior stem from the interplay between human biology and culture. Understanding *why* this is the case requires a more profound exploration of the foundations of human decision-making (Wilson 2024). One must account for philosophical, behavioral, and neuropsychological phenomena.

III. The confluence of the humanomics of “the mind” and the neuroeconomics of “the brain” on social cooperation

Human beings have a perpetual desire for both personal and social betterment, both on a material level and an existential one. Indeed, something is embedded in our heads that causes us to desire to better ourselves and improve our surroundings, often desiring the same for others. Human beings exhibit both biological and psychological propensities for social connections that animate learning, listening, teaching, and passing on cultural norms,

practices, and beliefs. Such behavior is often carried out intentionally to help others flourish. Human beings share their emotions and desires with others through complex communication, both verbal and written. Techniques, such as storytelling and a persuasive form of speech known as ‘sweet talk’, have proven to be particularly effective in bolstering economic activity. According to Deirdre McCloskey (2016), nearly a quarter of national income is generated as a direct result of “sweet talk.” McCloskey (2021) reminds us that Adam Smith “spoke often of ‘the faculty of speech’ and did consider meaning in all his writings” (p. 9). Written and oral speech enables humans to bargain, negotiate, reach settlements, find economic equilibriums, and even collaborate to achieve common aims and purposes. Persuasive speech, often ignored in the so-called “dismal science,” is a vital component in the economy. McCloskey (2021) shares Adam Smith’s own words with us in support of her assertion: “The offering of a shilling which to us appears to have such a plan, is in reality offering an argument to persuade one to do so as it is for his interest.” (Smith 1978, 1982 [1762–1763, 1766]. Report of 1762-3 vi. 56, p. 352)

Bart Wilson (2024) suggests that if economics is to remain relevant, we must start by posing interesting questions that focus on *why* human beings seek to enrich their lives by making choices they believe will add meaning and purpose. Indeed, our penchant for creating value and ascribing meaning to people, relationships, things and events is what makes us “human” and therefore, should be placed at the center of economic inquiry. That conclusion is not new. Adam Smith (1776) believed that human beings are social creatures who seek to add value to their lives by engaging, and indeed exchanging, with others. Smith (1776) argued that human nature is imbued with a “certain propensity” to “truck, barter and exchange one thing for another” (p. 25). Bart Wilson suggests that it comes from within. We agree wholeheartedly. Accordingly, we argue that that propensity is the result of the confluence of two inextricably related phenomena that co-exist within our heads—namely the mind and the brain.

If the mind and the brain are to be treated as distinct yet interrelated phenomena, then it would be useful to draw on insights from two distinct, often discrete, emerging areas of study—namely, neuroeconomics and humanomics. Neuroeconomics synthesizes aspects of cognitive neuroscience (a branch of neuroscience and psychology) and economics. Vernon Smith and Bart Wilson assert that human beings are moral agents and, therefore, values are at the core of economics. Deirdre McCloskey (2021) points out, however, that an exclusive focus on the brain that ignores the role of the mind in attempting to understand human behavior is akin to trying to comprehend “Jascha Hefetz violin playing by a closer and

closer study of his arm muscles” (p. 23). Thus, it might appear on the surface that the two approaches offer mutually exclusive explanations. However, Zak’s work explores how the biochemistry in our brains’ immersive experiences and sharing these experiences with others through storytelling is highly complementary with humanomics. Let us now examine the conceptual connection between the neural and cognitive processes that social contagion and conformity influence on cooperative behavior and decision-making.

IV. The neuropsychological influence on cooperation

Historically speaking, studies on how neural mechanisms affect decision making have been limited. In recent times, however, growing numbers of studies have begun investigating biology as a contributing factor to social conformity and contagion and how these social phenomena are related to what Adam Smith referred to as “fellow feeling” (sometimes referred to as other regarding sentiments.) The growing field of humanomics explores the human consciousness as well as the desires, aspirations, and temporal awareness that are generated within the human mind; neuroeconomics studies the connection between social interaction and biochemical reaction within the brain; mental models are a conceptual heuristic that synthesizes cognitive (brain) science and human social psychology (mind) to explain how humans process ideas, feelings, and experiences to interpret the world around them; they are internal (to the mind) representations of external realities. Humans process a wide variety of sensory data that is accumulated from or daily interactions and experiences, that are processed in our heads through cognitive filters or mental models in ways that help us formulate interpretations.

Paul Zak’s groundbreaking work examines how the sharing of cognitive knowledge contributes to voluntary forms of cooperation. His findings suggest that human beings are natural cooperators because fellow feelings, or empathy, are woven into our neurobiology. Studies utilizing advanced neural imaging technology disclose that the ventral striatum part of the brain is stimulated in a manner that causes a sudden release of oxytocin when individuals exhibit altruistic social behavior. Zak has identified oxytocin as “the trust molecule.” Zak’s research is inspired directly by Vernon Smith’s experimental work on moral sentiments, which explores the connections between morality, empathy, and interpersonal trust. Zak suggests that human empathy (fellow feeling) and trust (belief in others) are causally connected. The more people believe they have in common, the more likely they are to empathize with one another and, in turn, develop deeper trusting relationships. Denzau and North (1994) note that: “[i]ndividuals with common cultural

backgrounds and experiences will share reasonably convergent mental models, ideologies and institutions. Individuals with different learning experiences (both cultural and environmental) will have different theories (models, ideologies) to interpret that environment” (pp. 2-3). In other words, people with common backgrounds and those who engage in mutual experiences often develop emotional bonds that lead to sympathetic perspectives or similar ways of thinking. Common experiences help shape shared understandings and meanings in particular ways; they help cultivate SMMs among groups of people. Building social connections can cause people to think differently about costs and benefits associated with cooperative behavior. When we empathize with others, we tend to seek mutually beneficial outcomes. The cost-benefit calculus tends to change from one in which individuals attempt to maximize their self-interest exclusively to one in which both parties consider the interests of others as well.

Zak argues that if empathy allows us to connect with others, then sufficient levels of trust must be developed between participants. Effective communication is an essential element in the trust-building process and in helping participants “get on the same page,” reaching shared understandings and meanings (shared mental models) over aims, goals, and purposes. Initiating dialog or sharing information and feelings involves risk. Reaching consensus and devising mutual strategies and approaches to address shared problems and concerns requires a willingness to listen and share our ideas and beliefs with others. In so doing, we expose who we are and make ourselves vulnerable to others.

Zak has been studying the powerful influence of personal storytelling and shared immersive experiences in creating interpersonal empathy, in ways that contribute to cooperative behavior. Accordingly, Zak’s work in this area is highly sympathetic with Deirdre McCloskey’s analysis of the importance “sweet talk.” Zak (2014). When we share our personal experiences with others, we are, in essence, entrusting them with a part of ourselves, we expose our emotions, beliefs, and identities. Such demonstrations of “trustworthiness” trigger the release of the oxytocin molecule, which we referred to earlier. This empathy-causing molecule, also known as the “trust molecule” or the “moral molecule,” enables us to connect with others, including strangers, on an emotional level. Zak (2014) asserts that stories help place us in the lives of other people in ways that change our brain chemistries. In the workspace, developing personal connections and associations helps boost empathy for others, which in turn can add meaning to the tasks we perform and deepen a sense of common purpose among teammates and business partners. Data gathered over the course almost two and a half decades by Zak reveals that a shared sense of added meaning to

the work that individuals experience when collaborating with others in pursuit of a common purpose can lead to higher performance and better results. In other words, when human beings “make work personal,” productivity (under the right conditions) can be increased.

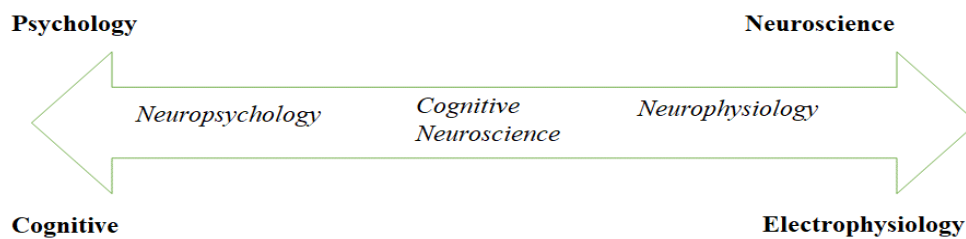


Figure 2 Cognitive - electrophysiology spectrum modified source:
Cohen,2014

Recently,

neuroeconomic science has begun to study how social conformity and contagion influence cooperation. Social contagion is a complex and multifaceted area of research that explores how neurological processing, interpretation, and responses to social information and social influences affect how individuals comprehend their social environments (Frith & Blakemore, 2006; Hunt et al., 2012; Parr, 2010; Pfeiffer et al., 2013; Rote & Smetana, 2011; Shany-Ur & Rankin, 2014). Conformity and contagion are two types of social influence that are very similar (Wheeler, 1996). Both involve adopting beliefs, feelings, values, and behaviors that align with the opinions of others. Consequently, both have a profound impact on shaping various types of social behavior (Levy, 2008; Xie et al., 2016; Zheng et al., 2021). In a paper entitled "Exploring the Neuropsychological Basis of Behavioral Contagion During Learning about Another Agent's Social Preferences: Evidence from an ERP Study," Deldoost et al. (2024) sought to better understand the functions of imitative behavior in humans as well as explore the underlying neuropsychological processes associated with social contagion. Using real-time EEGs, Deldoost et al. identified specific neural patterns that emerge during moments of social contagion, providing a clearer understanding of how conformity influences decision-making at the cognitive level. They found that social contagion led to a significant number of participants changing their personal preferences. The block diagram in Figure 3 illustrates the preprocessing of raw EEG data and calculating ERP steps. Deldoost et al. (2024) observed a P300 component in the midline and right posterior areas of the brain during the time window of 200-350 milliseconds following the presentation of a stimulus. The scalp map distribution provides evidence that the temporoparietal and parieto-occipital regions of the brain are

critically involved in processing information, specifically related to conformity and other-regarding information.

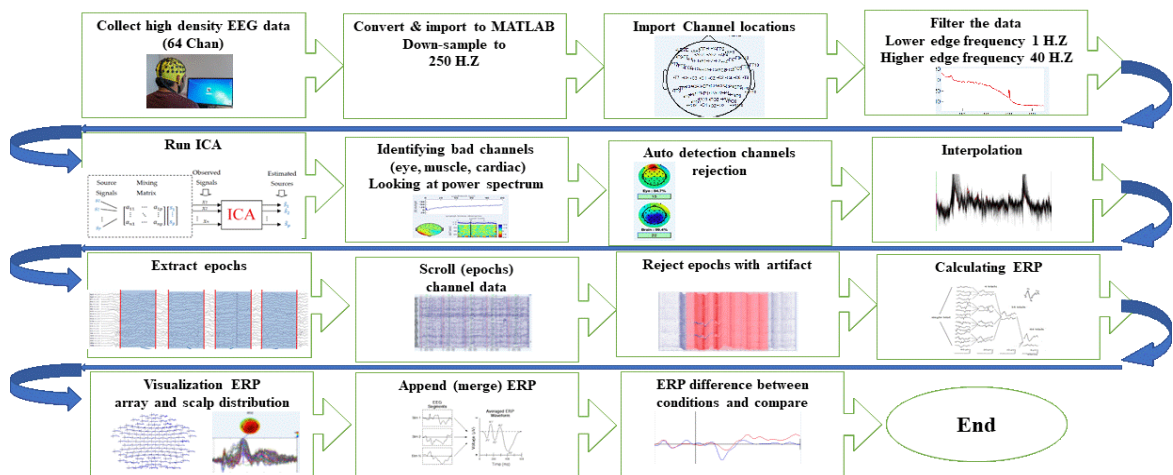


Figure 3 EEG / ERP data preprocessing pipeline

It appears that social cooperation is woven into the DNAs of our brains. Accordingly, human biological propensities to make social connections leading to cooperative relationships seem to be a contributing *cause* behind why markets work in ways that successfully bolster economic productivity and innovation, which, in turn, enables humans to flourish.⁷ Human behavior reflects both rational self-interest as well as moral sentiments (empathy or fellow feeling). By indulging both human desires and behaviors, free markets can facilitate social cooperation that, in the right institutional and environmental environments, can lead to human flourishing. When humans voluntarily cooperate through free market exchanges, they face potentially costly risks. Such risks, however, are often mitigated by human sentiments of trust and trustworthiness. The process is greatly assisted when human beings form shared identities and develop common purposes that are based on shared social experiences and stories. Exploring the connection between humanomics and neuroeconomics allows us to test the veracity of (a) Adam Smith's beliefs regarding human moral sentiments and social cooperation (b) provide clear, repeatable scientific evidence that accurately describes human behavior (in the lab and in the real world) by reflecting the interplay between rationality and sociality.

V. Conclusion: Contributions to *bettering* economics and public choice

Emphasizing the importance of humanomics need not imply a wholesale rejection MAX-U. That said, it is essential to note that Max-U models are often incomplete because they tend to overlook or discount the impact of varying cultural contexts on outcomes. (Denzau & North,

1994; Denzau, North, & Roy, 2006, 2007; Denzau, Minassians, & Roy, 2016; Roy & Denzau, 2020; Smith, 2003, 2020).

Recently, a group of public choice economists, political scientists, and political economists came together to honor Nobel laureate Vernon L. Smith and his colleague Bart J. Wilson's joint contribution to humanomics. A special issue of the *Public Choice* journal was published in March 2025, emphasizing the idea that "economics needed to reclaim an appreciation for insights of the arts and culture" (Schraeger, 2021) to make the "dismal science" more meaningful and relevant to the human experience. This special issue featured the works of Vernon L. Smith, Michael C. Munger, Diana Thomas and Michael Thomas, as well as Jordon K. Lofthouse and two of the present authors, just to name a few.⁸ Collectively, the participating authors outline an empirical and normative research program that emphasizes the virtues of free-market capitalism and how they are interwoven with the public choice research agenda. In doing so, they presented a compelling and convincing argument for why economics must incorporate the study of human meaning, understanding, and experience into its methodological analysis if it is to remain a relevant and important area of inquiry that serves the greater good.

Exploration in this vein continues. Roy & Yonk are commissioning a special symposium of papers devoted to humanomics from researchers representing different disciplines — political science, economics, history, philosophy, computer science, and various other fields — that explore the importance of emphasizing the protection and expansion of human values in AI systems and models. Contributors reflecting a broad array of disciplinary backgrounds and perspectives will explore the use of W. Edwards Deming's System of Profound Knowledge (SoPK)© (1994, 2000) as a conceptual framework for studying how AI models can be improved. Current research suggests that there is a pressing need to enhance AI relevance for effective human-AI collaboration. Deming's SoPK involves using an interdisciplinary framework that synthesizes insights from philosophy (theory of knowledge), statistical variation, systems theory, and psychology to help uncover the deeper causes behind *why*, thereby enabling better achievement of dynamic innovation and breakthroughs in human knowledge and understanding. Perhaps, without realizing it, systems thinkers like Deming were trying to teach us the art of humanomics.

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⁴ Michael Tomasello asserts that collaboration (co-labor-ing) is a unique form of human social behavior that is distinct from mere cooperation. When people collaborate, they work together in pursuit a joint goal or aim. The goal or aim is shared mutually in the heads of the collaborators. Collaboration involves shared intentionality, sometimes known as "we" intentionality.

⁵ (<https://www.mindbodygreen.com/articles/difference-between-mind-and-brain-neuroscientist>.)

⁶ From abstract that appears in Smith, V.L., & Wilson, B. *Humanomics: Moral sentiments and the wealth of nations for the twenty-first century*. Cambridge: Cambridge University Press.

⁷ The claim that free markets work effectively has been well-studied and documented (Faria & Montesinos, 2009; Roll & Talbottm 2003; Lawson, Murphy & Williamson, 2016; Esposto & Zaleski, 1999.)

⁸ The Full Special Issue can be found here: <https://link.springer.com/article/10.1007/s11127-024-01222-9>

Appendix A:

Acquisition of Behavioral and EEG Data for 'Contagion Effect' Project

This code has been developed to acquire both behavioral and electroencephalography (EEG) data from participants engaged in the 'Exploring the Neuropsychological Basis of Behavioral Contagion in Social and Economic Interaction' research project, which comprises three experimental sessions.

```
% Phase 1
```

Refresh Workspace

```
%  
% for x = 1:10  
%     disp(x)  
% end  
%  
close all  
clearvars  
clear global  
clc  
sca  
  
addpath("Functions")  
AssertOpenGL;  
%  
  
Subject.name = input("Please enter your name:\n", 's');  
global Graphics  
KbName('UnifyKeyNames')  
Graphics.validKeys = {'space', 'f'};  
  
% Initialization  
Graphics.font.huge           = 64;  
Graphics.font.big           = 42;  
Graphics.font.medium        = 25;  
Graphics.font.small         = 16;  
  
load(fullfile("Misc", "text.mat"))  
Graphics.unicode = unicode;  
clear unicode  
  
% Initialize <Config> struct, containing task control variables  
PsychDefaultSetup(2);  
Screen('Preference', 'SkipSyncTests', 1);  
Screen('Preference', 'TextRenderer', 1);  
Screen('Preference', 'TextAntiAliasing', 1);  
Screen('Preference', 'TextAlphaBlending', 0);  
Screen('Preference', 'DefaultTextYPositionIsBaseline', 1);
```

```

% Initialize Psychtoolbox Parameters
Graphics.screenPtr      = max(Screen('Screens'));
resol                   = Screen('Resolution',
    Graphics.screenPtr);
Graphics.screenWidth    = resol.width;
Graphics.screenHeight   = resol.height;
Graphics.screenPixelSize = resol.pixelSize;
Graphics.screenHz       = resol.hz;
Graphics.screenSize     = ceil([0, 0, Graphics.screenWidth,
    Graphics.screenHeight]);
Graphics.nScreenBuffers = 2;

Graphics.colorWhite     = WhiteIndex(Graphics.screenPtr);
Graphics.colorBlack     = BlackIndex(Graphics.screenPtr);
Graphics.colorGray      = Graphics.colorWhite / 2;

% Initialize Psychtoolbox Video
disp("Loading PTB Window")
[window, windowRect] = PsychImaging(...
    'OpenWindow', ...
    Graphics.screenPtr, ...
    Graphics.colorWhite, ...
    Graphics.screenSize, ...
    Graphics.screenPixelSize, ...
    Graphics.nScreenBuffers, ...
    [], ...
    [], ...
    kPsychNeed32BPCFloat...
);

Graphics.window = window;
% WaitSecs(5);

Screen('TextStyle', window, 0);
Screen('TextFont', window, 'Sahel');

% Generate Condition Matrix
% allocs = readmatrix(fullfile("Misc", "allocations.csv"));
allocations = load(fullfile('Misc', 'allocations.mat'))
allocations = allocations.allocations
nAllocation = size(allocations, 1);
option_shuffle = randi(2, nAllocation, 1);
allocations(option_shuffle == 2, 2:5) = allocations(option_shuffle ==
    2, [4,5,2,3]);

Subject.allocations = allocations;
Subject.allocationsHeader = {'Condition Index', 'Dictator
    1', 'Recipient 1', 'Dictator 2', 'Receipient 2'};
Subject.allocationOptionShuffle = option_shuffle;

Graphics.maxOption = max(max(Subject.allocations));
clear allocations option_shuffle

Graphics.barPlotRect = [400, 400];

```

```

Graphics.optionCoordinates = loccent(windowRect,
    Graphics.barPlotRect(1));
Graphics.optionPenWidth    = 3;

    Graphics.time.decisionTimeOut    =    0;
    Graphics.time.choiceDisplay      =    .8;
    Graphics.time.answerDisplay      =    2;
    Graphics.time.interTrialRestBase =    2;
Graphics.time.interTrialRestMaxJitter =    1;

    Graphics.trig.allow              =    false;
    Graphics.trig.taskInitiation     =    100;
    Graphics.trig.choiceSelection     =    110;
    Graphics.trig.sliderOnset        =    120;
Graphics.trig.confidenceSelection   =    130;
    Graphics.trig.interPhaseTrigger  =    140;

    Graphics.eyetrack.allow          =    false;
    Graphics.eyetrack.ipAddress      =    '127.0.0.1';
    Graphics.eyetrack.setting        =    {
{'RECORDED_EYE', 'L'},...
{'SCREEN_ORIGIN', 'Center'},...
{'TRACKER_ORIGIN', 'Center'},...
{'SCREEN_WIDTH', 1920},...
{'SCREEN_HEIGHT', 1080},...
{'VIEWING_DISTANCE', 57.3},...
{'DOTS_PER_CENTIMETER_H', 36},...
{'DOTS_PER_CENTIMETER_V', 36},...
{'SACCADE_VELOCITY_THRESHOLD', 20.0},...
{'SACCADE_ACCELERATION_THRESHOLD', 3800.0},...
{'SACCADE_MINIMUM_DURATION', 12},...
{'SACCADE_MINIMUM_AMPLITUDE', 0.2},...
{'FIXATION_MINIMUM_DURATION', 12},...
{'BLINK_MINIMUM_DURATION', 50},...
{'RESAMPLING', 0},...
{'FILTER_TYPE', 'identity'},...
{'FILTER_WN', 0.2},...
{'FILTER_SIZE', 5},...
{'FILTER_ORDER', 3}
};

Graphics.timer0 = tic;
    % Initialized after handleInstruction

clear ans
% Trigger Initialization
if Graphics.trig.allow
    Graphics.trig.ioObj = io64;
    Graphics.trig.address = hex2dec('3fd8');
    %standard LPT1 output port address
    status = io64(Graphics.trig.ioObj);
    assert(status == 0)
end
% Initialize Result Variables

```

```

% nAllocation = size(Subject.allocations, 1);
% nAllocation = 1;

Subject.phase1.conditions =
    Subject.allocations(randperm(nAllocation), :);
Subject.phase1.responses = nan * zeros(nAllocation, 2);
    % r, rt
Subject.phase1.mouseTraj = cell(nAllocation, 1);

Subject.phase2.conditions =
    Subject.allocations(randperm(nAllocation), :);
Subject.phase2.responses = nan * zeros(nAllocation, 4);
    % r, rt1, c, rt2
Subject.phase2.mouseTrajChoice = cell(nAllocation, 1);
Subject.phase2.mouseTrajConfidence = cell(nAllocation, 1);

% In phase 3, 1 corresponds with self trials and 2 corresponds with
% other
% trials
Subject.phase3.conditions1 =
    Subject.allocations(randperm(nAllocation), :);
Subject.phase3.conditions2 =
    Subject.allocations(randperm(nAllocation), :);
Subject.phase3.responses1 = nan * zeros(nAllocation, 2);
Subject.phase3.responses2 = nan * zeros(nAllocation, 4);
Subject.phase3.mouseTrajChoice1 = cell(nAllocation, 1);
Subject.phase3.mouseTrajChoice2 = cell(nAllocation, 1);
Subject.phase3.mouseTrajConfidence = cell(nAllocation, 1);

% HideCursor;

try
    if Graphics.eyetrack.allow
        cx = windowRect(3)/2;
        cy = windowRect(4)/2;
        param = SimpleGazeTracker('Initialize', window, windowRect);
        param.sendPort = 10003;
        param.recvPort = 10004;

        param.IPAddress = Graphics.eyetrack.ipAddress;
        param.imageWidth = cx;
        param.imageHeight = cy;
        param.calArea = windowRect;
        param.calTargetPos = [0 , 0 ;
            -400 , -300 ;
            0 , -300 ;
            400 , -300 ;
            -400 , 0 ;
            0 , 0 ;
            400 , 0 ;
            -400 , 300 ;
            0 , 300 ;
        ]
    end
end

```

```

        400 , 300
    ];
    for i=1:length(param.calTargetPos)
        param.calTargetPos(i,:) = param.calTargetPos(i, :)+[cx,cy];
    end
    result = SimpleGazeTracker('UpdateParameters',param);
    if result{1} < 0 %failed
        disp('Could not update parameter. Abort. ');
        Screen('CloseAll');
        return;
    end

    % Connect to SimpleGazeTracker and open data file
    res = SimpleGazeTracker('Connect');
    if res==-1 %connection failed
        Screen('CloseAll');
        return;
    end
    SimpleGazeTracker('OpenDataFile','data.csv',0); %datafile is
not overwritten.

    % Update camera image buffer (NEW in 0.4.0)
    imgsize = SimpleGazeTracker('GetCameraImageSize');
    param.imageWidth = imgsize(1);
    param.imageHeight = imgsize(2);
    result = SimpleGazeTracker('UpdateParameters',param);
    if result{1} < 0 %failed
        disp('Could not update parameter. Abort. ');
        Screen('CloseAll');
        return;
    end

    % Send settings (NEW in 0.4.0)
    res = SimpleGazeTracker('SendSettings',
Graphics.eyetrack.setting);

    % Perform calibration.
    while 1
        res = SimpleGazeTracker('CalibrationLoop');
        if res{1}=='q'
            %Quit if calibration loop is finished by 'q' key.
            SimpleGazeTracker('CloseConnection');
            Screen('CloseAll');
            return;
        end
        if strcmp(res{1}, 'ESCAPE') && res{2}==1
            %Leave from loop if calibration has been performed
(res{2}==1).
            break;
        end
    end
end

% Begin the Task

```

```

    handleIntro(fullfile('Images', 'Hello.JPG'), Graphics.validKeys)
    handleIntro(fullfile('Images', 'Overview.JPG'),
Graphics.validKeys);
    Graphics.timer0 = tic;
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %%%%%%%%%
    % Block 1
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %%%%%%%%%
    % Start recording.
    if Graphics.eyetrack.allow
        SimpleGazeTracker('StartRecording', 'Block 1', 0.1);
    end

    % Phase 1, Solo Trials: Choosing between Various Allocations
    % Trial window
    handleIntro(fullfile('Images', 'Part1_Start.JPG'),
Graphics.validKeys);
    phaseTransferNotifier('self')
    for iTrial = 1:nAllocation
        try
            [r, rt, mt] = ...
                handleSelfTrial(Subject.phase1.conditions(iTrial, :));
            Subject.phase1.responses(iTrial, :) = [r, rt];
            Subject.phase1.mouseTraj{iTrial} = mt;
        catch ME
            disp(ME.message)
        end
    end
    clear r rt mt iTrial

    % Stop recording.
    if Graphics.eyetrack.allow
        SimpleGazeTracker('StopRecording', '', 0.1);
    end

    handleIntro(fullfile('Images', 'Part1_End.JPG'),
Graphics.validKeys);

    % Model Fitting
    lb = [-2 -2 10];
    ub = [2 2 1000];

    % Create New Subject
    otherParams = otherParam(Subject.phase1.conditions(:, 2:5), ...
        Subject.phase1.responses(:, 1));
    Subject.phase2.otherDecisions = ...
        otherDecisions(Subject.phase2.conditions(:, 2:5),
otherParams);
    Subject.phase3.otherDecisions = ...
        otherDecisions(Subject.phase3.conditions2(:, 2:5),
otherParams);

    % Clear Screen

```

```

Screen('Flip',window);

% Transfer data from SimpleGazeTracker.
if Graphics.eyetrack.allow
    fid = fopen('log.txt','wt');
    %Get all messages.
    msglist = SimpleGazeTracker('GetWholeMessageList', 3.0);
    fprintf(fid, 'GetWholeMessageList test\n');
    for i=1:length(msglist)
        fprintf(fid, '%f,%s\n', msglist{i,1}, msglist{i,2});
    end
    fprintf(fid, '\n');

    SimpleGazeTracker('CloseDataFile');
    SimpleGazeTracker('CloseConnection');
end
Screen('CloseAll');
catch
    if Graphics.eyetrack.allow
        SimpleGazeTracker('CloseConnection');
    end
    Screen('CloseAll');
    psychrethrow(psychlasterror);
end

% ShowCursor;

% Close and Save
dataFileName = strcat(datestr(today, 'yyyymmdd'), '-',
    Subject.name, '-ph1');

save(fullfile(pwd, "Subjects",
    dataFileName), 'Subject', 'Graphics', 'otherParams')
save currentSubject.mat dataFileName

Subject.name = input("Please enter your name:\n", 's');

```

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Phase 2

```
for x = 1:10
    disp(x)
end
```

Refresh Workspace

```
close all
clearvars
clear global
clc
sca

addpath("Functions")
AssertOpenGL;

load currentSubject.mat
load (fullfile('Subjects', dataFileName))
clear dataFileName

% Initialize <Config> struct, containing task control variables
PsychDefaultSetup(2);
Screen('Preference', 'SkipSyncTests', 1);
Screen('Preference', 'TextRenderer', 1);
Screen('Preference', 'TextAntiAliasing', 1);
Screen('Preference', 'TextAlphaBlending', 0);
Screen('Preference', 'DefaultTextYPositionIsBaseline', 1);

% Initialize Psychtoolbox Video
disp("Loading PTB Window")
[window, windowRect] = PsychImaging(...
    'OpenWindow', ...
    Graphics.screenPtr, ...
    Graphics.colorWhite, ...
    Graphics.screenSize, ...
    Graphics.screenPixelSize, ...
    Graphics.nScreenBuffers, ...
    [], ...
    [], ...
    kPsychNeed32BPCFloat...
);

Graphics.window = window;

Screen('TextStyle', window, 0);
Screen('TextFont', window, 'Sahel');

% clear ans
% Trigger Initialization
if Graphics.trig.allow
```

```

Graphics.trig.ioObj = io64;
Graphics.trig.address = hex2dec('3fd8');
    %standard LPT1 output port address
status = io64(Graphics.ioObj);
assert(status == 0)

end
% Initialize Result Variables
nAllocation = size(Subject.allocations, 1);

% HideCursor;

try
    if Graphics.eyetrack.allow
        cx = windowRect(3)/2;
        cy = windowRect(4)/2;
        param = SimpleGazeTracker('Initialize', window, windowRect);
        param.sendPort = 10003;
        param.recvPort = 10004;

        param.IPAddress = Graphics.eyetrack.ipAddress;
        param.imageWidth = cx;
        param.imageHeight = cy;
        param.calArea = windowRect;
        param.calTargetPos = [0      , 0      ;
            -400 , -300 ;
             0  , -300 ;
            400  , -300 ;
            -400 ,  0  ;
             0  ,  0  ;
            400  ,  0  ;
            -400 , 300 ;
             0  , 300 ;
            400  , 300
        ];
        for i=1:length(param.calTargetPos)
            param.calTargetPos(i,:) = param.calTargetPos(i, :)+[cx,cy];
        end
        result = SimpleGazeTracker('UpdateParameters',param);
        if result{1} < 0 %failed
            disp('Could not update parameter. Abort. ');
            Screen('CloseAll');
            return;
        end

        % Connect to SimpleGazeTracker and open data file
        res = SimpleGazeTracker('Connect');
        if res==-1 %connection failed
            Screen('CloseAll');
            return;
        end
        SimpleGazeTracker('OpenDataFile','data2.csv',0); %datafile is
not overwritten.

```

```

% Update camera image buffer (NEW in 0.4.0)
imgsize = SimpleGazeTracker('GetCameraImageSize');
param.imageWidth = imgsize(1);
param.imageHeight = imgsize(2);
result = SimpleGazeTracker('UpdateParameters',param);
if result{1} < 0 %failed
    disp('Could not update parameter. Abort. ');
    Screen('CloseAll');
    return;
end

% Send settings (NEW in 0.4.0)
res = SimpleGazeTracker('SendSettings',
Graphics.eyetrack.setting);

% Perform calibration.
while 1
    res = SimpleGazeTracker('CalibrationLoop');
    if res{1}=='q'
        %Quit if calibrationloop is finished by 'q' key.
        SimpleGazeTracker('CloseConnection');
        Screen('CloseAll');
        return;
    end
    if strcmp(res{1}, 'ESCAPE') && res{2}==1
        %Leave from loop if calibration has been performed
        (res{2}==1).
        break;
    end
end
end

% Begin the Task
Graphics.timer0 = tic;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%
% Block 2 Predicting Another One's choice + Reporting Decision
Confidence
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%
    handleIntro(fullfile('Images', 'Part2_Start.JPG'),
Graphics.validKeys);
    phaseTransferNotifier('other')
    if Graphics.eyetrack.allow
        SimpleGazeTracker('StartRecording','Block 2',0.1);
    end
    for iTrial = 1:nAllocation
        try
            [r, rt1, c, rt2, mt1, mt2] = ...

handleOtherTrial(Subject.phase2.conditions(iTrial, :), ...
                Subject.phase2.otherDecisions(iTrial));

```

```

        Subject.phase2.responses(iTrial, :) = [r, rt1, c, rt2];
        Subject.phase2.mouseTrajChoice{iTrial} = mt1;
        Subject.phase2.mouseTrajConfidence{iTrial} = mt2;
    catch ME
        disp(ME.message)
    end
end
end
Screen('Flip', window);
clear r rt1 c rt2 mt iTrial
if Graphics.eyetrack.allow
    SimpleGazeTracker('StopRecording','',0.1);
end

    handleIntro(fullfile('Images', 'Part2_End.JPG'),
Graphics.validKeys);
    % Clear Screen
    Screen('Flip',window);

    % Transfer data from SimpleGazeTracker.
    if Graphics.eyetrack.allow
        fid = fopen('log.txt','wt');
        %Get all messages.
        msglist = SimpleGazeTracker('GetWholeMessageList', 3.0);
        fprintf(fid, 'GetWholeMessageList test\n');
        for i=1:length(msglist)
            fprintf(fid, '%f,%s\n', msglist{i,1}, msglist{i,2});
        end
        fprintf(fid, '\n');

        SimpleGazeTracker('CloseDataFile');
        SimpleGazeTracker('CloseConnection');
    end
    Screen('CloseAll');
catch
    if Graphics.eyetrack.allow
        SimpleGazeTracker('CloseConnection');
    end
    Screen('CloseAll');
    psychrethrow(psychlasterror);
end

% ShowCursor;

% Close and Save
dataFileName = strcat(datestr(today, 'yyyymmdd'), '-',
    Subject.name, '-ph2');
save(fullfile(pwd, "Subjects", dataFileName), 'Subject', 'Graphics')

Loading PTB Window

```

% Phase 3

Refresh Workspace

```
close all
clearvars
clear global
clc
sca

addpath("Functions")
AssertOpenGL;

load currentSubject.mat
load (fullfile('Subjects', dataFileName))
clear dataFileName

% Initialize <Config> struct, containing task control variables
PsychDefaultSetup(2);
Screen('Preference', 'SkipSyncTests', 1);
Screen('Preference', 'TextRenderer', 1);
Screen('Preference', 'TextAntiAliasing', 1);
Screen('Preference', 'TextAlphaBlending', 0);
Screen('Preference', 'DefaultTextYPositionIsBaseline', 1);

% Initialize Psychtoolbox Video
disp("Loading PTB Window")
[window, windowRect] = PsychImaging(...
    'OpenWindow', ...
    Graphics.screenPtr, ...
    Graphics.colorWhite, ...
    Graphics.screenSize, ...
    Graphics.screenPixelSize, ...
    Graphics.nScreenBuffers, ...
    [], ...
    [], ...
    kPsychNeed32BPCFloat...
);

Graphics.window = window;
% WaitSecs(5);

Screen('TextStyle', window, 0);
Screen('TextFont', window, 'Sahel');

Graphics.timer0 = tic;
    % Initialized after handleInstruction

% Trigger Initialization
if Graphics.trig.allow
```

```

Graphics.trig.ioObj = io64;
Graphics.trig.address = hex2dec('3fd8');
    %standard LPT1 output port address
status = io64(Graphics.ioObj);
assert(status == 0)

end
% Initialize Result Variables

% HideCursor;

try
    if Graphics.eyetrack.allow
        cx = windowRect(3)/2;
        cy = windowRect(4)/2;
        param = SimpleGazeTracker('Initialize', window, windowRect);
        param.sendPort = 10003;
        param.recvPort = 10004;

        param.IPAddress = Graphics.eyetrack.ipAddress;
        param.imageWidth = cx;
        param.imageHeight = cy;
        param.calArea = windowRect;
        param.calTargetPos = [0      , 0      ;
                               -400 , -300 ;
                               0    , -300 ;
                               400  , -300 ;
                               -400 , 0    ;
                               0    , 0    ;
                               400  , 0    ;
                               -400 , 300 ;
                               0    , 300 ;
                               400  , 300
                               ];
        for i=1:length(param.calTargetPos)
            param.calTargetPos(i,:) = param.calTargetPos(i, :)+[cx,cy];
        end
        result = SimpleGazeTracker('UpdateParameters',param);
        if result{1} < 0 %failed
            disp('Could not update parameter. Abort. ');
            Screen('CloseAll');
            return;
        end

        % Connect to SimpleGazeTracker and open data file
        res = SimpleGazeTracker('Connect');
        if res==-1 %connection failed
            Screen('CloseAll');
            return;
        end
        SimpleGazeTracker('OpenDataFile','data3.csv',0); %datafile is
not overwritten.
    end
end

```

```

    % Update camera image buffer (NEW in 0.4.0)
    imgsize = SimpleGazeTracker('GetCameraImageSize');
    param.imageWidth = imgsize(1);
    param.imageHeight = imgsize(2);
    result = SimpleGazeTracker('UpdateParameters',param);
    if result{1} < 0 %failed
        disp('Could not update parameter. Abort. ');
        Screen('CloseAll');
        return;
    end

    % Send settings (NEW in 0.4.0)
    res = SimpleGazeTracker('SendSettings',
Graphics.eyetrack.setting);

    % Perform calibration.
    while 1
        res = SimpleGazeTracker('CalibrationLoop');
        if res{1}=='q'
            %Quit if calibrationloop is finished by 'q' key.
            SimpleGazeTracker('CloseConnection');
            Screen('CloseAll');
            return;
        end
        if strcmp(res{1}, 'ESCAPE') && res{2}==1
            %Leave from loop if calibration has been performed
(res{2}==1).
            break;
        end
    end
end

    % Begin the Task
    handleIntro(fullfile('Images', 'Part3_Start.JPG'),
Graphics.validKeys);
    phaseTransferNotifier('self')
    Graphics.timer0 = tic;

    SimpleGazeTracker('StartRecording','Block 3',0.1);
catch ME
    disp(ME.message)
    if Graphics.eyetrack.allow
        SimpleGazeTracker('CloseConnection');
    end
    Screen('CloseAll');
    psychrethrow(psychlasterror);
    sca
end

for iTrial = 1:22
    [r, rt, mt] =
handleSelfTrial(Subject.phase3.conditions1(iTrial, :));
    Subject.phase3.responses1(iTrial, :) = [r, rt];
    Subject.phase3.mouseTrajChoice1{iTrial} = mt;

```

```

end
clear r rt mt iTrial

phaseTransferNotifier("other")
for iTrial = 1:33
    [r, rt1, c, rt2, mt1, mt2] =
        handleOtherTrial(Subject.phase3.conditions2(iTrial, :), ...
            Subject.phase3.otherDecisions(iTrial));
    Subject.phase3.responses2(iTrial, :) = [r, rt1, c, rt2];
    Subject.phase3.mouseTrajChoice2{iTrial} = mt1;
    Subject.phase3.mouseTrajConfidence{iTrial} = mt2;
end
clear r rt1 c rt2 mt iTrial

phaseTransferNotifier("self")
for iTrial = 23:44
    [r, rt, mt] = ...
        handleSelfTrial(Subject.phase3.conditions1(iTrial, :));
    Subject.phase3.responses1(iTrial, :) = [r, rt];
    Subject.phase3.mouseTrajChoice1{iTrial} = mt;
end
clear r rt mt iTrial

phaseTransferNotifier("other")
for iTrial = 34:66
    [r, rt1, c, rt2, mt1, mt2] =
        handleOtherTrial(Subject.phase3.conditions2(iTrial, :), ...
            Subject.phase3.otherDecisions(iTrial));
    Subject.phase3.responses2(iTrial, :) = [r, rt1, c, rt2];
    Subject.phase3.mouseTrajChoice2{iTrial} = mt1;
    Subject.phase3.mouseTrajConfidence{iTrial} = mt2;
end
clear r rt1 c rt2 mt iTrial

phaseTransferNotifier("self")
for iTrial = 45:66
    [r, rt, mt] =
        handleSelfTrial(Subject.phase3.conditions1(iTrial, :));
    Subject.phase3.responses1(iTrial, :) = [r, rt];
    Subject.phase3.mouseTrajChoice1{iTrial} = mt;
end
clear r rt mt iTrial
if Graphics.eyetrack.allow
    SimpleGazeTracker('StopRecording', '', 0.1);
end

% Clear Screen
Screen('Flip', window);

% Transfer data from SimpleGazeTracker.
if Graphics.eyetrack.allow
    fid = fopen('log.txt', 'wt');
    %Get all messages.
    msglist = SimpleGazeTracker('GetWholeMessageList', 3.0);

```

```
fprintf(fid, 'GetWholeMessageList test\n');
for i=1:length(msglist)
    fprintf(fid, '%f,%s\n', msglist{i,1}, msglist{i,2});
end
fprintf(fid, '\n');

SimpleGazeTracker('CloseDataFile');
SimpleGazeTracker('CloseConnection');
end

Screen('CloseAll');
% ShowCursor;

% Close and Save
dataFileName = strcat(datestr(today, 'yyyymmdd'), '-',
    Subject.name, '-ph3');
save(fullfile(pwd, "Subjects", dataFileName), 'Subject', 'Graphics')

Loading PTB Window
```

```
function displayOptions(win, allocations)
%PUTOPT Places the options around the windows
% Handles the pre-decision-making section of each trial
global Graphics
penWidth = Graphics.optionPenWidth;
axisRect = Graphics.barPlotRect;
yMax      = Graphics.maxOption;

for iOption = 1:2
    drawBarChart(win, allocations((iOption-1)*2 + 1:(iOption-1)*2 +
    2), ...
        Graphics.optionCoordinates.optionCentersSolo(iOption, :), ...
        axisRect, ...
        'YMax', yMax, ...
        'PenWidth', penWidth, ...
        'FontSize', Graphics.font.medium, ...
        'Labels', {Graphics.unicode.self, Graphics.unicode.other});
end
end
```

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```

function drawBarChart(win, vals, pos, rect, varargin)
%DRAWBARCHART Summary of this function goes here
% Detailed explanation goes here

yMax = max(vals);
penWidth = 3;
fontSize = 25;
labels = {'', ''};
% barColors = [174, 218, 198; ...
%             184, 177, 193] / 255;
barColors = [88, 148, 156; ...
            223, 152, 129] / 255;

pos = pos(:);
rect = rect(:);

if mod(length(varargin), 2) == 1
    error('drawBarChart: Mismatched input arguments')
end
for i = 1:2:length(varargin)
    if strcmp(varargin{i}, 'YMax')
        yMax = varargin{i+1};
    elseif strcmp(varargin{i}, 'PenWidth')
        penWidth = varargin{i+1};
    elseif strcmp(varargin{i}, 'FontSize')
        fontSize = varargin{i+1};
    elseif strcmp(varargin{i}, 'Labels')
        labels = varargin{i+1};
    end
end

if yMax < max(vals)
    error('drawBarChart: YMax should be larger than option values')
end
if length(labels) ~= 2
    error('drawBarChart: You should pass 2 labels to this function')
end

width    = rect(1);
height   = rect(2);
xCenter  = pos(1);
yCenter  = pos(2);

barWidth = floor(width / 4);
verticalPadding = floor(0.1 * height);
horizontalPadding = floor((width - 2 * barWidth) / 4);

yBaseline = yCenter + height / 2 - verticalPadding;
xBarRoots = xCenter + (horizontalPadding + barWidth / 2) * [-1; +1];

scaledVals = floor(vals / yMax * (height - 2 * horizontalPadding));

```

```

Screen('DrawLine', win, 0, ...
      xCenter - width / 2, yBaseline - penWidth / 2, ...
      xCenter + width / 2, yBaseline - penWidth / 2, ...
      penWidth);
Screen('DrawLine', win, 0, ...
      xCenter - width / 2 + 20, yBaseline + 2, ...
      xCenter + width / 2 - 20, yBaseline + 2, ...
      penWidth/3);

for iBar = 1:2
    Screen('FillRect', win, barColors(iBar, :), ...
          [xBarRoots(iBar) - barWidth / 2; yBaseline -
scaledVals(iBar); ...
          xBarRoots(iBar) + barWidth / 2; yBaseline], ...
          penWidth);
    Screen('FrameRect', win, 0, ...
          [xBarRoots(iBar) - barWidth / 2; yBaseline -
scaledVals(iBar); ...
          xBarRoots(iBar) + barWidth / 2; yBaseline], ...
          penWidth);
    Screen('TextSize', win, fontSize);
    Screen('DrawText', win, num2str(vals(iBar)), ...
          floor(xBarRoots(iBar) - fontSize * .75), ...
          floor(yBaseline - scaledVals(iBar) / 2 - fontSize / 2), ...
          1, barColors(iBar, :), 0);
    Screen('DrawText', win, labels{iBar}, ...
          floor(xBarRoots(iBar) - 35), ...
          floor(yBaseline + 20), ...
          0, 1, 0);
end
end

```

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```

function varargout = getChoice(win, allocations, isBordered)
%GETCHOICE Summary of this function goes here
% Detailed explanation goes here
global Graphics
mouseLog = [];
if nargin == 2
    isBordered = false;
end
isFinished = false;
SetMouse(round(Graphics.screenWidth / 2),
    round(Graphics.screenHeight / 2), Graphics.screenPtr);
choiceTransform = [1, 0, 2];

choiceTimer= tic;
while ~isFinished
    [mouseX, mouseY, buttons, ~, ~, ~] = GetMouse(win,
Graphics.screenPtr);
    mouseLog = [mouseLog; mouseX mouseY toc(Graphics.timer0)];
    displayOptions(win, allocations);
    choice = dsearchn([.42 * Graphics.screenWidth; ...
        .5 * Graphics.screenWidth; ...
        .58 * Graphics.screenWidth], mouseX);
    choice = choiceTransform(choice);
    displayChoice(win, choice)
    if isBordered
        displayBorder(win)
    end
    Screen('Flip', win);

    if buttons(1) && (choice ~= 0)
        isFinished = true;
    end
end
reactionTime = toc(choiceTimer);
if nargin == 2
    varargout = {choice, reactionTime};
elseif nargin == 3
    varargout = {choice, reactionTime, mouseLog};
end
end

```

```

function [choice, rt1, confidence, rt2, mouseTraj1, mouseTraj2] = ...
    handleOtherTrial(trialData, otherChoice)
%HANDLEOTHERTRIAL Summary of this function goes here
global Graphics
win = Graphics.window;

trialIndex = trialData(1);
allocations = trialData(2:end);

displayOptions(win, allocations);
displayBorder(win)
Screen('Flip', win);
sendTrigger(trialIndex)
[choice, rt1, mouseTraj1] = getChoice(win, allocations, true);
sendTrigger(Graphics.trig.choiceSelection)
displayOptions(win, allocations);
displayChoice(win, choice)
displayBorder(win)
Screen('Flip', win);
WaitSecs(Graphics.time.choiceDisplay);
KbEventFlush();

sendTrigger(Graphics.trig.sliderOnset)

[confidence, rt2, mouseTraj2] = getChoiceConfidence(win, allocations,
    choice);

sendTrigger(Graphics.trig.confidenceSelection)

WaitSecs(Graphics.time.choiceDisplay);
displayBorder(win)
Screen('Flip', win);

displayBorder(win)
displayOptions(win, allocations);
displayChoice(win, choice)
revealOtherChoice(win, otherChoice);
Screen('Flip', win);
WaitSecs(Graphics.time.answerDisplay);
displayBorder(win)
Screen('Flip', win);
end

```

```

function varargout = ...
    getChoiceConfidence(win, allocations, choice)
%DISPLAYSLIDER Summary of this function goes here
% Detailed explanation goes here
global Graphics
nPoint = 6;
radius = 35;

highlightColor = [177, 156, 216] / 255;
borderColor = 0.8;

isFinished = false;
mouseTraj = [];

xSlider = floor(0.5 * Graphics.screenWidth);
ySlider = floor(linspace(0.7 * Graphics.screenHeight, ...
    0.3 * Graphics.screenHeight, nPoint));
sliderLabels = linspace(0, 100, nPoint);
SetMouse(round(Graphics.screenWidth / 2), ySlider(1),
    Graphics.screenPtr);

confidenceTimer = tic;
while ~isFinished
    [mouseX, mouseY, buttons, ~, ~, ~] = GetMouse(win,
Graphics.screenPtr);
    mouseTraj = [mouseTraj; mouseX mouseY toc(Graphics.timer0)];

    displayOptions(win, allocations);
    displayChoice(win, choice)

    Screen('FillRect', win, borderColor, ...
        [xSlider - 3; ySlider(end); xSlider + 3; ySlider(1)]);
    for iPoint = 1:nPoint
        Screen('FillArc', win, 1, ...
            [xSlider-radius; ySlider(iPoint)-radius; xSlider+radius;
ySlider(iPoint)+radius], ...
            0, 360);
        Screen('FrameArc', win, borderColor, ...
            [xSlider-radius; ySlider(iPoint)-radius; xSlider+radius;
ySlider(iPoint)+radius], ...
            0, 360, 6);
        fontSize = 24;
        Screen('TextSize', win, fontSize);
        if iPoint == 1
            Screen('DrawText', win, num2str(sliderLabels(iPoint)), ...
                floor(xSlider - fontSize / 3), ...
                floor(ySlider(iPoint) - fontSize / 3), ...
                borderColor, 1, 0);
        elseif iPoint == nPoint
            Screen('DrawText', win, num2str(sliderLabels(iPoint)), ...

```

```

        floor(xSlider - fontSize * .8), ...
        floor(ySlider(iPoint) - fontSize / 3), ...
        borderColor, 1, 0);
    else
        Screen('DrawText', win, num2str/sliderLabels(iPoint)), ...
        floor(xSlider - fontSize * 0.5), ...
        floor(ySlider(iPoint) - fontSize / 3), ...
        borderColor, 1, 0);
    end
end

confidence = dsearchn(ySlider', mouseY);
Screen('FrameArc', win, highlightColor, ...
    [xSlider-radius; ySlider(confidence)-radius; ...
    xSlider+radius; ySlider(confidence)+radius], ...
    0, 360, 6);
if confidence == 1
    Screen('DrawText', win, num2str/sliderLabels(confidence)), ...
        floor(xSlider - fontSize / 3), ...
        floor(ySlider(confidence) - fontSize / 3), ...
        highlightColor, 1, 0);
elseif confidence == nPoint
    Screen('DrawText', win, num2str/sliderLabels(confidence)), ...
        floor(xSlider - fontSize * .8), ...
        floor(ySlider(confidence) - fontSize / 3), ...
        highlightColor, 1, 0);
else
    Screen('DrawText', win, num2str/sliderLabels(confidence)), ...
        floor(xSlider - fontSize * 0.5), ...
        floor(ySlider(confidence) - fontSize / 3), ...
        highlightColor, 1, 0);
end
confidence = (confidence - 1) * 100 / (nPoint - 1);

displayBorder(win)
Screen('Flip', win);

if buttons(1)
    isFinished = true;
end
end
reactionTime = toc(confidenceTimer);
if nargout == 2
    varargout = {confidence, reactionTime};
elseif nargout == 3
    varargout = {confidence, reactionTime, mouseTraj};
end
end

```

```
function handleIntro(impath, validKeys)
%DRAWINTRO Summary of this function goes here
% Detailed explanation goes here
global Graphics

[~, yCenter] = WindowCenter(Graphics.window);

iprint(Graphics.window, impath);
wprint(Graphics.window, Graphics.unicode.press_space,
    Graphics.font.medium, ...
        'center', 1.4*yCenter, Graphics.colorBlack);
Screen('Flip', Graphics.window);
pollev(validKeys, true);
Screen('Flip', Graphics.window);
end
```

```

function handleIntroductions()
%HANDLEINTRODUCTIONS Summary of this function goes here
% Detailed explanation goes here
% Hello, <space> to continue
global Graphics
[~, yCenter] = WindowCenter(Graphics.window);
sendTrigger(Graphics.trig.taskInitiation)
iprint(Graphics.window, fullfile("Images", "Hello.JPG"))
% wprint(Graphics.window, Graphics.unicode.hello,
    Graphics.font.big, ...
    'center', 'center', Graphics.colorBlack);
wprint(Graphics.window, Graphics.unicode.press_space,
    Graphics.font.medium, ...
    'center', 1.4*yCenter, Graphics.colorBlack);
Screen('Flip', Graphics.window);
pollev({'space'}, true);

% wprint(Graphics.window, Graphics.unicode.press_f_or_j,
    Graphics.font.medium, ...
    'center', 'center', Graphics.colorBlack);
iprint(Graphics.window, fullfile("Images", "Overview.JPG"))
wprint(Graphics.window, Graphics.unicode.press_space,
    Graphics.font.medium, ...
    'center', 1.4*yCenter, Graphics.colorBlack);
Screen('Flip', Graphics.window);
pollev({'space'}, true);
Screen('Flip', Graphics.window);
sendTrigger(Graphics.trig.taskInitiation)
end

```

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```
function [choice, reactionTime, mouseLog] = handleSelfTrial(trialData)
%HANDLESOLOTRIAL Summary of this function goes here
global Graphics
win = Graphics.window;

trialIndex = trialData(1);
allocations = trialData(2:end);

displayOptions(win, allocations);
Screen('Flip', win);

sendTrigger(trialIndex)

[choice, reactionTime, mouseLog] = getChoice(win, allocations);
sendTrigger(Graphics.trig.choiceSelection)
displayOptions(win, allocations);
displayChoice(win, choice)
Screen('Flip', win);

WaitSecs(Graphics.time.choiceDisplay);
KbEventFlush();
Screen('Flip', win);

WaitSecs(Graphics.time.interTrialRestBase + ...
    rand()*Graphics.time.interTrialRestMaxJitter);
end
```

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```

function Coordinations = loccent(winRect, r, varargin)
%LOCCENT Locates centers of task's positions
%   Inputs windowsRect, outputs center of circles and divider line's
%   coordinates

% if(nargin < 3)
%     trial = 'solo';
% else
%     trial = str(varargin{1});
% end

% y1 = 1 * (winRect(4) - winRect(2)) / 4;
y2 = 2 * (winRect(4) - winRect(2)) / 4;
% y3 = 3 * (winRect(4) - winRect(2)) / 4;

x2 = (winRect(3) - winRect(1)) / 2;
w = (winRect(3) - winRect(1) - 6 * r) / 6;
w = 2 * floor(w / 2);

% Coordinations.optionCentersInfo = [
%     x2-2*r-w,    y1;
%     x2,          y1;
%     x2+2*r+w,   y1;
%     x2-r-w/2,   y3;
%     x2+w/2+r,   y3
%     ];

Coordinations.optionCentersSolo = [
    x2-r-w,    y2;
    x2+w+r,    y2
    ];

% Coordinations.div.start    = [winRect(1), y2];
% Coordinations.div.finish  = [winRect(3), y2];
end

```

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```
function od = otherDecisions(allocs, params)
x1 = [allocs(:, 1) - allocs(:, 2), ...
      allocs(:, 3) - allocs(:, 4)];
x2 = -x1;
x1(x1<0) = 0;
x2(x2<0) = 0;

utility = allocs(:, [1 3]) - params(1) * x1 - params(2) * x2;
[~, od] = max(utility, [], 2);
end
```

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```
function op = otherParam(allocl1, sd)
T      = 1;
alphas = 0.1:.1:.9;
betas  = 0.1:.1:.9;

cost = nan(length(alphas), length(betas));
for ii = 1:size(cost, 1)
    for jj = 1:size(cost, 2)
        params = [alphas(ii), betas(jj), T];
        od = otherDecisions(allocl1, params);
        cost(ii,jj) = sum(od == sd);
    end
end

[mm, ind1] = min(cost);
[~, ind2] = min(mm);
jj = (ind2);
ii = ind1(ind2);
op = [alphas(ii), betas(jj), T];
end
```

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```
function phaseTransferNotifier(nextPhase)
%PHASETRANSFERNOTIFIER Summary of this function goes here
% Detailed explanation goes here
global Graphics
[~, yCenter] = WindowCenter(Graphics.window);
if strcmp(nextPhase, "self")
    iprint(Graphics.window, fullfile("Images", "Part1_Disc.JPG"));
    wprint(Graphics.window, Graphics.unicode.press_space,
Graphics.font.medium, ...
    'center', 1.4*yCenter, Graphics.colorBlack);
    Screen('Flip', Graphics.window);
    pollev({'space'}, true);
    Screen('Flip', Graphics.window);
elseif strcmp(nextPhase, "other")
    iprint(Graphics.window, fullfile("Images", "Part2_Disc.JPG"));
    wprint(Graphics.window, Graphics.unicode.press_space,
Graphics.font.medium, ...
    'center', 1.4*yCenter, Graphics.colorBlack);
    Screen('Flip', Graphics.window);
    pollev({'space'}, true);
    Screen('Flip', Graphics.window);
else
    error("nextPhase should be either 'self' or 'other'")
end
end
```

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```

function keyCode = pollev(keyset, is_introduutory, varargin)
%POLLEV polls on keyboard until one of a specific set of keys is
  pressed
%<keyset> is a vector of characters. Program halts at this command
  until
%   one of these keys is pressed. <is_introduutory> is a controlling
%   argument. If is_introduutory = false, function doesn't wait after
%breaking from while loop. This mode is designed for receiving
  keyboard
%commands during trials. is_introduutory = true on the other hand,
  is
%   used for introductory slides and waits for an additional 500 ms to
%   assure flushing of keyboard event buffer. The optional varargin
%<TimeoutDuration> may be passed to this function to set a timer at
  the
%   end of which the loop breaks anyway.

if mod(length(varargin), 2) == 1
    error("drawoption: Mismatched Input Arguments")
end
timeout_duration = 0;
for i = 1:2:length(varargin)
    if strcmp(varargin{i}, "TimeoutDuration")
        timeout_duration = varargin{i+1};
    end
end

if(~islogical(is_introduutory))
    error("pollev: is_introduutory is a logical variable")
end

if timeout_duration ~= 0
    timeout = tic;
end

is_pressed = false;
while ~is_pressed
    if timeout_duration ~= 0
        if (toc(timeout) >= timeout_duration)
            keyCode = 'none';
            break
        end
    end
end

[keyIsDown, ~, key] = KbCheck();
if (keyIsDown)
    keyCode = KbName(key);
    for i = 1:length(keyset)
        if strcmp(keyCode, keyset{i})
            is_pressed = true;
            break
        end
    end
end

```

```
        end
        if strcmp(keyCode, 'q')
            Screen('CloseAll')
            break
        end
    end
end

if(is_introductory)
    WaitSecs(0.5);
    KbEventFlush();
end
end
```

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```

function revealOtherChoice(win, answer)
%REVEALOTHERCHOICE Summary of this function goes here
% Detailed explanation goes here
global Graphics

penWidth = Graphics.optionPenWidth;
axisRect = 1.1 * Graphics.barPlotRect;

posCorrect      =
    Graphics.optionCoordinates.optionCentersSolo(answer, :);
posIncorrect    = Graphics.optionCoordinates.optionCentersSolo(-answer
    + 3, :);

expansionFactor = 1.1;
Screen('FrameRect', win, [128, 186, 157] / 255, ...
    floor([posCorrect(:) - expansionFactor * axisRect(:) / 2; ...
    posCorrect(:) + expansionFactor * axisRect(:) /
    2]), ...
    2 * penWidth);
Screen('FrameRect', win, [255, 156, 159] / 255, ...
    floor([posIncorrect(:) - expansionFactor * axisRect(:) /
    2; ...
    posIncorrect(:) + expansionFactor * axisRect(:) /
    2]), ...
    2 * penWidth);
end

```

t

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```

function displayChoice(win, choice)
%OPREVIEW Option Review (Selected Choice Review)
%After decision making's offset, the window is
  refreshed and subject's
%  decision is displayed on the monitor, along with
other options. global Graphics
penWidth =
Graphics.optionPenWidth;
axisRect = 1.25 *
Graphics.barPlotRect;
frameColor = [177, 156,
216] / 255;

if choice == 1 || choice == 2
    pos =
        Graphics.optionCoordinates.optionCentersSolo(choice, :);

        Screen('FrameRect', win, frameColor, ...
            floor([pos(:) - axisRect(:) / 2; pos(:) +
axisRect(:) / 2]), ...
            2 * penWidth);
end

end
end

```

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Appendix B:

Trials	Self	Other	Self	Other
1	520	870	140	870
2	450	900	210	840
3	490	970	170	780
4	420	960	240	780
5	450	1020	210	720
6	400	980	260	760
7	420	1040	240	700
8	380	990	280	750
9	390	1050	270	690
10	350	990	310	750
11	350	1060	310	680
12	330	1000	330	740
13	310	1060	350	680
14	310	990	350	750
15	270	1050	390	690
16	280	990	380	750
17	240	1040	420	700
18	260	980	400	760
19	210	1020	450	720
20	240	960	420	780
21	170	970	490	780
22	210	900	450	840
23	790	600	410	600
24	720	630	480	570
25	760	700	440	510
26	690	690	510	510
27	720	750	480	450
28	670	710	530	490
29	690	770	510	430
30	650	720	550	480
31	660	780	540	420
32	620	720	580	480

Trials	Self	Other	Self	Other
33	620	790	580	410
34	600	730	600	470
35	580	790	620	410
36	580	720	620	480
37	540	780	660	420
38	550	720	650	480
39	510	770	690	430
40	530	710	670	490
41	480	750	720	450
42	510	690	690	510
43	440	700	760	510
44	480	630	720	570
45	1060	330	680	330
46	990	360	750	300
47	1030	430	710	240
48	960	420	780	240
49	990	480	750	180
50	940	440	800	220
51	960	500	780	160
52	920	450	820	210
53	930	510	810	150
54	890	450	850	210
55	890	520	850	140
56	870	460	870	200
57	850	520	890	140
58	850	450	890	210
59	810	510	930	150
60	820	450	920	210
61	780	500	960	160
62	800	440	940	220
63	750	480	990	180
64	780	420	960	240
65	710	430	1030	240
66	750	360	990	300

Appendix C:

The Fehr-Schmidt model is an economic theory that explains why people care about fairness in social interactions. Unlike traditional models that assume people only want to maximize their own wealth, this model proposes that individuals also experience discomfort from inequality. Specifically, a person feels "envy" if someone else receives a larger payoff (disadvantageous inequality), and they feel "guilt" if they receive a larger payoff themselves (advantageous inequality). The model mathematically combines a person's own payoff with these two negative feelings (envy and guilt) to calculate their overall utility. This helps explain why people often make decisions that are not purely selfish, such as rejecting unfair offers in the Ultimatum Game or sharing resources more equally, because the psychological cost of unfairness can outweigh the benefit of a larger personal gain.

Fehr Schmidt model estimation

The likelihood function for a logistic regression model with observations indexed by i is:

$$L(\gamma_0, \gamma_1) = \prod_{i=1}^n P(y_i)^{y_i} \cdot (1 - P(y_i))^{1-y_i}$$

Where : $P(y_i = 1) = \frac{1}{1 + \exp(-(\gamma_0 + \gamma_1 \cdot \Delta U_i))}$, $y_i = 1$ if option A is chosen and ΔU_i ,

representing the utility difference on the probability of choosing Option A.

Taking the log of the likelihood function (the log-likelihood) simplifies it for estimation:

$$\log L(\gamma_0, \gamma_1) = \sum_{i=0}^n (y_i \cdot \log(P(y_i)) + (1 - y_i) \cdot \log(1 - P(y_i)))$$

Appendix D: Experimental instructions

The experimental instructions were in **Persian**, and their translation into **English** is as follows:

Welcome to Our Experiment!

Thank you for participating in our study. The purpose of this experiment is to better understand human preferences and decision-making processes. All data collected will remain **strictly confidential** and will be analyzed anonymously. Participation is **voluntary**, and there are no right or wrong answers — we are simply interested in your choices and judgments.

At the end of the session, a monetary payment will be calculated based on your decisions during the experiment and paid to you. Please note that this payment is **contingent upon completing all parts of the experiment**.

During the session:

- Please **turn off your mobile phone**.
- Remain **silent** unless asking the experimenter a question.
- If you have any questions, please ask them **only from the experimenter**.

After leaving the laboratory, you will receive a link to complete several **online follow-up questionnaires**. You will have **one week** to submit them. Your timely completion is appreciated.

Thank you for your cooperation.

Experiment Overview

This experiment consists of three parts:

1. **Choice**
2. **Prediction**
3. **Choice & Prediction**

You will receive instructions for each part before it begins.

Part 1: Choice

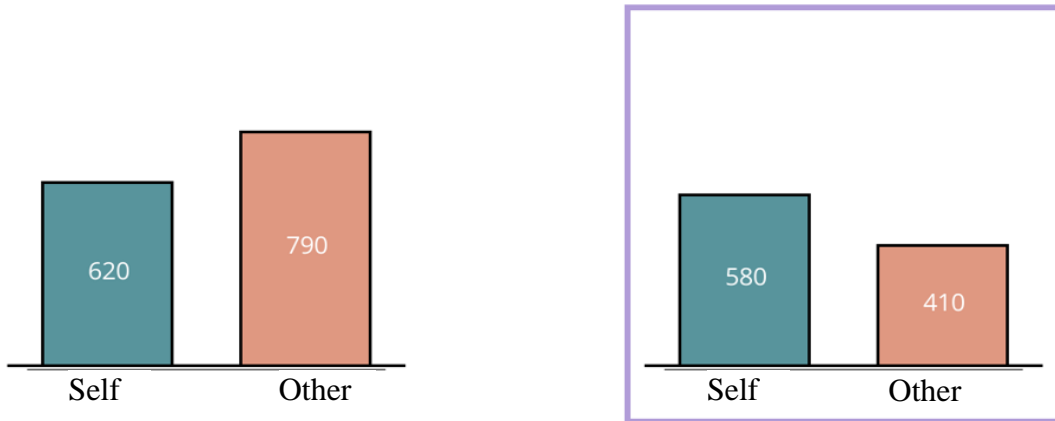
In each round, two options will be displayed on the screen. You must choose **one** of them.

Each option specifies two monetary amounts:

- “**Self**”: the amount you will receive.
- “**Other**”: the amount allocated to another anonymous participant (Person A), who previously took part in this study and was randomly assigned to you.

Example:

- Option 1: You receive 580 points; Person A receives 410 points.



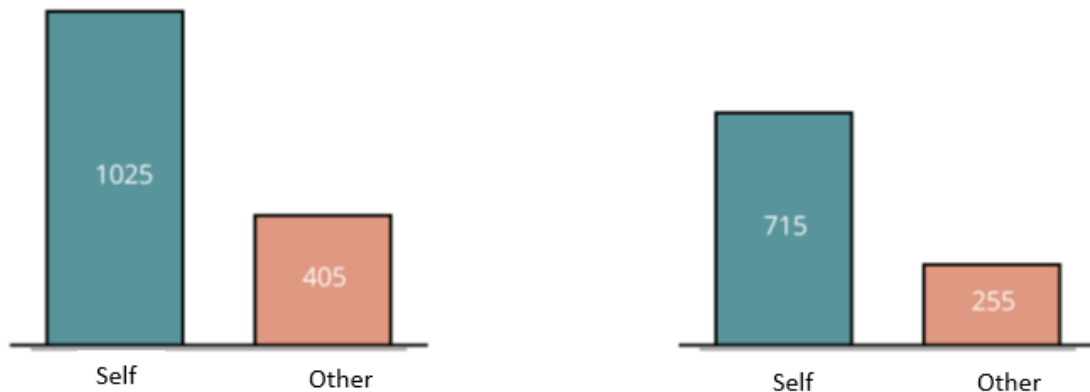
Important Notes:

- Use the **mouse** to click on your preferred option.
 - The identity of **Person A** **remains constant** throughout Part 1.
 - All values are expressed in **points**, which will later be converted into **Iranian Toman** at a fixed exchange rate.
 - At the end of the experiment, **two rounds** from this part will be randomly selected for payment. The corresponding amounts will be paid to **both you and Person A**.
 - You will **not be informed in advance** which rounds will be selected. Therefore, please treat **every round as potentially consequential** for your payment.
 - **Person A and Person B are distinct individuals.** Specifically, the person who receives the outcome of your choices (Person A) is different from the person whose choices determine the outcomes you receive (Person B).
 - There are **no correct or incorrect answers** — we are interested in your personal preferences.
-

Part 2: Prediction

In this part, you will predict the choices made by another anonymous participant, **Person C**, who previously completed the same experiment.

You will be shown the same pair of options that Person C faced, and you must predict which one they chose. After making your prediction, you will also indicate your **level of confidence** on a scale.

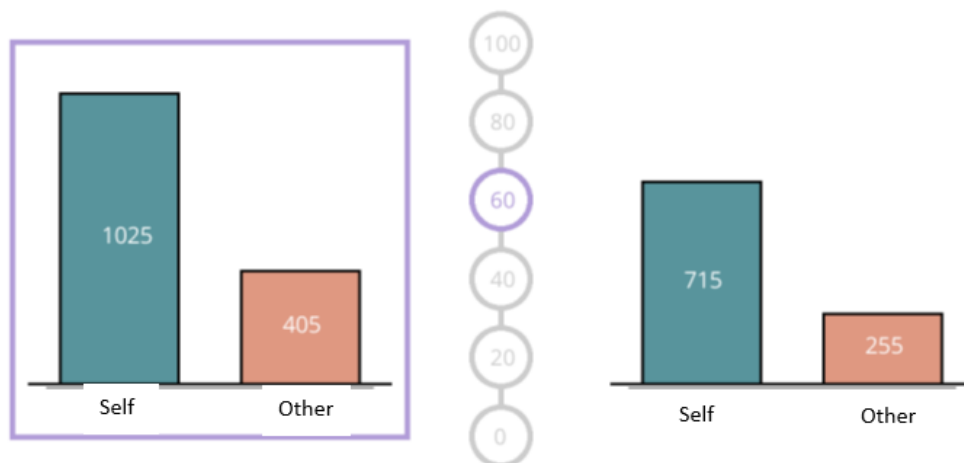


If you select the left option as your prediction, this means that Person C:

Allocated 1025 points to self.

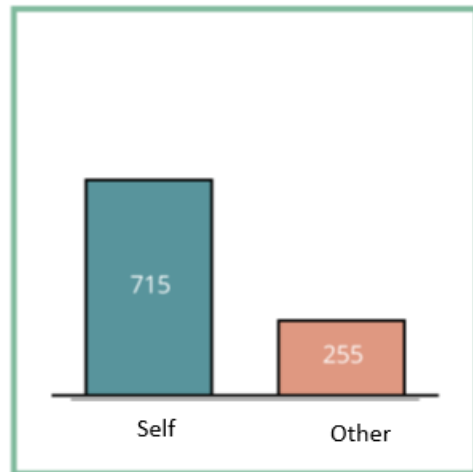
And 405 points to an anonymous other participant ("Other").

The payment assigned by Person C to another participant does not affect or determine your own earnings in any way.



After submitting your response, you will immediately receive feedback:

- **Green** indicates a correct prediction.
- **Red** indicates an incorrect prediction.



Important Notes:

- Use the **mouse** to select both your prediction and your confidence level.
- You will only see the options Person C faced — **no personal information** about Person C will be provided.
- **Person C is different from Person A.**
- Again, there are **no right or wrong opinions** — we are interested in your judgment and confidence.

Part 3: Choice & Prediction

This final part combines the tasks from Parts 1 and 2.

You will alternate between:

- Making **your own choices** (as in Part 1), and
- Predicting the choices of **another participant** (as in Part 2).

The procedures are identical to the previous parts — only the sequence is combined.

Please pay close attention to the on-screen instructions, as the task type will change from trial to trial.