Revealing perceptions of post-conflict actors in Colombia using entropic finger tracking and economic experiments

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Abstract

Regular citizens, not directly involved in violent conflict, show different economic attitudes toward post-conflict actors. However, it is unknown if social perceptions exhibit diverse bias intensities. In this article, I examine the conviction of attitudes towards post-conflict actors in Colombia using finger-tracking and economic games. Conviction, referring to the level of certainty or firmness in the decisions made by a sample of students who take the roles of an ex-combatant or a victim. I find that people's level of conviction differs depending on the role they assume, even when they perceive the other person as selfish or altruistic. Furthermore, I observe that conviction in risky decisions is higher in loss scenarios compared to win scenarios, aligning with findings in psychology. These results highlight the impact of role assumptions and the enforcement of hidden biases on choice processes.

JEL classification: A13, C72, C90, D91

Keywords: conviction, experiment, label, perception, post-conflict

1 Introduction

The aftermath of conflict leaves behind deep social wounds that often take a long time to heal. In Colombia, the government has been working towards the reintegration of former combatants into society (Kaplan and Nussio, 2018). However, public perceptions towards ex-combatants and their reintegration remain mixed. To truly understand these perceptions, it is essential to explore the decision-making processes that underlie attitudes towards post-conflict actors in Colombia. By delving into the factors that shape individuals' choices and attitudes, this study provides valuable insights into the dynamics of public perception. Understanding the decision-making processes surrounding post-conflict actors is crucial for informing effective policies, interventions, and strategies aimed at promoting social cohesion, reconciliation, and successful reintegration efforts in post-conflict societies like Colombia.

How certain is a person when being prosocial or selfish toward post-conflict actors? How strong are our social biases? To address these issues, the study estimate the conviction behind decisions made in economic games, such as the dictator, lotteries, and inter-temporal discount, using field laboratory data and surveys. The research employ finger tracking technology to approximate the conviction on motor actions that represent a decision. Motor actions can serve as proxies for conviction because they reflect subconscious beliefs and attitudes, revealing the intensity of confidence or hesitation behind decisions, providing insights into individuals' preferences towards post-conflict actors in Colombia.

Reintegration and understanding how people perceive ex-combatants in society are fundamental for achieving stable and lasting peace. The first few years after a peace agreement are the most fragile for a country and carry the risk of a return to the previous period of violence (Manning, 2002; Rocha Menocal, 2011). If peace is not perceived as a certain future reality and does not provide new opportunities for people to reintegrate, it will generate anxiety and distrust in government promises. Additionally, if third parties in society who were not directly affected by the violence perceive post-conflict actors as unreliable and unable to reintegrate or work alongside them, it will lead to their exclusion and isolation, resulting in an unstable and short-lived peace.

(Alonso-Díaz et.al, 2022) uncovered misconceptions about the economic behavior of post-conflict actors among university students in their study. The students perceived victims as less altruistic than actual victims who, in reality, were risk-averse and patient. Similarly, the students believed that former combatants were risk-seeking, impatient, and more altruistic towards victims, which contradicts the actual behavioral patterns of former combatants. However, it is possible that people do not make altruistic decisions with full conviction, and the measured discrete decisions may not fully capture people's preferences. We will take these findings into account when interpreting the results of the current research.

The use of finger tracking technology to estimate conviction [1] is a relatively new and innovative approach that has the potential to provide new insights into the decision-making

[1] To avoid confusion among readers, the term "confidence" is used in the english context to refer to the level of certainty or firmness in decisions made by participants (Pouget et al., 2016; Kimball, 2015; Calcagnì et al., 2017) derived from cognitive science. However, it is important to note that in the spanish language, the term "confianza" can have dual meanings of both trust and confidence.For that reason, the term "conviction" will be used instead now on.

processes in the context of post-conflict reintegration. This approach is based on the premise that motor actions have a high correlation with the decision-making process in the human brain (Koop and Johnson, 2013) Thus, vector trajectories for finger tracking can be used to acquire knowledge that reveals the dynamics based on choices and decision criteria.

Previous research has provided insights into the distinction between confidence and certainty as separate probabilistic quantities with distinct roles in the decision-making process (Pouget et al., 2016). Furthermore, studies have shown that choice research tasks can uncover hidden cognitive states, enabling the identification of underlying cognitive processes that contribute to decision-making outcomes (Song and Nakayama, 2009). By understanding these nuances and exploring the hidden cognitive processes, we can gain a deeper understanding of the factors influencing decision-making and the mechanisms behind the observed choices.

This investigation contributes by employing new technologies, such as finger-tracking technology, to measure conviction in economic games. In these economic games, participants serve as decision-makers, making choices regarding attitudes towards post-conflict actors in Colombia. By incorporating these advanced measurement techniques, the study capture participants' level of conviction in their decisions. The analysis of these decisions provides valuable insights into the decision-making processes underlying perceptions and preferences towards post-conflict actors.

By shedding light on the decision-making processes that underlie public perceptions towards ex-combatants, this study has the potential to inform policy and interventions that aim to promote social inclusion and reconciliation in Colombia. Moreover, the study aims to reveal the real preferences that are hidden in the motor actions, providing insights into how individuals weigh different options and make decisions in pro-social contexts.

In what follows, this article will explore the literature on measuring conviction and perceptions towards post-conflict actors in Section 2. Section 3 will present the experimental design, treatments, and economic games. In Section 4, an explanation of how conviction on perceptions towards ex-combatants will be measured and the identification strategy. In Section 5 the data will be described followed by Section 6 where the results are presented, and Section 6 will provide the conclusion.

2 Perceptions and conviction toward post-conflict actors.

i Perceptions toward post-conflict actors

The study of social perceptions and reintegration of ex-combatants have been crucial to understand the key elements necessary to rebuild trust in society. From one side, (Nilsson and González Marín, 2020) examines the perceptions of local communities towards ex-combatants in Colombia's post-conflict context. Affected communities express fear regarding the promise of peace after the conflict and the potential return to war with FARC dissidents. Some community members cannot differentiate between state forces and illegal armed actors, primarily due to the persistence of various ongoing threats. The communities' relationship with the FARC ex-combatants is ambivalent; negative perceptions have been increasing because some of these groups continue to extort or dispossess people of their territory. The study highlights that the success of reintegration efforts depends on addressing the structural inequalities and exclusion that fuel conflict and hinder reconciliation. In a similar vein, (Carey et al., 2022) talk about the importance of reconciling different interpretations of peace to build sustainable peace in divided societies such as Sri Lanka. The authors argue that grassroots actors, including ex-combatants, share a common vision of a fair and inclusive society, and their participation is crucial for achieving this goal.

On the other hand, (González-Mendoza et al., 2019) shifts the focus to the role of the private sector in promoting sustainable peace and social cohesion in post-conflict Colombia. The study shows that while some businesses perceive ex-combatants as potential employees and contributors to economic growth, others view them as a security threat or a source of reputational risk. The authors argue that a socially responsible approach that goes beyond profit-maximization is needed to unlock the potential of ex-combatants as agents of change. Building upon this strand of literature, our paper contributes by including the perspective of a third party as students, which have a reintegrating crucial impact in the society. Our study provides a deeper understanding of the underlying factors influencing perceptions towards ex-combatants within a private university. We aim to shed light on the role of conviction and decision-making in shaping the private university students perceptions of ex-combatants, thereby advancing the discourse on sustainable peace and social cohesion in post-conflict contexts.

From a different perspective, it is interesting how media has changed the vision in modern world and how it affects the people's perception. (Barbero, 2003) explores the role of media in shaping the perceptions of TV viewers in post-conflict Colombia. Violence is depicted on television in various forms, including drama series, news, and propaganda, and is often held responsible for the increase in aggression and social acceptance. This has a significant impact on how third parties perceive massacres or violent events, primarily because the media appears to diminish their capacity to empathize. The habitual portrayal of violence in the media leads to the normalization of such perceptions due to its inherent nature. The author argues that the media plays a critical role in constructing social imaginaries and shaping public opinion. The article calls for a more nuanced and inclusive media representation that recognizes the agency and diversity of ex-combatants.

Finally, (Kaplan and Nussio, 2018) provides a comprehensive overview of the challenges and opportunities of ex-combatant reintegration in Colombia. The authors emphasize the importance of community-centered approaches that address the needs and aspirations of both ex-combatants and host communities. The study shows that community-based initiatives and participatory approaches can foster trust and social cohesion, but social stigma and exclusion remain significant obstacles.

Overall, these articles highlight the complexity of perceptions in post-conflict societies and the need for a holistic and inclusive approach that recognizes the agency and diversity of ex-combatants, fosters community participation, and addresses structural inequalities and exclusion. They also highlight the role of different actors, including the media, the private sector, and grassroots organizations, in shaping perceptions and promoting sustainable peace. These articles contribute to a growing body of post-conflict perceptions literature that recognizes the centrality of social reintegration for achieving sustainable peace and highlights the importance of community participation and inclusive approaches.Our research complements existing literature by exploring the measurement of conviction and perceptions toward post-conflict actors. It offers novel insights into decision-making processes and their implications, based on a student university sample engaging with ex-combatants. By incorporating these perspectives, our study contributes to broader discussions on sustainable peace building and the multifaceted role of different stakeholders in fostering social inclusion and reconciliation in post-conflict societies.

ii Conviction measurement

Numerous research studies have investigated how the conviction level of an agent's decisions is influenced by the task and information presented to them during lab experiments. (Koop and Johnson, 2013) examined the response dynamics of preferential choice and developed a model that predicts an individual's level of conviction based on response time, accuracy and reaching trajectories from a mouse. According to the article, an individual's level of conviction can be inferred from their response dynamics. In the context of this analysis finger trajectories can be also used to extract confidence decision levels.

New data sources as mouse trajectories have been used to identify motor patterns of human behavior and understand choice processes. Various statistical and pattern recognition algorithms have been developed to comprehend it better. In addition, different metrics are commonly used to extract information from this source of information, such as Euclidean distance, distance of the traveled trajectory, speed, acceleration, curvature degree, symmetry, deviation distance, stability, among other. Geometric metrics such as Area Under the Curve (AUC) are also used to determine the point of maximum deviation from the target or end point of the experiments (Khan and Hou, 2022).

The importance of measuring conviction level in decision-making is a recurring theme across several articles. (Oppenheimer and Kelso, 2015) emphasizes the significance of the conviction level in assessing the quality of decision-making using information processing as a paradigm, while (Khan and Hou, 2022) explore the potential use of mouse movements as a biometric measure of cognitive processes, including confidence level, to improve decision-making measurement. Measuring conviction levels in decision-making goes beyond a simple revealed preference approach. It provides a more comprehensive understanding of decision quality, allows for deeper analysis of decision-making processes, enhances predictive accuracy, and offers valuable insights into the impact of interventions. By capturing individuals' commitment, confidence, and underlying cognitive processes, measuring conviction levels provides a richer and more nuanced assessment of decision-making phenomena.

Additionally, (Kimball, 2015) advocates for the integration of cognitive factors, such as conviction level, to enhance economic decision-making outcomes. Their work highlights the importance of considering subjective measures of conviction in understanding decision-making processes. Moreover, (Maniscalco and Lau, 2012) propose a signal detection theoretic approach to estimate metacognitive sensitivity based on conviction ratings. This approach offers a implicit measure of conviction level by capturing the ability to discriminate between correct and incorrect decisions.

Furthermore, (Pouget et al., 2016) distinguish between confidence and certainty as distinct probabilistic quantities with different decision-making goals. Their research emphasizes the importance of differentiating between these two constructs to better understand decision-making processes. It is important to clarify that the mentioned study distinguishes certainty as the probability of relevant variables not conditioned on the choice made, on the other hand, confidence refers to the likelihood of a choice being correct. This differentiation is crucial in understanding the nuanced aspects of conviction and its relationship to decision-making.

By incorporating insights from these studies, our research further explores the measurement of conviction in economic decision-making and build upon existing literature by employing innovative techniques and methodologies to provide a comprehensive understanding of conviction and its implications for decision-making outcomes in the post-conflict, a new interesting area for the use of this methodological tools.

The current study is conducted within the (Calcagnì et al., 2017) framework, which provides a new methodology for analyzing trajectories from an entropic approach called Entropic Mouse Tracker (EMOT). Entrophy in this context is defined from information theory which calculates the uncertainty related to a source of information(Ash, 2012). This new technical approach involves analyzing and decomposing the uncertainties of fast movements and motor pauses on the screen to measure the conviction with which people make decisions.

In summary, these articles highlight the importance of measuring conviction levels in decision-making processes. Authors building on the work of their predecessors has made possible to improve the accuracy on conviction measurements with greater interpretability. This article in particular pretend to integrate these new technologies and estimate conviction in the perceptions toward post-conflict actor's decisions.

3 Experimental design

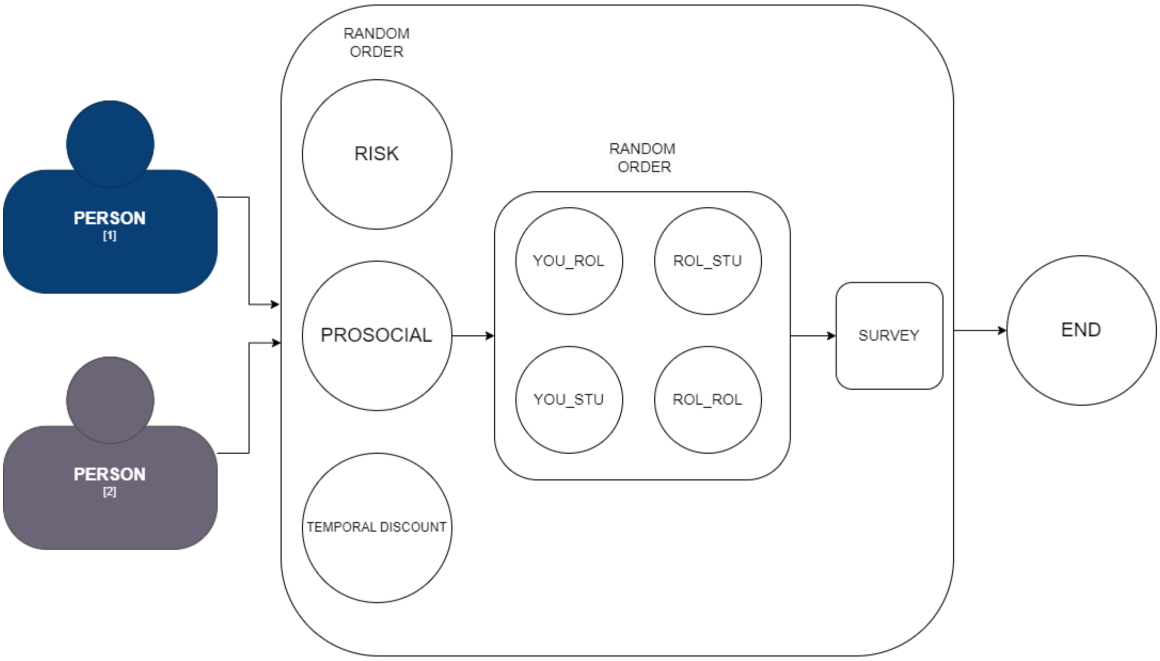
To estimate convictions regarding perceptions towards post-conflict actors, risk and discount decisions, three tasks were designed for a lab-in-the-field experiment. The first task was a modified dictator game, the second was a discount task, and the last was a lottery. Data was collected using touch-screen tablets, specifically Samsung Galaxy Tab A 10.1 inches from 2016. 270 university students were recruited in Bogota to form 135 pairs. Our objective was to ensure a minimum of 30 pairs in the prosocial task, with several pairs surpassing this threshold. (refer to Table 6 in the Appendix).

The experimental design (described in Figure 3.1) involved randomly selecting a pair of students on campus to participate in exchange for a monetary reward. Paired individuals were located in different places on the university campus and were kept from seeing each other. Prior to the actual experiments, participants underwent a training phase to familiarize themselves with how to choose and interact with the tablet.

Participants were presented with two options in Colombian pesos and were required to make discrete choices using their index finger. The process began by placing their finger in a square region located in the middle of the screen. Once they had placed their finger in the starting region, a pair of options appeared. Participants were then free to move their finger to the left or right target at the top of the screen, representing a distribution of resources with risk or intertemporal changes depending on the task. Depending on their assigned role, participants' movement speed or motor pauses varied, which would indicate if they had changed their internal decision-making processes.

To ensure non experiment order bias, each participant completed the three experiments: the modified dictator, risk, and discount games, in a random order. For example, one participant might complete the experiments in the order of dictator, risk, and discount, while another might complete them in the order of risk, dictator, and discount. In the prosocial task, each pair of individuals played as themselves and were assigned one of three labels or roles: victim (VIC), ex-guerrilla (EXG), or ex-paramilitary (EXP), which were assigned by the experimenter. Participants were not given the option to decide which label to play.

Figure 3.1: Experimental Design



Experimental design: The participants took part in three economic games, including the dictator game which they played four times, accounting for all possible combinations of pairings between "you" and "other". The "other" role could be labeled as Ex-Guerrilla, Ex-Paramilitary, or Victim (ROL). To avoid any sequence effects, the order of the tasks was randomized. After completing the experiment, participants were asked to complete a survey and received payment.

Following with the experiment protocol, participants were asked to answer demographic questions, which included information about their university degree, city of residence, parent's residence, semester, age, and gender. In addition to this, participants were asked questions about their personal exposure to violence, knowledge of the history of the Colombian conflict and the peace deal, and ethical, diversity, and inclusion perspectives (refer to Figure 8.4 in the Appendix). The survey aimed to control for as many individual characteristics as possible. It is important to note that all experiments were approved by the Ethics Committee at Pontificia Universidad Javeriana.

i Economic games

i.1 Game 1: modified dictator game.

In each trial of the prosocial task, participants were presented with two hypothetical partitions of money displayed on the left and right sides of the tablet, respectively (refer to Figure 8.3 in the Appendix). The left partition was always prosocial, offering an equal or higher amount to the other person (e.g., self = \$X, other = \$1.1X where X represents the Colombian minimum wage), while the right partition was always selfish, offering a higher amount to the self (e.g., self = \$1.3X, other = \$0.8*X). These partitions were hypothetical due to budget constraints but designed to maintain the role-playing aspect of the experiment. Participants knew that their choices would have consequences on their final reward.

Participants completed four blocks of six trials each, with each block representing a different role combination: 1) You - Other Student, 2) You - Other Student's Role, 3) Your Role - Other Student, and 4) Your Role - Other Student's Role. The order of these blocks was randomized across participants. Before each trial, the screen clearly displayed the roles of the participants for that block, which could be victim (VIC), ex-guerrilla (EXG), or ex-paramilitary (EXP). Participants could not choose their label, as it was assigned by the experimenter, and reflected the main actors of the post-conflict in Colombia.

i.2 Game 2: intertemporal discount task

During the intertemporal task, participants were presented with nine hypothetical decisions between receiving a smaller amount of money tomorrow or a larger amount in six months. The amount of money to be received tomorrow was fixed at \$400,000 COP (\$121 USD), while the delayed options increased in value from \$404,000 COP to \$800,000 COP. The number of times participants chose the immediate reward was used as a measure of their level of patience. (see Figure 8.2 in the Appendix)

Unlike the economic games, this task did not involve any pairing. At the end of the task, participants were asked to directly compare their own level of patience to that of their assigned role (Ex-Guerrilla, Ex-Paramilitary, or Victim) by indicating whether they believed their assigned role would be less patient, equally patient, or more patient than themselves. Participants' movement speed or motor pauses variation would also indicate if they had changed their internal decision-making processes.

i.3 Game 3: risk aversion task

In the Risk Aversion task, participants were repeatedly presented with two options in both win and loss frames. The safe option on the left side of the tablet provided a certain amount of money with a 100% probability, while the risky option on the right side of the tablet offered a higher amount of money ($950,000 COP or $280 USD) with only a 30% chance of winning, and nothing with a 70% chance of losing. The safe option gradually increased from amounts below the expected value of the risky option to amounts above it, with the safe amounts being: $750,000 COP($220 USD); $600,000 COP($176 USD); $400,000 COP($117 USD); $300,000 COP($88 USD); $200,000 COP($58 USD), and $150,000 COP($46 USD). The number of times participants chose the risky option was used as a proxy for their level of risk aversion and trajectory dynamics will be also interpreted as the conviction of agents' decision. (see Figure 8.1 in the Appendix).

The loss frame was identical to the win frame in terms of amounts, but the options were colored red to signify losses (while they were gray in the win frame). The decisions were hypothetical but contributed to the participant's payment. At the end of the task, participants were asked to indicate whether they believed their assigned role (Ex-Guerrilla, Ex-Paramilitary, or Victim) would be less, equally, or more risk averse than themselves. Importantly, the task did not involve any pairing.

i.4 Payment

Participants received vouchers worth between 2 and 4 payments of $5,000 COP ($1.5 USD) each, only valid on the university campus. The number of vouchers depended on their performance in the prosocial and risk tasks (discount task not included in payment and participants were notified before starting). Participants were compared to a hypothetical selfish agent, and if they earned 1.3 times the amount or more, they received four vouchers; if they earned between 0.7 and 1.3 times the amount, they received three vouchers; and if they earned less than 0.7 times the amount, they received two vouchers.

Participants were not explicitly informed of this payment scheme to avoid influencing their behavior in the experiments. However, they were aware that their performance on the tasks and the decision of their counterpart in the dictator game would determine the number of vouchers they received, which is a limitation of the study.

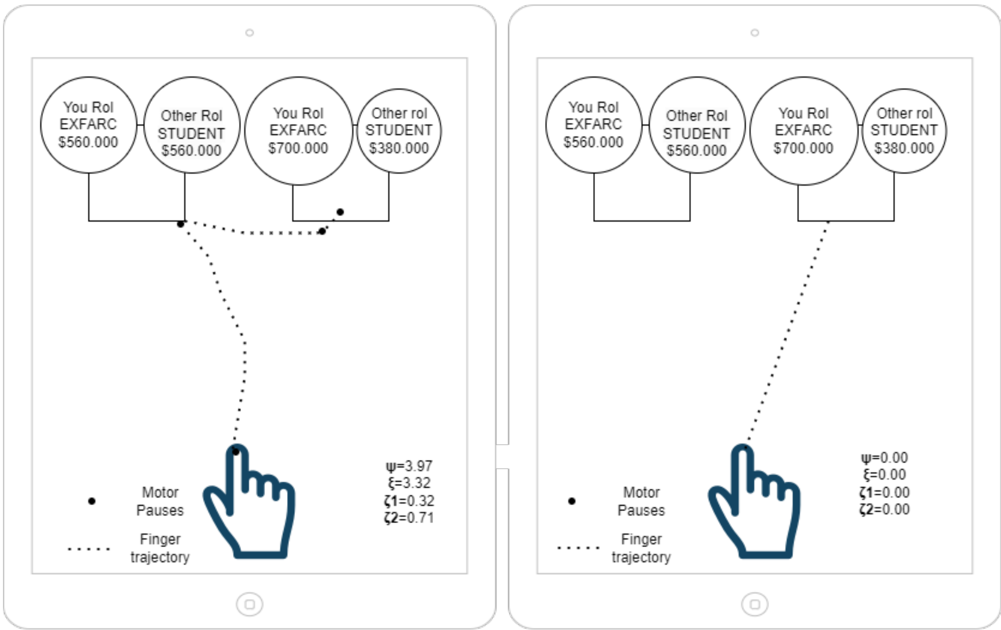
4 Entropic Finger Tracker and Model Specification

i Entropic Finger Tracker (EFIT)

The objective of this study is to implement and modify the Entropic Mouse Tracker (EMOT) methodology presented in (Calcagnì et al., 2017), which quantifies decision-making processes by calculating entropy from spatial components of movement trajectories and motor pauses. However, unlike the original method, this study utilizes participants' fingerprint trajectories on tactile tablets, resulting in a modified methodology referred as Entropic Finger Tracker (EFIT). The EFIT process retains all fundamental components of Calcagnì approach. For more details about EMOT technique the entire procedure is described in Section i in Appendix.

The cumulative residual entropy obtained through the previous methodology, denoted as ψ, serves as a measure of the overall spatial motion information within the movement data. It reflects the dynamics of x-y trajectories in the movement space, encompassing factors such as freedom of movement and spatial exploration while also indicating the level of conviction resulting from movement dynamics. Referring to Figure 4.1, even when the intended destination is the prosocial response, if the movement exhibits attraction toward the selfish decision, ψ attains its maximum value, indicating the lowest conviction decision. Conversely, when the movement is exclusively directed toward a prosocial decision without any attraction to the selfish choice, ψ reaches its minimum value (0), representing the highest conviction response.

Figure 4.1: Trajectory Decomposition



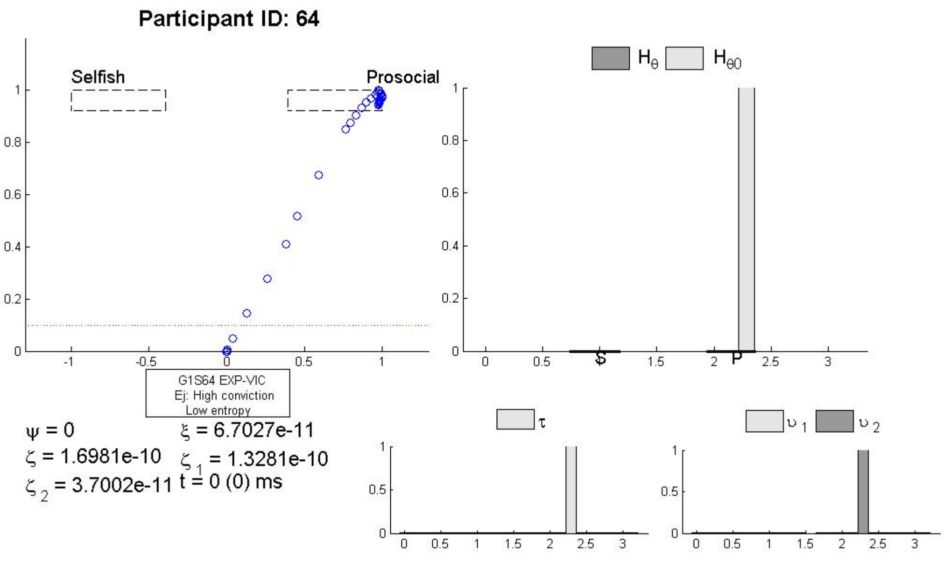
Note: Two examples illustrate participants' decision-making based on stimuli displayed on the screen. The image on the right depicts a direct trajectory from the starting point to the final response, resulting in a fast movement entropy (ξ) of zero. Additionally, there are no motor pauses on either side of the screen, reflected in the values of ζ_1 and ζ_2, which are both zero.Conversely, the left image demonstrates a scenario where the movement is attracted to the left choice. Before reaching the final response, various motor pauses occur on both sides of the screen. This pattern results in a fast movement entropy (ξ) of 3.32. Notably, two motor pauses occurred on the right side of the screen and just one in the left side, leading to ζ_1 being 0.32, which is lower than ζ_2 at 0.71.

Calcagnì's analysis allows for the additive decomposition of ψ, expressed as $\psi = \xi + \zeta_1 + \zeta_2$. This decomposition provides insights into the motor information present in recorded finger trajectories during the task. It separates the unknown residual cumulative entropies associated with fast movements (ξ), which is relates to motor-execution behaviors, often occurring after a decision has been in the mind. And motor pauses ζ_1 and ζ_2 that represent pause movement events in two sides of the screen, divided by an imaginary line in the middle of the screen linked, for instance, to the processes of goal formulation and/or reformulation, shedding light on the dynamics of the decision-making process. These measures are significant in finger-tracking as they can reveal essential aspects of cognitive processes, including decision conflicts and uncertainties.

Examining these factors in the context of economic relevance adds an intriguing dimension to the discussion. Different approaches to revealed preference literature often feature respondents who may initially present as prosocial. In controlled environments, their responses may seem consistent. However, individuals with low conviction in their answers might be more susceptible to change when are placed in different contexts. Social norm have different dynamics depending on the society, these can evolve over time due to changes in societal values, beliefs, and external factors, additionally individuals may conform to certain norms to gain social acceptance or avoid social disapproval. Hence, changes in convictions can serve as quantitative indicators into the strengthening or weakening of social implicit biases. This phenomenon can be better understood through the following experimental cases.

The EFIT process facilitates the differentiation between high and low conviction decisions. As shown in Figure 4.2, the finger movement trial from the modified dictator game experiment by the student with ID=64. In this scenario, the student acts as an ex-paramilitary individual against a victim. Notably, the participant proceeds directly to make a prosocial decision, and upon observing the ξ parameter, it has a low associated entropy (6.6027e-11). In other words, it reflects a high-conviction response based on the fast movement parameter, with very low coefficients reported for the ζ_1 and ζ_2 parameters (1.32e-10 and 3.70e-11). The last two coefficients indicate the absence of motor pauses on either the selfish or prosocial side of the screen.

Figure 4.2: Trajectory Decomposition: High conviction/Low Entropy

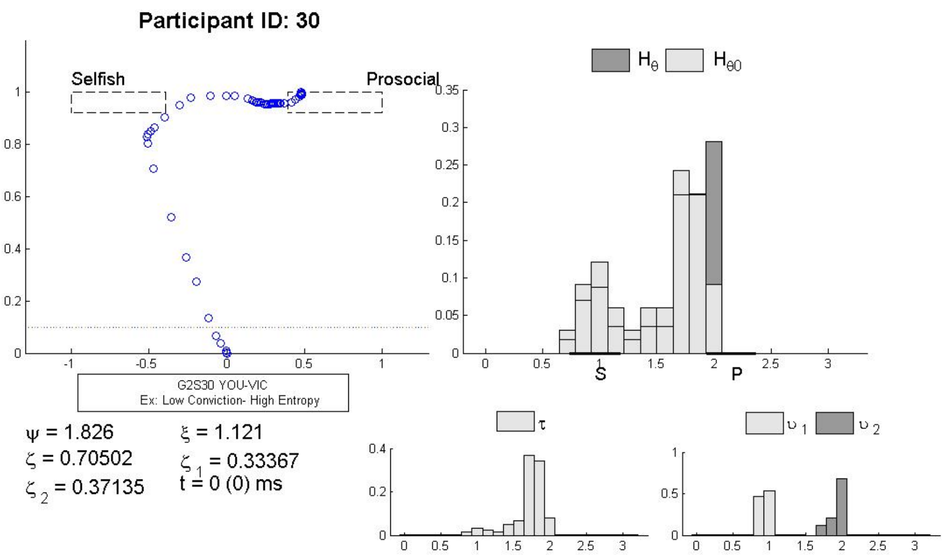


Note: This figure shows a high conviction movement example. In this case, a student acts as a ex-paramilitar against a victim, his final decision was prosocial and his movement represents a low associated entropy and also low amount of more pauses. Below the trajectory graph, the entropy variables for fast movements (ξ) and motor pauses (ζ_1,ζ_2) are proxies of the inverse of the conviction, in this case entropy metrics are almost zero.

On the contrary, Figure 4.3 presents a graph from the same modified dictator game. In this instance, Student with ID=30 acts as an individual against a victim, and even though the final decision is prosocial, the movement depicted by the segmented line exhibits an attraction to the selfish response. In this case, the fast movement parameter (ξ) has a high associated entropy or low conviction, taking a value of 1.121, in contrast to the previous example. Furthermore, the motor pauses on the selfish and prosocial sides (ζ_1 and ζ_2) are positive. Since the motor pauses before reaching the response occur more frequently on the prosocial side of the screen, the motor pause-related parameter ζ_2 is 0.7, which is greater than the ζ_1 selfish parameter, which is 0.3.

On the right side of both figures, you'll find three histograms presenting the estimates of τ for ξ concerning fast movements and (υ_1, υ_2) for (ζ_1, ζ_2) regarding motor pauses, which represent the frequency distribution of these three variables, this comes from the EMOT original analysis described in section i in appendix.

Figure 4.3: Trajectory Decomposition: Low conviction/High Entropy



Note: This figure shows a low conviction movement example. In this case, a student acts as himself in front of a victim, his final decision was prosocial but his movement represents a high associated entropy and also more pauses on the prosocial side than on the egotistical side. Below the trajectory graph, the entropy variables for fast movements (ξ) and motor pauses (ζ_1,ζ_2) are proxies of the inverse of the conviction. On the right side are the histograms that represent the above mentioned metrics τ for ξ on fast movements and (υ_1,υ_2) for (ζ_1,ζ_2) on motor pauses.

Entropy parameters (ξ, ζ_1 and ζ_1) belong to the positive irrational number range, with a minimum value of zero and maximum values of 3.32 (ξ) , 1.32 (ζ_1) and 1.28 (ζ_1) . Table 9 in Appendix presents eight distinct cases resulting from the multiple combinations of these three parameters. The characterization of each case depends on whether the parameter assumes a value of zero or falls within the range greater than zero but less or equal than its maximum value. This helps us in the results section when interpreting the results and changes in behavioral dynamics.

There are eight profiles, although three of these scenarios (2, 3, and 5) are not feasible due to the nature of the variables(described in section i in appendix). When the fast movement parameter ξ equals zero, ζ_1 and ζ_2 are also zero by design. The five remaining profiles provide insight into the individual's intentions, reflected in their conviction levels, based on the information used to estimate these conviction measures.

For example, Case 1 represents the highest conviction response, with all parameters equal to zero this person goes directly to his/her final answer without detouring or stopping along the way. In contrast, Case 7 reflects the lowest conviction decision, with all parameters reaching their maximum values. In other words, in Case 7, finger movements repetitively pause on both sides of the screen and are attracted by competitive selfish or prosocial responses before reaching its finial decision.

ii Identification Strategy

The identification strategy is based on a wave of experimental and survey data for all treatment groups. The analysis uses both a within subject (student assumes different roles) and a between subject (students are paired with other student) design.

The estimation involves a sequence of trials j depending on the number of trails by task (Prosocial=6, Risk=9, Discount=9) ($j = 1, 2, 3, ...n$), The subscript i represents the individual participant.The results obtained from the movement vector described in the previous section, fast movements τ and motor pauses ζ_1 and ζ_2, are used as dependent variables Y_{ij} of the specification as the following formula.

$$Y_{ij} = \beta_0 + \sum_{m=1}^{15} \beta^m T_{ij}^m + \lambda_i + X_{ij}\beta + \epsilon_{ij} \tag{1}$$

T_{ij}^m: Consists of m (16) possible pairs at trial j for subject i, corresponding to the combination of four groups of labels: students (STU), victims (VIC), ex-guerrillas (EXG), and ex-paramilitaries (EXP).

X_{ij}: Is a vector that include movement and reaction time controls.(See Table 8.4 in data section)

λ_i: Is a fixed effects estimator by participant i.

The coefficients β^m represents the effect of the treatment variable, which is the combination of the labels of the participants in the experiment against another student with a similar or different label. Specifically, it measures the impact of being paired with an ex-guerrilla, ex-paramilitary or victim, compared to being paired with another university student with similar characteristics (the base couple).

Main Hypothesis:

H1: Participants will exhibit different conviction on prosocial or selfish responses when assumes the role of a victim or an ex-combatant compared to when interacting with another university student with similar characteristics (H0: $\beta^V = 0$; Ha: $\beta^V \neq 0$ for victims and H0:$\beta^E = 0$; Ha: $\beta^E \neq 0$ for ex-combatants).

H2: Participants' conviction on prosocial/selfish responses will not change in the economic game when the pair has the same role (EXG-EXG, EXP-EXP or VIC-VIC)compared to the baseline (H0: $\beta^m \geq 0$; Ha: $\beta^m < 0$ for all pair labels).

The dependent variable in the analysis will be the movement vector, consisting of fast movements ξ and motor pauses ζ_1 and ζ_2, measured in each trial (j) of the economic games. The independent variables include the treatment variable (T_{ij}^m), which consists of 16 possible pairs corresponding to the combination of four groups of labels (students, victims, ex-guerrillas, and ex-paramilitaries), and a random effects estimator by participant (λ_i). The coefficient β^m represents the effect of the treatment variable on the dependent variable, measuring the impact of being paired with an ex-guerrilla, ex-paramilitary, or victim, compared to being paired with another university student with similar characteristics (the base couple). For the intertemporal and risk tasks, the treatment variable becomes simply T_i, which is specific to each individual participant since there is no partner to compare with.

In the case of the inter temporal and risk tasks, there is no pairing involved, so the treatment variable T_{ij} becomes $Sideresponse_i j$, this variable indicates the risky/not risky or patient/impatient decision the participant i takes in the trial j. The hypothesis that are tested in these games are following ones.

H3: Participants' conviction on risky responses will increase in the risk games compared to the baseline (H0: $\beta^m \geq 0$; Ha: $\beta^m < 0$ for all treatments).

H4: Participants' conviction on patient responses will increase in the inter temporal game compared to the baseline (H0: $\beta^m \geq 0$; Ha: $\beta^m < 0$ for all treatments).

5 Data

The economic games and survey were conducted in the field by the Behavioral Economics study group of Pontificia Universidad Javeriana between 2019 and 2020. The participants were anonymous students from the same university from different faculties. The data collection consisted of two rounds, resulting in a total of 266 participants (133 couples) and 24 trials, with 6 trials per 4 tasks labeled on the modified dictator game. This yielded a total of 6384 observations. Please refer to Table 1 for variables description.

The variables used as dependent variables in the model specification to track entropy based on finger trajectories correspond to ξ, with a mean of 0.19 and a range from 0 to 3.32. In the case of entropy motor pauses, ζ_1 (selfish side) and ζ_2 (prosocial side) have reported means of 0.02 and 0.04, respectively, with ranges between 0 and 1.32 and 1.28. Each observation or trial in the database is associated with parameters ξ, ζ_1 , and ζ_2. Side response variable indicates the final decision of the participant 1 being prosocial/not risky/patient and 2 selfish/risky/patient depending on the task.

Figures 8.5, 8.6 and 8.7 in appendix show the distribution of the dependent variables mentioned above. The three of them have similar distributions concentrated at the left side of the tail, less concentrated ξ than ζ parameters but similar asymmetry.

Table 1: Variable Descriptive

	count	mean	std	min	max
ξ	6151.00	0.19	0.25	0.00	3.32
$\zeta 1$	6151.00	0.02	0.07	0.00	1.32
$\zeta 2$	6151.00	0.04	0.10	0.00	1.28
Aemester	6168.00	5.21	2.76	1.00	14.00
Age	6192.00	20.31	2.53	16.00	38.00
Gender (Female= 1)	6192.00	0.55	0.50	0.00	1.00
From_Capital	5784.00	0.93	0.26	0.00	1.00
Father_Capital	5784.00	0.76	0.42	0.00	1.00
Harmed by the conflict	6192.00	21.98	27.00	1.00	100.00
Affected physically/psycologically by the conflict	6192.00	19.75	26.03	1.00	100.00
Affected directly/indirectly by the conflict	6192.00	33.97	32.52	1.00	100.00
Family affected by the conflict	6192.00	41.05	35.90	1.00	100.00
Conflict knowledge	6192.00	61.51	21.42	1.00	100.00
Conflict history knowledge	6192.00	63.65	22.52	1.00	100.00
Peace jurisdiction(JEP) knowledge	6192.00	64.01	28.90	1.00	100.00
Peace jurisdiction(JEP) changes knowledge	6192.00	56.54	29.84	1.00	100.00
Homosexual Marrige	6192.00	85.37	26.71	1.00	100.00
Adoption by homosexual couples	6192.00	79.90	31.02	1.00	100.00
Euthanasia legalization	6192.00	83.29	25.64	1.00	100.00
Abortion legalization	6192.00	74.33	33.02	1.00	100.00
Marijuana legalization	6192.00	71.79	33.82	1.00	100.00
Flexible gender roles	6192.00	77.68	32.35	1.00	100.00
RT	6384.00	3947.95	3896.33	0.00	75468.00
MT	6384.00	1220.48	3458.29	4.00	63276.00
Side response	6384.00	1.55	0.50	1.00	2.00

Note: This table shows the variable descriptive from prosocial task where are the variables extracted from the Entropic Finger Tracker, it also shows sociodemographic questions, level of exposure to violence, knowledge of the armed conflict, peace agreements, ethical issues, diversity and inclusion issues. From the 270 participants, 253 (93%) answer the survey and 266 (98%) answer the Prosocial(Modified DG). This amount times 24 trials per participant gives a total of 6384 trials.

Looking at Table 1, we observe that 55% of the sample are women, with an average age of 20 years. The majority of participants (93%) come from the central region of the country, and 73% of their parents also reside in the same region. It is noteworthy that the participants display a low psychological or physical impact from the conflict, possess a relatively high understanding of the Colombian conflict and peace agreement, and tend to support left-leaning policy implementations like the legalization of abortion and flexible gender roles.

To ensure proper randomization of participant role (labels), Table 5 in the Appendix presents the results of a Chi-squared test. The test indicates that none of the tracked socioeconomic variables differed significantly at any conventional level of significance. This provides assurance that any observed differences in entropy and conviction in decision movements are not attributed to preexisting disparities among the groups under study.

6 Measuring conviction on economic attitudes and perceptions toward ex-combatants

In the subsequent result subsections, the sample is limited to trials where participants made only prosocial or selfish final decisions. This restriction is done to ensure the interpretability of the results based on the participant's final decision.

To present the results in terms of conviction proxy, the dependent variables ξ, ζ_1, and ζ_2 are normalized and multiplied by -1. Before a higher value of ξ is indicative of greater associated uncertainty, now serves as a proxy for stronger conviction related to the fast-moving trajectory. Before a higher value of ζ_1 and ζ_2 represented an increase of motor pauses in the prosocial side or selfish side, now serves as a proxy for conviction by each side of the screen.

i Prosocial Responses

In Table 2, the model is observed with a sample restricted to just prosocial decisions. Out of 6,151 total observations, 2,766 prosocial decisions were made by 259 participants. This is an OLS model with fixed effects by participant and trial, controlling by the reaction time(RT) and movement time(MT).

Each column represents a different dependent variable: the first column presents the fast movement conviction proxy ξ, the second contains the ζ_1 conviction proxy for motor pauses on the prosocial side of the screen, and the last column shows the ζ_2 conviction proxy for motor pauses on the selfish side of the screen.

Let's focus on the first four rows of the table, where the student assumes the role of an ex-guerrilla. In line with our initial hypothesis with violent ex-combatants, none of the pairs exhibit differences in fast movement or motor pause conviction in their responses, except for the EXG-VIC pair.

In the scenario where a student acts as an ex-guerrilla in contrast to a victim, there is a notably higher occurrence of motor pauses on the selfish side of the screen. This suggests a decision with reduced conviction, with a decrease of 0.34 standard deviations, despite their ultimate decision being prosocial, in comparison to students interacting with another student with similar characteristics. This difference is statistically significant at any traditional level of significance, with all other factors held constant.

Now, let's turn our attention to the following four rows (4-8) of Table 2, focusing on scenarios where the student assumes the role of an ex-paramilitary. In this context, only one pair displayed notable differences in the proxy measure for fast movement conviction. Specifically, when a student acted as an ex-paramilitary against an ex-guerrilla, the conviction associated with fast movements decreased by 0.307 standard deviations in comparison to a scenario where a student interacted with another student. This result exhibits statistical significance at the 5 percent level, holding all other variables constant.

Table 2: Prosocial Model (MDG) with prosocial responses

VARIABLES	(1) Fast movements ξ	(2) prosocial side ζ_1	(3) selfish side ζ_2
EXG_EXG	-0.073	0.129	0.060
	(0.138)	(0.146)	(0.146)
EXG_EXP	-0.216	-0.124	0.059
	(0.156)	(0.165)	(0.164)
EXG_STU	-0.017	-0.104	-0.066
	(0.084)	(0.088)	(0.088)
EXG_VIC	-0.069	0.083	-0.348***
	(0.120)	(0.127)	(0.126)
EXP_EXG	-0.307**	0.180	0.011
	(0.140)	(0.148)	(0.148)
EXP_EXP	0.138	-0.116	0.098
	(0.145)	(0.153)	(0.152)
EXP_STU	-0.074	0.036	-0.032
	(0.080)	(0.085)	(0.084)
EXP_VIC	-0.015	0.150	0.098
	(0.118)	(0.124)	(0.124)
VIC_EXG	-0.047	-0.011	0.146
	(0.160)	(0.169)	(0.168)
VIC_EXP	0.321**	0.168	-0.029
	(0.163)	(0.172)	(0.172)
VIC_STU	0.260***	0.062	0.087
	(0.086)	(0.091)	(0.091)
VIC_VIC	0.161	0.328**	0.090
	(0.127)	(0.134)	(0.134)
YOU_EXG	0.091	0.108	0.080
	(0.079)	(0.084)	(0.084)
YOU_EXP	-0.025	0.018	-0.043
	(0.088)	(0.093)	(0.093)
YOU_VIC	0.023	0.154**	-0.013
	(0.072)	(0.076)	(0.076)
Constant	0.113***	0.032	0.098**
	(0.043)	(0.045)	(0.045)
Fixed effects by participant and trial	✓	✓	✓
RT and MT controls	✓	✓	✓
Observations	2,766	2,766	2,766
R-squared	0.080	0.018	0.065
Number of respondents	259	259	259

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the modified dictator game results applying fixed effects by participant and trial, also controlling by reaction time(RT) and movement time(MT).The sample in this table is restricted to the prosocial final decision trials for all the participants. The dependent variable in the first column is the normalized inverse of the ξ parameter that corresponds to fast movements conviction proxy, the second column dependent variable corresponds to the normalized inverse of the ζ_1 parameter or motor pauses in the selfish side of the screen and finally ζ_2 is the explained variable in column 3 that corresponds to the normalized inverse of motor pauses in the prosocial side for conviction proxy. The treatment variable represent the random assigned pair between three possible labels victim (VIC), ex-guerrilla (EXG), ex-paramilitary (EXP), and Student (YOU/STU). This gives 16 possible pairs where the excluded one is YOU-STU.
Source: Own calculations.

Based on the last finding, students who assumed the role of an ex-paramilitary and displayed prosocial behavior towards an ex-guerrilla member exhibited a less strongly convicted response. This observation aligns with the historical context of violence between these two groups.Unfortunately, a similar pattern was not observed for their counterparts in the EXP-EXG role pair, introducing uncertainty regarding the lower prosocial decisional conviction between these two roles.

Now lets focus from the row nine to the twelve. In this case the student assumes the role of a victim of the conflict. When considering prosocial decisions, students who portrayed themselves as victims against ex-paramilitary (VIC-EXP) or other students (VIC-STU) displayed an increase in conviction by 0.32 and 0.26 standard deviations in their final decisions compared to a student against another student. These differences are significant at the 5% and 1% levels of significance, respectively, holding everything else constant.

Another interesting result is that when a student portrayed themselves or acted as a victim against another victim with a prosocial final decision, they showed a relatively higher conviction with fewer motor pauses on the prosocial side of the screen. This indicates that compared to a student against another student, these pairs did not stop as much before reaching the prosocial decision, representing a more confident movement. In other words, the student had no difficulties in choice process and show a prosocial decision with more conviction.

ii Selfish Responses

In Table 3, the prosocial model is observed with a sample restricted to prosocial decision samples. Out of 6,151 observations, 3,385 were selfish decisions made by 264 participants. This is an OLS model with fixed effects by participant and trial, and all columns have reaction time and movement time controls.

Examining the first part of the table, students who assumed the roles of ex-guerrillas against another student (EXG-STU) in selfish scenarios showed an increase in motor pauses on the selfish side of the screen. This increase indicates a lower conviction, reduced by 0.17 standard deviations compared to a student versus another student. This outcome suggests that even when the role of an ex-guerrilla member is associated with a selfish decision against a student, the conviction of that decision remains relatively low. This reflects changes in the participants' perceptions of ex-guerrillas showing doubt in their decision.

However, in the case of a student assuming the role of an ex-guerrilla against a victim, there were relatively fewer motor pauses on the selfish side of the screen, increasing the conviction of the decision by 0.29 standard deviations compared to a student versus another student. All of these results are statistically significant at the 5% level of significance, with all other factors held constant.

Continuing with the next part of the table, where the role assumed is an ex-paramilitary, we observe the following: An ex-paramilitary against a student (EXP-STU) exhibits a decrease in motor pauses on the selfish side of the screen. This decrease indicates a relatively higher

Table 3: Prosocial Model (MDG) with selfish responses

VARIABLES	(1) Fast movements ξ	(2) prosocial side ζ_1	(3) selfish side ζ_2
EXG_EXG	-0.020	-0.077	-0.188
	(0.116)	(0.124)	(0.123)
EXG_EXP	-0.138	-0.091	0.022
	(0.109)	(0.117)	(0.115)
EXG_STU	0.095	0.099	-0.168**
	(0.075)	(0.080)	(0.079)
EXG_VIC	-0.143	0.080	0.289**
	(0.139)	(0.148)	(0.147)
EXP_EXG	0.074	0.086	-0.012
	(0.108)	(0.116)	(0.115)
EXP_EXP	-0.102	-0.078	0.037
	(0.111)	(0.118)	(0.117)
EXP_STU	0.022	0.018	0.161**
	(0.073)	(0.078)	(0.077)
EXP_VIC	-0.294**	-0.540***	0.085
	(0.141)	(0.151)	(0.150)
VIC_EXG	0.255**	-0.097	0.023
	(0.108)	(0.115)	(0.114)
VIC_EXP	-0.174*	-0.031	0.071
	(0.104)	(0.112)	(0.110)
VIC_STU	-0.030	-0.095	-0.008
	(0.068)	(0.073)	(0.072)
VIC_VIC	0.002	-0.080	-0.248**
	(0.117)	(0.125)	(0.123)
YOU_EXG	0.155**	-0.050	-0.015
	(0.073)	(0.078)	(0.077)
YOU_EXP	0.010	0.002	0.095
	(0.070)	(0.075)	(0.074)
YOU_VIC	-0.074	-0.116	0.078
	(0.092)	(0.098)	(0.097)
Constant	0.117***	0.110***	0.082**
	(0.036)	(0.039)	(0.039)
Fixed effects by participant and trial	✓	✓	✓
RT and MT controls	✓	✓	✓
Observations	3,385	3,385	3,385
R-squared	0.036	0.033	0.019
Number of respondents	264	264	264

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the modified dictator game results applying fixed effects by participant and trial, also controlling by reaction time(RT) and movement time(MT).The sample in this table is restricted to the prosocial final decision trials for all the participants. The dependent variable in the first column is the normalized inverse of the ξ parameter that corresponds to fast movements conviction proxy, the second column dependent variable corresponds to the normalized inverse of the ζ_1 parameter or motor pauses in the selfish side of the screen and finally ζ_2 is the explained variable in column 3 that corresponds to the normalized inverse of motor pauses in the prosocial side for conviction proxy. The treatment variable represent the random assigned pair between three possible labels victim (VIC), ex-guerrilla (EXG), ex-paramilitary (EXP), and Student (YOU/STU). This gives 16 possible pairs where the excluded one is YOU-STU.
Source: Own calculations.

conviction, increasing by 0.16 standard deviations compared to a student versus another student.

In contrast to what is observed when an ex-guerrilla faces a student, in this case, the reinforcement of the bias of a selfish ex-paramilitary, based on the right-wing tendencies of this group, may contribute to shaping a stronger perception of violence and a more selfish attitude.

Students who act as ex-paramilitary against victims (EXP-VIC) exhibited lower conviction in their fast movement decision by 0.29 standard deviation and reported more motor pauses on the prosocial side of the screen decreasing the conviction in 0.54 standard deviation. These differences are significant at the 5% and 1% levels of significance, respectively, holding everything else constant. This result shows the weakening of the selfish bias between ex-paramilitaries and victims.

Following with the row 9 to 12, where the role assumed is a victim, students who acted as themselves or as victims against ex-guerrilla(VIC-EXG) demonstrated a higher level of fast movement conviction by 0.25 in their selfish decision compared with a student against another student. This is is consistent with the previous finding when the ex-guerrilla is selfish against a victim (EXG-VIC). Both roles being selfish present decision with relative higher convictions that shows a reinforcement of the selfish bias between ex-guerrilla and victims. Students who act as victims against ex-paramilitary exhibited lower conviction in their prosocial decision. This difference is significant at 10% significance, holding everything else constant

Additionally, students who acted as themselves or as victims against ex-paramilitary (VIC-EXP) demonstrate a lower level of fast movement conviction by 0.17 standard deviations in their selfish decision compared with a student against another student. This is also consistent with the previous finding when the ex-paramilitary is selfish against a victim (EXP-VIC). Both roles being selfish present decision with relative lower convictions weakening the selfish bias between these two groups. Both results are significant at 5% significance, holding everything else constant.

In the final three rows, where the student acts as themselves against the other three roles, I observed that a student against an ex-guerrilla shows a higher fast movement conviction in selfish responses, with an increase of 0.15 standard deviations at a level of significance of 5%. This result is intriguing because, in the case of the pair EXG-STU, I found the opposite trend. Apparently, when a student assumes the role of an ex-guerrilla, the bias weakens, but when it's a student against an ex-guerrilla, the bias is reinforced.

As a robustness check, Tables 10 and 11 in the appendix were constructed using the same specifications as Tables 2 and 3. The key difference is that I included sociodemographic controls and political orientation variables, along with random effects due to perfect collinearity with the treatment variable. Most of the previously mentioned results remained robust; however, some lost significance. This could be attributed to two factors. First, there might have been a loss of statistical power due to a reduced sample size in these new tables, as not all participants answered every question in the survey, introducing potential noise in the estimates. Second, the introduction of variables such as age and gender, which were found to be statistically significant, might indicate pre-existing differences between the treated groups, placing them in a zone where they fail to reject the null hypothesis.

iii Conviction and economic attitudes: risk aversion and inter-temporal discount

During the risk aversion and inter-temporal task, the x and y coordinates were also tracked in the screen to see the conviction of finger movements by the EFIT process while subjects answered moving their finger index of the skillful hand between risky/non risky or patience/impatience responses.

The Table 4 shows the risk model trials in wins in the first column, the second column presents the risk model trials in looses and the third one the inter temporal model trials. The dependent variable in the three columns is the normalized inverse of the ζ_1 parameter which tracks motor pauses in the not risky or impatient side of the screen. The independent variable is one when the participant choose the risky or impatient option in the respective trial of the task.

Table 4: Risk and Inter-temporal games with motor pauses in not risky or impatience side

	(1)	(2)	(3)
Task	Risk Win	Risk Loose	Intertemporal Discount
VARIABLES	ζ_1	ζ_1	ζ_1
risky/patient decision =1	0.482***	0.838***	0.611***
	(0.080)	(0.070)	(0.049)
Constant	-0.080**	-0.651***	-0.260***
	(0.042)	(0.069)	(0.041)
Fixed effects by participant and trial	✓	✓	✓
RT and MT controls	✓	✓	✓
Observations	1,525	1,547	2,313
R-squared	0.028	0.105	0.081
Number of respondents	261	263	264

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the Risk Aversion(Column 1 Wins and Column 2 Looses) and Inter temporal games results applying fixed effects by participant and trial, also controlling by reaction time(RT) and movement time(MT). The dependent variable in the three columns is the normalized inverse of the ζ_1 parameter or motor pauses in the not risky or impatience side of the screen which gives a conviction proxy. The independent variable is one when the participant choose the risky or patient option in the respective trial of the task.

Source: Own calculations.

Observing the results in the first two columns reveals that people tend to increase their conviction in risky responses when there's a lower frequency of motor pauses on the non-risky side of the screen. This increase is 0.48 standard deviations larger in winning scenarios and even stronger in losing scenarios, with an increase of 0.83 standard deviations. These results are statistically significant at any traditional level, holding all other variables constant. Additionally, these findings align with the idea that people tend to be more risk-seeking in scenarios involving losses compared to gains.

Finally the third column shows an increase on subjects conviction responses with lower frequency of motor pauses on the impatient side of the screen. This effect increase in 0.61 standard deviations and is statistically significant at any traditional level, holding all other variables constant. In sum, looking at the table 8 in appendix the column 3 where the dependent variable changes now to the motor pauses in the patient side, the opposite significant effect occurs. More motor pauses occur in that respective side, which gives a less conviction response in 0.66 standard deviations.

Table 7 in the appendix presents the risk and inter temporal model with the dependent variable of conviction proxy, denoted as ξ. This model does not reveal any significant differences in the conviction of fast movement trajectories between risky and patient responses.

7 Conclusions and recommendations

The findings of this study shed light on the dynamics of decision-making processes and hidden biases in post-conflict contexts, specifically in perceptions towards post-conflict actors in Colombia. The main contribution of this research is the ability to decompose agent preferences, which allows for the identification of hidden information and biases within the choice-making process.

The study revealed that when students assumed the role of ex-guerrillas, interactions with victims led to lower conviction in their prosocial decisions, indicated by increased motor pauses on the selfish side of the screen. Conversely, when students took on the role of ex-paramilitaries, they showed increased conviction in selfish decisions when interacting with other students, which might be influenced by the right-wing tendencies associated with the ex-paramilitary role. However, when they interacted with victims, their fast movement conviction decreased significantly.

Students portraying themselves as victims or interacting with ex-guerrillas exhibited higher fast movement conviction in selfish decisions, reinforcing the selfish bias between these groups. In contrast, interactions with ex-paramilitaries resulted in lower prosocial conviction, weakening the selfish bias.An intriguing finding was observed when students acted against ex-guerrillas; they exhibited higher fast movement conviction in selfish responses. However, the opposite trend was noticed when students assumed the role of ex-guerrillas, where the bias weakened.

An important aspect that needs to be addressed is the absence of certain controls in the experiments. One significant factor is the handedness of the participants, as this could introduce bias, especially if individuals are right or left-handed. Unfortunately, this information was not collected in the survey.

Additionally, it's worth noting that in the dictator, risk, and intertemporal games, the prosocial, risky, and patient decisions are consistently presented on the same side of the screen. This lack of randomization could be argued to introduce a right bias tendency or potentially underestimate findings on the left side. However, the results obtained do not seem to be dependent on the side, as increases in conviction were observed on both the right and left sides of the screen.

Furthermore, tracking decisions at a deeper level can aid in identifying the underlying factors that drive individuals to exhibit different levels of conviction when assuming various roles in prosocial or selfish scenarios. This knowledge can inform policymakers, practitioners, and educators about the potential strengthening biases or real preferences that may shape individuals' perceptions, allowing for the development of targeted interventions and initiatives that address and challenge these biases.

In conclusion, incorporating this technique and conducting further research that delves into the decision-making process provide valuable insights and enhance our understanding of perceptions towards ex-combatants,victims and/or any other group of interest. This knowledge can pave the way for more effective approaches to post-conflict reconciliation, social reintegration, and the promotion of empathy and understanding among individuals in post-conflict societies.

8 Appendix

Table 5: Chi-square balance test

Variable	Chi-square	p-value
semester	29.593224	0.861716
age	44.338554	0.373325
gender	0.726642	0.993898
From_Capital	0.135584	0.999951
Father_Capital	0.643480	0.995631
Harmed by the conflict	124.951114	0.999997
Affected physically/psycologically by the conflict	115.564483	0.999797
Affected directly/indirectly by the conflict	150.695175	0.999995
Family affected by the conflict	156.595053	0.999712
Conflict knowledge	160.554314	0.999329
Conflict history knowledge	133.895533	0.999979
Peace jurisdiction(JEP) knowledge	164.503595	0.991132
Peace jurisdiction(JEP) changes knowledge	129.615495	1.000000
Homosexual Marrige	94.731542	0.999873
Adoption by homosexual couples	105.171928	0.998843
Euthanasia legalization	90.563411	0.999848
Abortion legalization	114.593834	0.999701
Marijuana legalization	104.471560	1.000000
Flexible gender roles	86.011873	0.999926

Note: This table contain the Chi-square test that shows the not difference between groups treated and the the labels randomly assigned in the prosocial task (Modified Dictator Game)

Table 6: Modified Dictator Game Post-Conflict Pairs

Pair (YOU-OTHER)	N
YOU-STUDENT	270
YOU-EXG	90
YOU-EXP	90
YOU-VIC	90
EXG-STUDENT	90
EXP-STUDENT	90
VIC-STUDENT	90
EXG-EXG	30
EXP-EXP	30
VIC-VIC	30
EXG-EXP	30
EXG-VICTIM	30
EXP-EXG	30
EXP-VIC	30
VIC-EXP	30
VIC-EXG	30

Note: In DG participants were assigned with one of the following labels EXG= Exguerrilla , EXP= Exparililitary and VIC= Victim.270 university students in Bogota were recruited to form 135 pairs to maintain at least 30 pairs between post conflict actor labels.

Table 7: Risk and Inter temporal Models with conviction fast movements parameter ξ.

	(1)	(2)	(3)
Task	Risk_Win	Risk_Loose	Intertemporal_Discount
VARIABLES	ξ	ξ	ξ
risky/patient decision =1	0.030	0.116	-0.007
	(0.075)	(0.071)	(0.048)
Constant	0.114***	0.020	0.125***
	(0.040)	(0.070)	(0.040)
Fixed effects by participant and trial	✓	✓	✓
RT and MT controls	✓	✓	✓
Observations	1,525	1,547	2,313
R-squared	0.026	0.026	0.034
Number of respondents	261	263	264

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the Risk Aversion(Column 1 Wins and Column 2 Looses) and Inter temporal games results applying fixed effects by participant and trial, also controlling by reaction time(RT) and movement time(MT). The dependent variable in the three columns is the normalized inverse of the ξ parameter or fast movements entropy which gives a conviction proxy. The independent variable is one when the participant choose the risky or patient option in the respective trial of the task).

Source: Own calculations.

Table 8: Risk and Inter-temporal games with motor pauses in risky/impatience side of the screen ζ_2

	(1)	(2)	(3)
Task	Risk_Win	Risk_Loose	Intertemporal_Discount
VARIABLES	ζ_2	ζ_2	ζ_2
risky/patient decision =1	-0.938***	-0.569***	-0.660***
	(0.072)	(0.071)	(0.047)
Constant	0.252***	0.463***	0.323***
	(0.038)	(0.070)	(0.039)
Fixed effects by participant and trial	✓	✓	✓
RT and MT controls	✓	✓	✓
Observations	1,525	1,547	2,313
R-squared	0.123	0.048	0.094
Number of respondents	261	263	264

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the Risk Aversion(Column 1 Wins and Column 2 Looses) and Inter temporal games results applying fixed effects by participant and trial, also controlling by reaction time(RT) and movement time(MT). The dependent variable in the three columns is the normalized inverse of the ζ_2 parameter or motor pauses in the risky or patience side of the screen which gives a conviction proxy. The independent variable is one when the participant choose the risky or patient option in the respective trial of the task).

Source: Own calculations.

Table 9: Conviction Profiles

Case	ξ (Fast Movement)	ζ_1 (Motor pauses selfish side)	ζ_2 (Motor pauses prosocial side)	Profile
1	$3.32 >= \xi > 0$	$\zeta_1 = 0$	$\zeta_2 = 0$	This represents a person who moves their finger with low conviction but never stops on any side of the screen until they reach a selfish or prosocial response. It can indicate a person who lacks conviction in either of the available answers but continues moving across the screen.
2	$\xi = 0$	$1.32 >= \zeta_1 > 0$	$\zeta_2 = 0$	This case is not possible if the person experiences motor pauses on any sides of the screen. In such a situation, the conviction related with fast movement will not be zero by definition. Therefore, any finger movement with any motor pause exhibits a strict positive fast movement entropy.
3	$\xi = 0$	$\zeta_1 = 0$	$1.28 >= \zeta_2 > 0$	This case is not possible if the person experiences motor pauses on any sides of the screen. In such a situation, the conviction related with fast movement will not be zero by definition. Therefore, any finger movement with any motor pause exhibits a strict positive fast movement entropy.
4	$3.32 >= \xi > 0$	$1.32 >= \zeta_1 > 0$	$\zeta_2 = 0$	This represents a person whose fast finger movement has low conviction and exhibits motor pauses on the prosocial side of the screen but never stops on the selfish side of the screen until reaching the target or response. It appears that the person is slowly approaching their to his/her final answer, and the level of conviction decreases due to the presence of motor pauses on the selfish side of the screen until they reach the prosocial or selfish answer.
5	$\xi = 0$	$1.32 >= \zeta_1 > 0$	$1.28 >= \zeta_2 > 0$	This case is not possible, if the person exhibits motor pauses in both sides of the screen, the conviction in fast movement will be low, indicating that the related entropy will be greater than zero. Therfore any finger movement has a strict positive fast movement entrophy if there is any pause on either side of the screen.
6	$3.32 >= \xi > 0$	$\zeta_1 = 0$	$1.28 >= \zeta_2 > 0$	This represents a person whose fast finger movement has low conviction and displays motor pauses on the selfish side of the screen but never stops on the prosocial side of the screen until reaching the target or response. Apparently, the person is slowly approaching their final answer, but the level of conviction decreases due to the presence of motor pauses on the prosocial side of the screen until they reach the prosocial or selfish answer.
7	$3.32 >= \xi > 0$	$1.32 >= \zeta_1 > 0$	$1.28 >= \zeta_2 > 0$	This represents a person whose fast finger movement has low conviction and exhibits motor pauses on both sides of the screen. In this case, it shows the lowest conviction response because the finger movement slowly approaches the final response and pauses on both the selfish and prosocial sides of the screen.
8	$\xi = 0$	$\zeta_1 = 0$	$\zeta_2 = 0$	This case represents a person with the highest conviction in their response. This type of profile proceeds directly to the final response (prosocial or selfish) without any motor pauses on the screen.

Note: This table displays various profile types resulting from the interaction of our three conviction measures. These variables include the ξ parameter, which represents the conviction proxy for fast movements and ranges from zero to the maximum value within the sample (3.32). The ζ_1 parameter accounts for motor pauses on the selfish side of the screen and ranges from zero to the maximum value within the sample (1.32), while ζ_2 corresponds to motor pauses on the prosocial side of the screen and falls within the range of imaginary numbers from zero to the maximum value within the sample (1.28).
There are eight possible profiles, although three of these scenarios (2, 3, and 5) are not present due to the nature of the variables. If the ξ parameter is zero, then ζ_1 and ζ_2 will also be zero by design.

Table 10: Prosocial Model (MDG) with prosocial responses and sociodemographic controls

VARIABLES	(1) Fast movements ξ	(2) prosocial side ζ_1	(3) selfish side ζ_2
EXG_EXG	-0.054	0.060	0.043
	(0.129)	(0.133)	(0.125)
EXG_EXP	-0.101	-0.058	0.062
	(0.145)	(0.149)	(0.140)
EXG_STU	0.085	-0.070	-0.028
	(0.077)	(0.079)	(0.074)
EXG_VIC	0.022	0.111	-0.271***
	(0.109)	(0.112)	(0.104)
EXP_EXG	-0.222*	0.139	0.034
	(0.132)	(0.137)	(0.129)
EXP_EXP	0.023	-0.090	0.065
	(0.135)	(0.140)	(0.132)
EXP_STU	-0.122	0.037	-0.078
	(0.077)	(0.080)	(0.075)
EXP_VIC	-0.105	0.128	0.031
	(0.112)	(0.114)	(0.106)
VIC_EXG	-0.164	0.028	0.017
	(0.152)	(0.157)	(0.148)
VIC_EXP	0.220	0.160	0.047
	(0.149)	(0.154)	(0.145)
VIC_STU	0.238***	0.060	0.067
	(0.082)	(0.085)	(0.081)
VIC_VIC	0.118	0.212*	0.045
	(0.120)	(0.124)	(0.117)
YOU_EXG	0.071	0.088	0.046
	(0.075)	(0.078)	(0.073)
YOU_EXP	-0.036	0.038	-0.020
	(0.081)	(0.084)	(0.079)
YOU_VIC	0.031	0.144**	-0.039
	(0.067)	(0.068)	(0.064)
RT	-0.000	-0.000*	0.000*
	(0.000)	(0.000)	(0.000)
MT	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Semester	0.003	0.017	-0.003
	(0.012)	(0.011)	(0.009)
Age	0.034**	0.004	-0.008
	(0.014)	(0.012)	(0.010)
Gender (Female = 1)	0.108*	-0.024	-0.020
	(0.060)	(0.053)	(0.043)
Harmed by the conflict	-0.002	0.001	0.000
	(0.002)	(0.001)	(0.001)
Affected physically/psycologically by the conflict	0.002	0.002	0.001
	(0.001)	(0.001)	(0.001)
Affected directly/indirectly by the conflict	0.001	-0.001	-0.000
	(0.001)	(0.001)	(0.001)
Family affected by the conflict	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Conflict knowledge	0.000	-0.000	0.001
	(0.002)	(0.002)	(0.001)
Conflict history knowledge	0.000	0.001	-0.001
	(0.002)	(0.002)	(0.001)
Peace jurisdiction(JEP) knowledge	0.000	0.001	-0.001
	(0.001)	(0.001)	(0.001)
Peace jurisdiction(JEP) changes knowledge	-0.001	-0.001	0.001
	(0.001)	(0.001)	(0.001)
Homosexual Marrige	0.002	0.002	0.003**
	(0.002)	(0.002)	(0.001)
Adoption by homosexual couples	-0.000	-0.001	-0.000
	(0.001)	(0.001)	(0.001)
Euthanasia legalization	-0.001	0.002*	0.001
	(0.001)	(0.001)	(0.001)
Abortion legalization	0.001	-0.001	-0.002*
	(0.001)	(0.001)	(0.001)
Marijuana legalization	-0.001	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Flexible gender roles	-0.000	-0.000	-0.001**
	(0.001)	(0.001)	(0.001)
Arts	0.128	0.045	0.039
	(0.190)	(0.164)	(0.133)
Sciences	0.105	0.026	-0.058
	(0.140)	(0.121)	(0.099)
Economic and Administrative Sciences	-0.042	-0.015	0.059
	(0.114)	(0.100)	(0.083)
Legal Sciences	0.171	-0.154	0.146
	(0.174)	(0.152)	(0.125)
Political Sciences and I.R.	-0.057	-0.080	-0.115
	(0.162)	(0.141)	(0.115)
Social Sciences	0.057	0.050	-0.142
	(0.143)	(0.125)	(0.103)
Communication and language	0.102	0.068	0.040
	(0.126)	(0.109)	(0.089)
Education	-0.339	0.202	-0.370
	(0.373)	(0.332)	(0.279)
Nursing	0.139	0.080	-0.036
	(0.239)	(0.209)	(0.172)
Philosophy	0.256	-0.135	-0.012
	(0.388)	(0.324)	(0.255)
Engineering	0.018	-0.066	-0.009
	(0.115)	(0.100)	(0.082)
Medicine/Nutrition	-0.004	-0.028	-0.101
	(0.203)	(0.177)	(0.145)
Odontology	-0.292	-0.146	-0.345
	(0.310)	(0.265)	(0.214)
Psychology	-0.287*	-0.129	0.033
	(0.156)	(0.136)	(0.112)
Constant	-0.720**	-0.238	0.176
	(0.313)	(0.275)	(0.228)
Observations	2,676	2,676	2,676
Number of participants	250	250	250

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the modified dictator game results applying random effects by participant and trial, also controlling by reaction time(RT), movement time(MT) sociodemographic and political orientation variables.The sample in this table is restricted to the prosocial final decision trials for all the participants. The dependent variable in the first column is the normalized inverse of the ξ parameter that corresponds to fast movements conviction proxy, the second column dependent variable corresponds to the normalized inverse of the ζ_1 parameter or motor pauses in the selfish side of the screen and finally ζ_2 is the explained variable in column 3 that corresponds to the normalized inverse of motor pauses in the prosocial side for conviction proxy. The treatment variable represent the random assigned pair between three possible labels victim (VIC), ex-guerrilla (EXG), ex-paramilitary (EXP), and Student (YOU/STU). This gives 16 possible pairs where the excluded one is YOU-STU.

Source: Own calculations.

Table 11: Prosocial Model (MDG) with selfish responses and sociodemographic controls

VARIABLES	(1) Fast movements ξ	(2) prosocial side ζ_1	(3) selfish side ζ_2
EXG_EXG	-0.063	0.019	-0.170
	(0.110)	(0.108)	(0.111)
EXG_EXP	-0.097	-0.087	0.119
	(0.106)	(0.103)	(0.106)
EXG_STU	0.093	0.068	-0.143**
	(0.071)	(0.071)	(0.072)
EXG_VIC	-0.134	-0.094	0.199
	(0.131)	(0.129)	(0.132)
EXP_EXG	0.026	0.108	-0.012
	(0.109)	(0.106)	(0.110)
EXP_EXP	-0.175*	-0.075	0.011
	(0.105)	(0.103)	(0.106)
EXP_STU	0.003	0.038	0.138*
	(0.071)	(0.071)	(0.072)
EXP_VIC	-0.290**	-0.530***	0.066
	(0.138)	(0.136)	(0.139)
VIC_EXG	0.217**	-0.047	0.067
	(0.104)	(0.101)	(0.104)
VIC_EXP	-0.143	-0.092	0.031
	(0.100)	(0.098)	(0.101)
VIC_STU	-0.042	-0.088	-0.003
	(0.066)	(0.067)	(0.067)
VIC_VIC	0.010	-0.009	-0.259**
	(0.113)	(0.112)	(0.114)
YOU_EXG	0.099	0.004	0.007
	(0.072)	(0.072)	(0.073)
YOU_EXP	0.005	-0.017	0.131*
	(0.068)	(0.068)	(0.069)
YOU_VIC	-0.086	-0.172*	0.032
	(0.090)	(0.092)	(0.092)
RT	-0.000***	-0.000	-0.000***
	(0.000)	(0.000)	(0.000)
MT	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Semester	0.016	0.004	0.015
	(0.013)	(0.008)	(0.011)
Age	0.023	-0.005	0.009
	(0.015)	(0.009)	(0.012)
Gender (Female = 1)	0.108	-0.087**	0.021
	(0.067)	(0.041)	(0.054)
Harmed by the conflict	0.001	0.002	-0.001
	(0.002)	(0.001)	(0.001)
Affected physically/psycologically by the conflict	0.001	0.000	0.002
	(0.002)	(0.001)	(0.001)
Affected directly/indirectly by the conflict	-0.000	-0.001*	-0.000
	(0.001)	(0.001)	(0.001)
Family affected by the conflict	0.000	-0.000	0.001
	(0.001)	(0.001)	(0.001)
Conflict knowledge	-0.000	-0.001	-0.002
	(0.002)	(0.001)	(0.002)
Conflict history knowledge	-0.000	0.003**	-0.000
	(0.002)	(0.001)	(0.002)
Peace jurisdiction(JEP) knowledge	0.002	-0.001	0.000
	(0.002)	(0.001)	(0.001)
Peace jurisdiction(JEP) changes knowledge	-0.002	0.000	0.000
	(0.001)	(0.001)	(0.001)
Homosexual Marrige	0.004*	0.002**	0.001
	(0.002)	(0.001)	(0.002)
Adoption by homosexual couples	-0.003*	-0.000	0.000
	(0.002)	(0.001)	(0.001)
Euthanasia legalization	-0.001	-0.001	0.001
	(0.002)	(0.001)	(0.001)
Abortion legalization	0.000	0.000	-0.002*
	(0.001)	(0.001)	(0.001)
Marijuana legalization	-0.001	-0.001*	-0.001
	(0.001)	(0.001)	(0.001)
Flexible gender roles	-0.000	0.000	0.002*
	(0.001)	(0.001)	(0.001)
Arts	-0.022	0.057	0.197
	(0.228)	(0.146)	(0.185)
Sciences	-0.101	0.097	0.135
	(0.162)	(0.101)	(0.130)
Economic and Administrative Sciences	-0.084	-0.019	0.053
	(0.127)	(0.078)	(0.102)
Legal Sciences	0.142	0.137	-0.187
	(0.194)	(0.118)	(0.155)
Political Sciences and I.R.	-0.255	-0.060	0.101
	(0.185)	(0.114)	(0.148)
Social Sciences	-0.047	0.078	-0.016
	(0.159)	(0.098)	(0.128)
Communication and language	-0.104	0.102	0.050
	(0.145)	(0.091)	(0.117)
Education	-0.201	0.264	-0.107
	(0.395)	(0.233)	(0.311)
Nursing, Enfermeria	-0.308	0.057	0.448**
	(0.265)	(0.163)	(0.212)
Philosophy	-0.337	-0.036	-0.244
	(0.516)	(0.365)	(0.434)
Engineering	-0.148	-0.026	0.044
	(0.129)	(0.080)	(0.104)
Medicine/Nutrition	-0.126	-0.025	-0.073
	(0.197)	(0.116)	(0.155)
Odontology	-0.495	0.244	-0.090
	(0.381)	(0.254)	(0.314)
Psychology	-0.039	0.141	-0.021
	(0.179)	(0.111)	(0.144)
Constant	-0.361	0.073	-0.287
	(0.343)	(0.211)	(0.275)
Observations	3,267	3,267	3,267
Number of participants	255	255	255

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*T*he three columns shows the modified dictator game results applying random effects by participant and trial, also controlling by reaction time(RT), movement time(MT) sociodemographic and political orientation variables.The sample in this table is restricted to the selfish final decision trials for all the participants. The dependent variable in the first column is the normalized inverse of the ξ parameter that corresponds to fast movements conviction proxy, the second column dependent variable corresponds to the normalized inverse of the ζ_1 parameter or motor pauses in the selfish side of the screen and finally ζ_2 is the explained variable in column 3 that corresponds to the normalized inverse of motor pauses in the prosocial side for conviction proxy. The treatment variable represent the random assigned pair between three possible labels victim (VIC), ex-guerrilla (EXG), ex-paramilitary (EXP), and Student (YOU/STU). This gives 16 possible pairs where the excluded one is YOU-STU.

Source: Own calculations.

Figure 8.1: Risk Task (6 trials in Winning and 6 in losses)

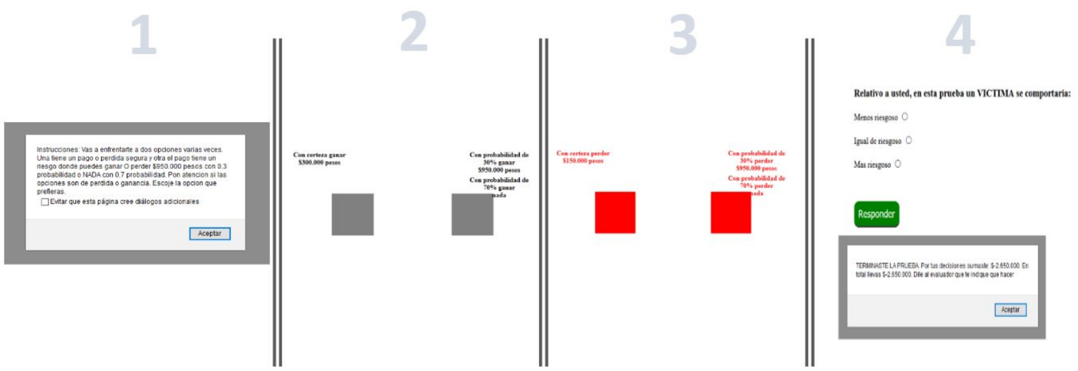


Figure 8.2: Intertemporal discount task (9 trials)

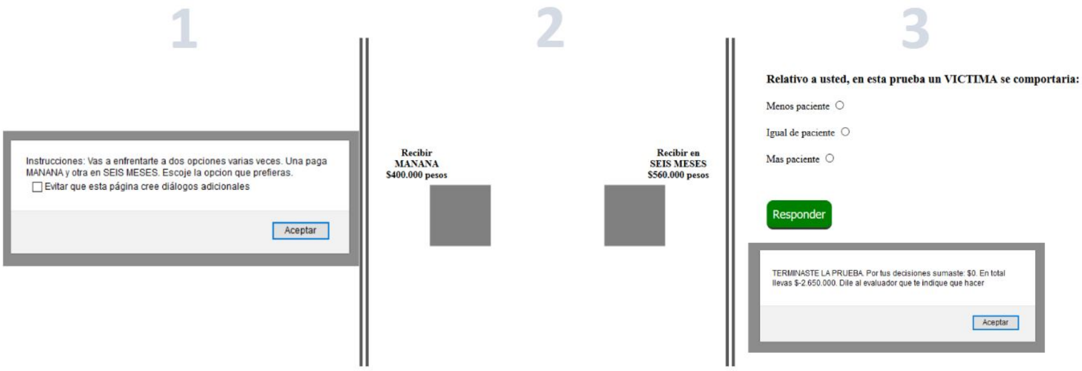


Figure 8.3: Modified Dictator Game(6 trials)

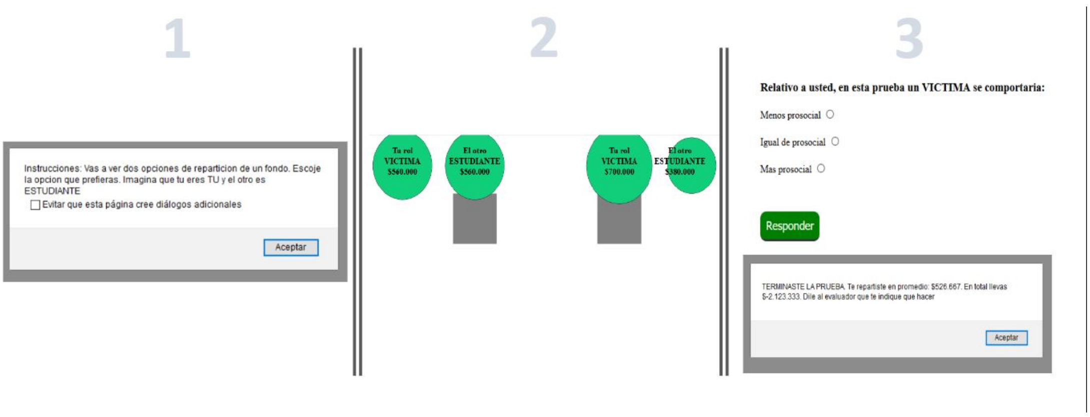


Figure 8.4: Survey (Ideological inclination, knowledge and exposure to conflict.)

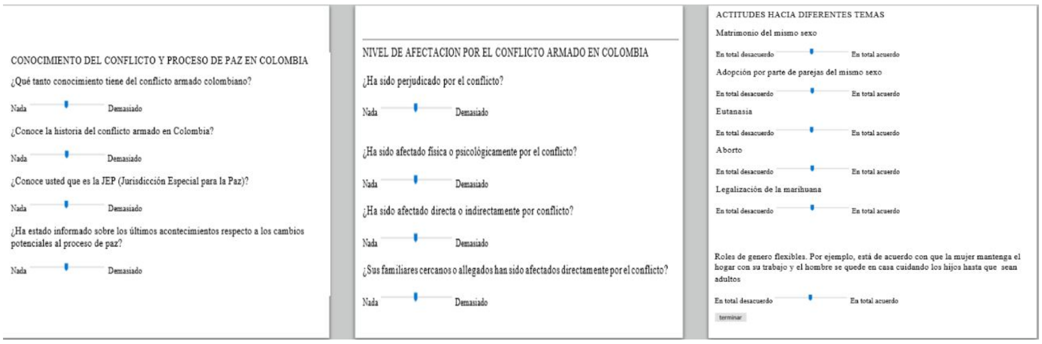
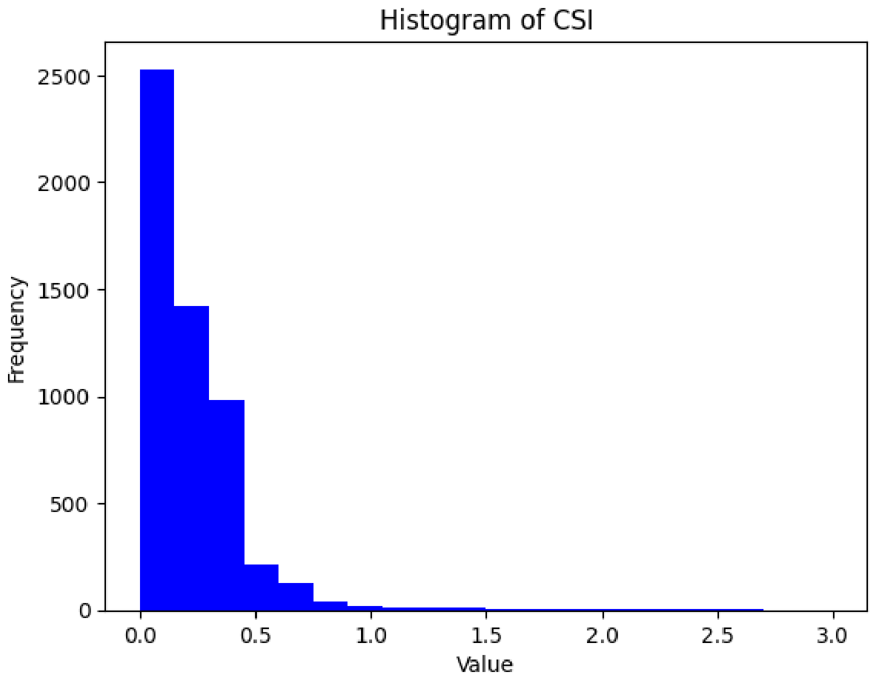


Figure 8.5: ξ Histogram

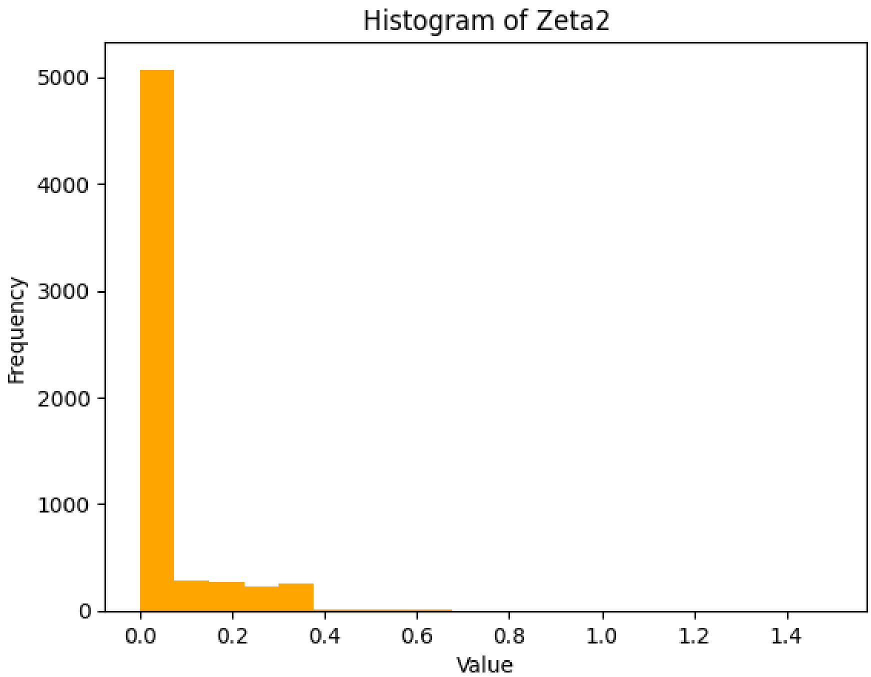


Note: This figure shows the fast movement entropy distribution ξ used as one of the dependent variables.

Figure 8.6: ζ_1 Histogram

Note: This figure shows the motor pause entropy distribution from selfish side ζ_1 used as one of the dependent variables modified dictator game.

Figure 8.7: ζ_2 Histogram



Note: This figure shows the motor pause entropy distribution from prosocial side ζ_2 used as one of the dependent variables modified dictator game.

i Entropic Mouse Tracker (EMOT)

The process begins with the transformation of tablet finger movement data into a spatial motion model. This transformation is based on a linear histogram of movement angles, simplifying the analysis of mouse trajectories. The transformed data is represented as $p = (r, \theta)$, where r is calculated as the square of the Euclidean distance, and θ is the arctan calculation for each x and y coordinate to determine the angles.

To continue, the linear histogram of movement angles is transformed using an operator known as $\phi(\eta, \omega)$. This operator calculates cumulative frequencies for distinct bins η_t and smoothes them using a standard interpolation algorithm. This tool helps us figure out how often different angle ranges occur in our data by grouping them into bins.

Next, the cumulative residual entropy ψ of the transformed data is computed using a specific formula, as shown in Equation 1. This equation involves the use of the operator $\phi(\eta, \omega)$ and is defined as:

$$\psi = [\phi(\eta, \omega) - 1] \log[1 - \phi(\eta, \omega)]^T 1, \tag{2}$$

Where 1 is a vector of all ones. The cumulative residual entropy, denoted as ψ, serves as a measure of the overall spatial motion information in the movement data. Essentially, ψ encapsulates the dynamics of the x-y trajectory within the movement space, reflecting factors such as freedom of movement and spatial exploration. It also signifies the level of spatial uncertainty resulting from the movement dynamics. As illustrated in Figure 8.7 in the appendix, when the movement is executed directly towards the prosocial decision, with no attraction to the selfish decision, ψ reaches its minimum value, representing the lowest conviction decision. Conversely, as shown in Figure 8.6 in the appendix, when the movement dynamics involve attraction or competition with the selfish decision, ψ reaches its maximum value, signifying the highest conviction decision.

Calcalgni analysis allow us to make the additive decomposition of ψ, expressed as $\psi = \xi + \zeta_1 + \zeta_2$, this offers a straightforward and insightful analysis of the motor information contained in the recorded finger trajectories during the task. To isolate the unknown residual cumulative entropies associated with fast movements (ξ) and motor pauses (ζ), a decomposition of ψ is performed. This decomposition is expressed in Equation 2, and it involves τ and υ as vectors of unknown weights related to models of fast movements and motor pauses, respectively.

$$\psi = \xi + \zeta \equiv [\phi(\eta, \tau) - 1] \log[1 - \phi(\eta, \tau)]^T 1 + [\phi(\eta, \upsilon) - 1] \log[1 - \phi(\eta, \upsilon)]^T 1 \tag{3}$$

For a more detailed breakdown, ζ is further decomposed into ζ_1 and ζ_2, representing the cumulative residual entropies of motor pauses associated with competing cues and the target, respectively. This decomposition is described in Equation 3, where υ_1 and υ_2 are vectors of unknown weights for the corresponding components.

$$\psi = \xi + \zeta_1 + \zeta_2 \equiv [\phi(\eta, \tau) - 1] \log[1 - \phi(\eta, \tau)]^T 1 + [\phi(\eta, \upsilon_1) - 1] \log[1 - \phi(\eta, \upsilon_1)]^T 1 \quad (4)$$

$$+ [\phi(\eta, \upsilon_2) - 1] \log[1 - \phi(\eta, \upsilon_2)]^T 1$$

Indeed, the measures ξ, ζ_1, and ζ_2 quantify motion events that hold significance in the context of finger-tracking, as they can unveil crucial aspects of the underlying cognitive processes, including decision conflicts and uncertainty, akin to the scenarios involving selfish and prosocial decisions.

To elaborate, the component ξ quantifies rapid movement events, which may relate to motor-execution behaviors, often occurring after a decision has been made. On the other hand, the components ζ_1 and ζ_2 represent pause movement events linked, for instance, to the processes of goal formulation and/or reformulation, shedding light on the dynamics of the decision-making process.

The ultimate goal is to estimate the values of these unknown quantities, ξ, ζ_1, and ζ_2, in a manner that satisfies Equation 3 based on the observed data θ.This involves reformulating the decomposition problem as a non-linear optimization problem. To apply this procedure effectively, Calcagni establish a set of external feasible information about ξ, ζ_1, and ζ_2 that constrains the range of possible solutions for the decomposition problem.

The information available to us primarily consists of the vector of movement angles, denoted as θ. To address this, he uses θ to derive proxies for solving the decomposition problem. he begins by defining θ_0 as $F_0(\theta)$, which represents the zeroth-frequency moment of θ. This moment, θ_0, only includes distinct elements of θ without any duplicate entries. A standard algorithm, F_0, is used for this purpose. Similar to H_θ, he defines a histogram model for θ_0, denoted as H_{θ_0}. This is expressed as η, π, where π represents the occurrences of movements without duplicates in θ_0. he leverage π as a proxy for τ.

To establish proxies for υ_1 and υ_2, he employs a procedure similar to spatial pyramid matching, a pattern recognition technique that recursively divides an image histogram into sub-histograms of features. We define U as the difference between H_θ and H_{θ_0}. By computing the median class η_S of U, he splits U into two sub-models: U_1, associated with the semi-space of the target, and U_2, linked to the semi-space of competing cues. The resulting vectors λ_1 and λ_2 serve as proxies for υ_1 and υ_2.

Now, he can define the cumulative residual entropies associated with fast movements (ξ), motor pauses related to competing cues (ζ_1), and motor pauses related to the target (ζ_2). These are expressed as functions of τ, υ_1, and υ_2 and are defined as:

$$\xi(\tau) = [\phi(\eta, \tau) - 1] \log[1 - \phi(\eta, \tau)]^T 1$$
$$\zeta_1(\upsilon_1) = [\phi(\eta, \upsilon_1) - 1] \log[1 - \phi(\eta, \upsilon_1)]^T 1$$
$$\zeta_2(\upsilon_2) = [\phi(\eta, \upsilon_2) - 1] \log[1 - \phi(\eta, \upsilon_2)]^T 1$$

In these equations, τ, υ_1, and υ_2 represent the associated $T \times 1$ unknown vectors.

The non-linear optimization problem is formulated with the proxies π, λ_1, and λ_2 as follows:

$$\begin{aligned} \text{Minimize} \quad & \{\tau, \upsilon_1, \upsilon_2\} \\ & 1^T[\log(\tau) - \log(\pi)]^T \tau + 1^T[\log(\upsilon_1) - \log(\lambda_1)]^T \upsilon_1 + 1^T[\log(\upsilon_2) - \log(\lambda_2)]^T \upsilon_2 \\ \text{Subject to} \quad & \psi = \xi(\tau) + \zeta_1(\upsilon_1) + \zeta_2(\upsilon_2) \\ & 1 = 1^T\tau, 1 = 1^T\upsilon_1, 1 = 1^T\upsilon_2 \end{aligned}$$

Here, 1 is a vector of ones of the appropriate order, and the objective function is the well-known Kullback–Leibler (KL) divergence, expressed as a function of the unknown quantities τ, υ_1, υ_2, and the proxies π, λ_1, and λ_2. The first constraint ensures compatibility with the decomposition of ψ, while the other constraints serve as normalization factors to ensure well-posed estimates.

Given the nature of this problem, approximate solutions can be found numerically using an interior-point method, which efficiently handles the equality constraints.

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