CENTRO DE INVESTIGACIÓN Y DOCENCIA ECONÓMICAS, A.C.

PROMOTING SUSTAINABLE MOBILITY THROUGH BEHAVIORAL CHANGE: AN ONLINE PUBLIC GOOD EXPERIMENT USING A JUNIOR HIGH SCHOOL STUDENT SAMPLE

TESINA

QUE PARA OBTENER EL GRADO DE

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PRESENTA

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Chapter 1

1 Introduction

Today, "55% of the world´s population lives in urban areas, a proportion that is expected to increase to 68% by 2050" (United Nations, 2018).

Each day, urban areas are getting more important for the economic and social development of all societies in the world; this fact implies the necessity to design new urban policies committed to mitigate climate change and to adapt cities to actual or expected future climate. This necessity comes from the broader concept of sustainable development, defined by the World Commission on Environmental and Development, as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Bank, 2015). More recently, the United Nations encourages among its members the implementations of 17 Sustainable Development Goals calling to action to end poverty, protect the planet and improve the lives and prospects of everyone.

"Goal 11: Make cities inclusive, safe, resilient, and sustainable"; explicitly declares that rapid urbanization is resulting in a growing number of slum dwellers, inadequate and overburdened infrastructure and services. One of these urban problems is the excessive use of private cars and the infrastructure dedicated exclusively to this way of mobility. This way of mobility causes a significant number of negative externalities, which include road congestions, road accidents, unequal urban development, pollution and high mobility logistics costs. In particular, air pollution is a major and serious problem in large urban areas, causing severe impacts on human health (Gallo & Marinelli, 2020).

An interesting approach that helps to answer the problem about how to promote walking and cycling within the behavioral economic framework, involves making people aware of the negative impacts of their transport choices and potentially nudge them towards the use of sustainable modes of transport. Applications of these kinds of strategies rely on the concept of persuasive systems which have been successfully utilized in domains such as health, education, environmental awareness, and sustainable mobility.

These systems refer to the application of psychological principles of persuasion intending to change users´ attitudes and behaviors; they guide users towards the adoption of desired attitudes or actions by infusing persuasive strategies; they use traveler´s information behavior to generate recommendations that correspond to their needs; and they may consist of primary task support,

computer-human dialogue support and perceived system credibility (see e.g., Anagnostopoulou et al. (2020). In the transport domain, these systems are usually tested on GPS´s smartphone applications. Also, economic and psychological experiments are often run over these applications, which categorize them into field experiments.

Sometimes, running field experiments could have some limitations when looking to replicate them in other sociodemographic contexts. Also, nowadays in the middle of the covid world pandemic, economists not only have limitations in running field experiments; but also, laboratory-based experiments due to social distancing.

This situation has encouraged novel methodologies that help to contribute to the literature of experiment replications and economic online laboratory experiments. In this sense, I aim to test a persuasive system, that potentially could increase sustainable mobility behavior, by employing a methodology consisting of a description of an urban commuting situation as a public good game.

The public good game has the purpose to mirror the urban mobility social dilemma by modeling a real-life commuter decision as closely as possible, where the sustainable mobility choice functions as a signal of the participant´s willingness to cooperate with others. This work also contributes to the academic community in the field of sample diversification. The sample used in this work consists of junior high school students and it has the purpose to compare my results with those found in the past.

Consequently, I focus my research on the following research questions:

- How can I design a persuasive system that applies personalized strategies depending on the participant´s characteristics?
- How can I design an online public good game that mirrors the urban mobility social dilemma and where the above persuasive system is applied?

To achieve this, I first conducted an exploratory analysis seeking to find which is the best approach to design a persuasive system that could be applied within an online economic experiment. Second, I designed and applied an economic experiment whose main section is a public good game mirroring the urban social dilemma. Altogether, these actions will allow me

to test the effectiveness of a persuasive system and analyze further hypotheses regarding the preferences and beliefs of the participants.

Chapter 2

2 Literature Review

In this section I present the related work in the field and describe how my work differs from the existing ones.

Given the status quo in urban cities, promoting sustainable mobility is one of the most widespread objectives in transport policy, and from an economic point of view, it is an interesting area to be investigated due to the positive contributions to the environmental, social, and economic sustainability. According to Van Vugt, Van Lange, & Meertens (1996), the strategies to improve sustainable mobility vary from actions that affect the supply of transport to actions that affect the demand side. Gallo & Marinelli (2020) classified these policies into four general categories:

- Vehicle policies: low emission vehicles, electric vehicles, hybrid vehicles, etc.
- Fuel policies: low carbon fuels, biodiesel.
- User policies: use of less-polluting modes of transport, changes in mobility habits, incentives, pricing.
- Management technology policies: intelligent transportation systems, new construction techniques.

According to Gallo & Marinelli (2020), behavioral economics has recently seen much application to environmental economics and its approach has been successful in describing and analyzing transport reality. These studies analyze how behavioral choices can be influenced by factors like heterogeneity in preferences and pay more attention to how altruism, fairness, norms, reputation, and status-seeking concerns influence our behavior.

This area of research has also been promoted by international organizations seeking to explore new approaches to social problems. For example, the World Bank Development Report of 2015 aims to “inspire and guide the researcher and practitioners who can help advance a new set of development approaches based on a fuller consideration of psychological and social influences”. According to this report, findings in behavioral economics have helped to explain decisions that individuals make in many aspects of development, for example, the persistence of poverty, early childhood development, household finance, productivity, health, climate

change, and urban mobility; and conclude that "new economic research would benefit from richer diagnoses of behavioral drivers and experimentation in the field and laboratory environments" (World Bank, 2015).

Gaker, Zheng, & Walker (2010) stipulated that behavioral economics has made inroads in transportation in the areas of survey design, prospect theory, and attitudinal variables; and stated that findings suggest high transferability of lessons from behavioral economics and great potential for influencing transport behavior. They highlighted that there is more to learn by transferring lessons from behavioral economics to transportation in the areas of social influences and personalized information; and highlighted two important things: critical questions must include how other segments of society behave in economic experiments; and researchers need to think useful ways to nudge people toward more sustainable mobility choices.

A social dilemma is defined by two principles: the outcome of a non-cooperative choice is always more beneficial for an individual than the cooperative choice; and, if all individuals make the cooperative choice, then the social benefit will exceed the non-cooperative situation. And under the behavioral economic framework, many researchers have described urban mobility as a social dilemma due to the existence of conflict between immediate self-interest and long-term collective interest (Gaker et al., 2010; Sunitiyoso, Avineri, & Chatterjee, 2011; Vugt, 1996; Van Vugt et al., 1996).

A common aspect of a social dilemma is the existence of individual behavior which is not desirable in terms of its long-term social impact but is desirable from the perspective of short-term individual benefit. This social dilemma has been researched by various sciences and it has been defined in a variety of ways, Dawes (1980) described that a social dilemma is a social situation in which the following two conditions are met:

- The social payoff to each individual for defecting behavior is higher than the payoff for cooperative behavior, regardless of what the other society members do.
- All individuals in the society receive a lower payoff if all defect than if all cooperate.

Additionally, Fujii (2017) defined defective behavior or defection as a behavior that contributes to increasing private benefit (or self-interest) in the short term, while decreasing public benefit in the long term; and Cooperative behavior or cooperation as a behavior that

contributes to increasing public benefit (or collective interest) in the long term, while decreasing private benefit in the short term. He resumes the social dilemma simply as follows: “A situation in which a person has to make a choice between cooperation and defection”.

The urban social dilemma arises when individuals face their mobility choice and have to choose between a private car or another more sustainable way of mobility. Commonly, individuals tend to choose private cars following their immediate self-interest concerns (better comfort, reduction of travel time, time control). However, when an individual changes their decision to switch from private car to a sustainable way of mobility, the negative externalities marginally decrease, which implies that the social well-being will increase.

Many economists have researched social dilemmas by experimentally examining behavior when individual interest and collective interest conflict; research that has been stimulated from Hardin´s influential essay on the “tragedy of the commons”. For example, Sunitiyoso et al. (2011) stated that individuals´ use of different decision-making procedures in different contexts suggests the need for hypothesis-specific laboratory-based experiments required to identify the incidence of different decision-making procedures, the factors that influence them, and the conditions under which these procedures change.

These experiments also have some advantages regarding issues like saving monetary resources, and specific variables manipulation. However, regarding external validation and despite the efforts made in the field, there is a deficit of empirical research designed to test whether the characterization of the commuting situation could be represented as a public good game. Arechar, Gächter, & Molleman (2018) expand this area stating that online interactive experimentation is potentially valuable to complement these laboratory-based experiments.

One way to analyze the urban mobility social dilemma is through public good game experiments. The main objective of these kinds of games is to catch the tension between individuals gains and social efficiency. The choice that maximizes the individual interest is presumed as a defective behavior; and vice versa, the choice that follows the social interest is presumed as the cooperative option. According to Croson, R. (2008), this type of game has a unique Nash equilibrium in which no participant allocates any resources towards producing the public good. However, “deviations from the equilibrium are both welfare-enhancing and represent deviations from pure self-interest maximization; and are thus referred to as cooperation”. Within this framework, the urban social dilemma is analyzed through a public

good game, where sustainable mobility behavior could be understood as a way of cooperation, as it functions as a signal of an individual´s willingness to increase social well-being.

Previous works have already revealed reliable information about the determinants and dynamics of individual contribution levels in public good games mirroring social dilemmas. One important result to consider is that social dilemmas analyzed as repeated public goods games often reach an equilibrium in which no participants allocate any resources towards the public good, and deviations from the equilibrium are both welfare-enhancing and represent deviations from pure self-interest maximization; and are thus referred to as cooperation (Croson, R. 2008). Ackermann & Murphy (2019) analyzed this propensity to cooperate in public good games and emphasize that standard economic theory is unable to account for the observed range of cooperation because it relies on the assumption of complete homogeneity among participants' preferences. They highlight the existence of ample evidence from empirical studies showing that people have heterogeneous preferences and beliefs; and state that to gain a better understanding of aggregate behavior in public good games, one should consider how individual preferences and beliefs yield behavior on the individual level.

Some results from these studies state the existence of conditional cooperation preferences, that contributions in public good games are positively correlated with their beliefs, that conditional cooperation is a stable preference type that is robust across cultures, and that the usual decaying pattern of contributions can be better understood by appealing to heterogeneity in the types of players interacting with one another.

Following this line of thought, Ackermann & Murphy (2019) used a methodology consisting of the measurement of social preferences and beliefs from participants to test how well individual contribution decisions can be explained with these variables. They highlighted that people enter a public good game with very diverse preferences, reinforcing the result about the existence of heterogeneity among players´ behaviors and willingness to cooperate. And they conclude that people´s beliefs about the behavior of others are especially critical to their own behavior and that beliefs are the best single predictor of a person´s future behavior in a repeated public good game.

Regarding heterogeneous preferences and how to motivate individuals towards making more eco-friendly choices, Anagnostopoulou et al. (2020) analyze how to nudge travelers towards adopting sustainable transportation in a real-life social dilemma. Following a demand-side

approach, they make use of a persuasive system designed to provide behavioral change interventions. Persuasive systems refer to those applications that make use of persuasive strategies to change traveler´s behavior from private cars to a more sustainable way of transportation. They noticed that these persuasive systems employ a one-size-fits-all persuasive mechanism and do not consider traveler´s characteristics and preferences, concluding that persuasive systems can be more effective and can have a greater impact on transport behavior change if they consider personalized persuasive strategies. This idea is extended by Oyibo, Adaji, Orji, Olabenjo, & Vassileva (2018), who noted that persuasive applications aimed to change travel behavior will be more effective if they are personalized to user´s characteristics.

Following a social dilemma approach, my work aims to design and test a persuasive system that could potentially increase sustainable mobility behavior. To test the persuasive system, my work makes use of a relatively novel methodology consisting of a description of an urban commuting situation as a public good game. The public good game seeks to mirror the urban mobility social dilemma by modeling a real-life commuting decision as closely as possible, where the sustainable mobility choice functions as a signal of the participant´s willingness to cooperate with each other. The persuasive system takes into account the heterogeneity in preferences of the participants to increase its persuasive power towards more cooperative behavior in the public good game.

This work is divided into two parts. The first part consisted of an exploratory study trying to find the best persuasive system design that potentially could be applied in an online economic experiment. The second part consisted of an online economic experiment, whose main section is a public good game mirroring the urban social dilemma to test the effectiveness of the persuasive system, and which allow me to measure social preferences and elicit beliefs to test how well individual contribution decisions can be explained with these predictor variables.

This study aims to contribute to the literature in the fields of the new frontier studies exploring: the relationship between environmental, economic, and psychology sciences; behavioral economics literature replication in new sociodemographic contexts; sample diversification in academic studies; novel methodologies in online economic experiments; how to run economic experiments without the use of ample economic resources; and it is an example of how to test solutions to specific environmental problems before they are applied in real life.

Chapter 3

3 Objectives and Research Questions

The main hypothesis in this work is that personalized interventions that consider the participant´s preferences would increase the level of cooperation in a public good game.

Consequently my research is divided into two parts, each one trying to answer each of the two research questions:

- How can I design a persuasive system that applies personalized strategies depending on the participant´s characteristics?
- How can I design an online public good game that mirrors the urban mobility social dilemma and where the persuasive system could be applied?

The objective of the first part consists in designing the best persuasive system that potentially could be applied within an online economic experiment. The design stage of the persuasive system follows the steps of Anagnostopoulou et al. (2017), consisting of finding the best persuasive strategy for a specific set of preferences of the individuals. The difference is that Anagnostopoulou et al., (2017) used the persuasive system in a real-life cellphone app, and the system developed in this work is applied in an online public good game.

The objective of the second part is to design and apply an online economic experiment, whose main part is a public good game mirroring the urban social dilemma.

Chapter 4

4 Methodology

In this work, I combine two elements that together will allow me to analyze if personalized interventions would increase the level of cooperation in a public good game. In the first section, I will explain how I design the persuasive system, and in the second section, I will explain how I designed and applied the online economic experiment.

The first element consisted in the design of a persuasive system that captures traveler´s susceptibility to different strategies. As mentioned in the literature review, persuasive strategies will be more effective in changing the behavior of individuals if they consider users´ individual preferences. Therefore, they must make use of persuasive profiles within the system, which should provide enough information about which type of strategy is more effective in changing user´s behavior. To integrate this feature in my system design, I examined the perceived susceptibility to 11 different persuasive strategies on individuals and correlate them with different measures of individual preferences. I found that, to work properly with the persuasive system within the online experiment, the design should use the individual´s social preferences as the basis of the persuasive profiles.

The second element consists in the design and application of an online economic experiment, whose main part is a public good game mirroring the urban social dilemma. This experiment has the following characteristics: it makes use of the persuasive system designed in the first part of the work and it uses a sample of junior high school students which will allow me to test how well a non-conventional sample behaves in this experiment.

4.1 Persuasive System Design

In this section, I will explain the exploratory study executed to design the persuasive system to use in the online economic experiment. The exploratory study consisted of an online survey instrument applied to 201 voluntary participants. The instrument measured their social preferences, mobility preferences, personality traits, sociodemographic data and susceptibility to 11 persuasive strategies. I collected the data through the Google Forms application, gathering a total of 201 valid responses between November 21 and 24 of 2020. Of the participants, 48% were women, the average age of the participants was 28 years old, and 62% of the respondents reported having college studies.

The instrument consists of: a classic Prisoner's Dilemma to measure their social preferences; a mobility section based on Anable (2005) to measure their mobility preferences; a section to measure their personality based on Gosling, Rentfrow, & Jr (2003); a section dedicated to measuring the perceived susceptibility to 11 persuasive strategies based on the instruments of Busch, Schrammel, & Tscheligi (2013) and Alkis¸ & Tas¸kaya Temizel (2015); and a final section regarding basic sociodemographic data.

To explore the correlation between the measurements of their preferences and personality traits with the perceived susceptibility to persuasive strategies, I follow the works of Alkis¸ & Tas¸kaya Temizel (2015), Anagnostopoulou et al. (2017), Heredia, Díaz, & Monzón (2014), Lehto, Oinas-Kukkonen, & Drozd (2012), Lehto et al. (2012), Orji, Vassileva, & Mandryk (2014), Pangbourne, Bennett, & Baker (2020) which had introduced latent variables to enrich econometric models and improve their performance. Specifically, I used a "Partial-Least-Squared Structural Equation Models "(PLS-SEM) to analyze which persuasive strategy is more effective for each preference measurement and personality trait.

4.1.1 Instrument Validation

The batteries of questions used to measure the susceptibility to persuasive strategies were already applied and verified in two different geographic contexts. However, it is not clear if the items applied will measure the same latent variable in another geographic context. Since both batteries are being adapted for the Mexican context and it is the first time they are applied in the Spanish language, a validation phase is needed to identify those items that are representing a latent
variable.

To validate the items of the susceptibility to persuasive section, I run an internal item consistency analysis and an exploratory factor analysis. This step is important because the latent variables are an input for the PLS-SEM model, and also, those validated items will be part of the design of the public good experiment.

The instrument used in this work makes use of two batteries of questions that look to measure the level of susceptibility to certain strategies. Both scales measure the level of susceptibility by a series of items that mirror different persuasive strategies represented as latent variables. These batteries were taken from the works of Alkis¸ & Tas¸kaya Temizel (2015) and Busch et al.

(2013). The first battery consists of a set of 26 items that measure the susceptibility of six different strategies: reciprocation, scarcity, liking, commitment, consensus, and authority. The second battery consists of a set of 25 items that measure five different strategies: rewards, competition, social comparison, trustworthiness, and social learning. Considering both batteries, we have a total of 11 persuasive strategies. All items were rated on a 7-point "Likert" scale from 1-Strongly disagree to 7-Strongly agree.

Cronbach´s Alpha coefficient measures the contribution to the internal consistency of each item. In theory, the batteries should measure 11 latent variables, each representing the susceptibility to a specific strategy. However, we can observe in Table 4.1 that some Alpha values are below the optimal level of acceptance of good consistency: 0.70 specifically, liking, commitment, consensus, and authority. Therefore, some items could be removed in order to increase the internal consistency of the instrument.

Table 1 Overview of the composite Alpha Scores

No.	Scales	Items	std. Alpha
1	reciprocity_items	("reci1","reci2","reci3","reci4","reci5")	0.72
2	scarcity_items	("esca6","esca7","esca8","esca9","esca10")	0.69
3	liking_items	("simpa11","simpa12","simpa13","simpa14")	0.63
4	commitment_items	("compro15","compro16","compro17")	0.23
5	consensus_items	("conse18","conse19","conse20","conse21")	0.67
6	authority_items	("auto22","auto23","auto24","auto25","auto26")	0.67
7	rewards_items	("recom27","recom28","recom29","recom30","recom31","recom32")	0.85
8	competition_items	("compe33","compe34","compe35","compe36","compe37")	0.76
9	comparison_items	("compa38","compa39","compa40","compa41","compa42","compa43")	0.86
10	trust_items	("confi44","confi45","confi46")	0.69
11	learning_items	("apren47","apren48","apren49","apren50","apren51")	0.78

Own elaboration

After the fitting process, I end with a final battery of 20 questions measuring seven different strategies: reciprocity, commitment, trust, authority, rewards, competition, and comparison. In Table 4.2 we can observe that only one of the Alpha values is below the standard value but is very close to 0.70 (Authority).

Table 2 Final overview of the composite Alpha Values

No.	Scales	Items	std. Alpha
1	reciprocity_items8	("reci1","reci2","reci3")	0.78
2	commitment0trust_items8	("compro15","compro16","confi45","confi46")	0.77
3	authority_items8	("auto23","auto24","auto25")	0.69
4	rewards_items8	("recom27","recom29","recom30")	0.87
5	competition_items8	("compe33","compe34","compe37")	0.70
6	comparison_items8	("compa39","compa41","compa42","compa43")	0.89

Own elaboration

In Table 4.3 we can analyze factor loadings patterns. Factor loading helps to identify an appropriate factor structure for our data. We can observe that for the Reciprocation scale, items reci1, reci2, reci3 are loading for factor 4; for Commitment and Trust scale, items compro15, compro16, confi45, confi46 are loading for factor 2; for Authority scale, items auto23, auto24, auto25 are loading for factor 5; for Rewards scale, items recom27, recom29, recom30 are loading for factor 3; for Competition scale, items compe33, compe34, compre37 are loading for factor 6; and for Comparison scale, items compa39, compa41, compa42, compa43 are loading for factor 1. These results imply that factor loadings were from moderate to strong and that the factor structure was fitted in order to have the best structure for the SEM model.

Table 3 Factor loadings for the final 20 items

Loadings:

	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6
reci1				0.606		
reci2				0.767		
reci3				0.745		
compro15		0.568				
compro16		0.634				
confi45		0.761				
confi46		0.579				
auto23					0.926	
auto24		0.334			0.601	
auto25	0.308				0.414	
recom27	0.449		0.591			
recom29			0.862			
recom30			0.764			
compe33					0.342	0.395
compe34						0.564
compe37						0.784
compa39	0.898					
compa41	0.691					
compa42	0.710					
compa43	0.628					

	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6
SS loadings	2.768	2.114	2.074	1.867	1.729	1.448
Proportion Var	0.138	0.106	0.104	0.093	0.086	0.072
Cumulative Var	0.138	0.244	0.348	0.441	0.528	0.600

Own elaboration

4.1.2 Econometric Model and Results

After exploring the results from the previous instrument, the best setup to design the persuasive system is to use social preferences as the basis of the persuasive profiles. This was motivated by the ease of programming the online economic experiment, which would be based solely on two persuasive profiles: one for cooperators and one for free riders.

To analyze the susceptibility to persuasive strategies, I create a PLS-SEM model that examines the persuasiveness of the six strategies mentioned above and the two types of social preferences (free-riders and cooperators). The measurement part of the model was based on the results from the exploratory factor analysis described in the previous section and it consists of three indicators for Reciprocity, four indicators for Commitment, three indicators for Authority, three indicators for Rewards, three indicators for Competition, and four indicators for Comparison.

The structural relations to the latent variables and the measurement model are specified as:

$$\eta = \Gamma x + \zeta; y = \Lambda \eta + e \tag{4.1}$$

Where y is a vector of 20 latent variables η. Γ and Λ are matrices of unknown parameters to be estimated; and ζ and e are measurement independent errors.

The structural and measurement model specification for the susceptibility of the strategies by the two social preferences are:

$$\eta_{li} = \gamma_{l1} FreeRider + \zeta_i; \quad (4.2)$$

$$\eta_{li} = \gamma_{l1} Cooperator + \zeta_i \quad (4.3)$$

l=reciprocity, commitment and trust, authority, rewards, competition, comparison

The coefficients obtained from the PLS-SEM models are summarized in Table 4.4. The table highlighted the results for $p<0.05$.

Table 4 PLS-SEM results

Variable	LVreci	LVcomtrust	LVauto	LVrew	LVcompe	LVcompa
LVcoop	0.155 (0.039)	0.111 (0.141)	-0.148 (0.049)	-0.267 (0.000)	-0.072 (0.340)	-0.263 (0.000)
r2_a	0.018	0.007	0.016	0.066	-0.000	0.064

Variable	LVreci	LVcomtrust	LVauto	LVrew	LVcompe	LVcompa
LVFR	0.134 (0.074)	0.163 (0.030)	0.120 (0.110)	0.258 (0.001)	0.106 (0.158)	0.211 (0.005)
r2_a	0.012	0.021	0.009	0.061	0.006	0.039

Own elaboration

The results are summarized in Table 4.5 and show that cooperators are more susceptible to reciprocity strategies; and for free-riders, commitment-trust, rewards, and comparison strategies are a good way to persuade them.

Table 5 Best strategies for each social preference

Social Preferences	Best Strategies
Cooperative	Reciprocity
Free-Rider	Commitment & Trust; Rewards; Comparison

Own elaboration

These profiles will help to categorize the sample of the participants, and therefore, apply personalized interventions that nudge them toward sustainable mobility options.

4.2 Online Economic Experiment Design

This online economic experiment allows me to test the effectiveness of the persuasive system, and to measure social preferences and elicit beliefs to test how well individual contribution decisions can be explained with these variables. I also analyze further hypotheses regarding internal and external validation of the online experiment.

The current work employs a relatively novel methodology for studying transportation preferences. Specifically, this part consists of an online economic experiment, whose main section is a public good game mirroring the urban social dilemma by modeling a real-life commuter decision as closely as possible. This type of study has been carried out more constantly in the area of environmental economics, finding significant results of interest for economic theory and public policy recommendation.

Previous work has already used public good games to mirror the urban social dilemma and has already revealed information about the determinants of individual contribution levels in these type of games (see e.g. Ackermann & Murphy (2019); Gaker et al. (2010); Sunitiyoso et al. (2011); Van Vugt et al. (1996)). These works serve as the basis for my experimental design, and while my goal is in part to replicate previous research in a new sociodemographic context, I also contribute to the literature in several important ways.

First, I combined and simplified in a coherent way, different methodologies looking to mirror the urban social dilemma as a public good game to test the effectiveness of the persuasive system. Second, I test how well the simultaneous Prisoner Dilemma game is useful in measuring

social preferences. Third, I elicit participants' individual beliefs about their own social preferences, about the contribution levels of others, and their beliefs about other participants´ social preferences. Fourth, I applied this experiment to a sample of junior high school students, allowing me to compare my results with those found in the research done in the field.

4.2.1 Experimental Setup

The experiment consisted of five parts. First, the measurement of social preferences through a simultaneous Prisoner's Dilemma game. Second, a public good game mirroring a commuting situation in which the persuasive system is applied, and where the outcome associated with the public good game was represented in terms of trips by bicycle (collective outcome) or trips by car (individual outcome). Third, the elicitation of individuals' beliefs about their and other´s behavior. Fourth, an environmental judgment task to analyze if participants construct the commuting situation as a social dilemma. And fifth, a sociodemographic questions section.

The experiment was applied during an online class and participants were told they would have an academic evaluation for their mathematics class. Instructions were specifically detailed for the Prisoner Dilemma and public good games. To test the level of understanding of participants, three control questions were applied, two for the Prisoner Dilemma and one for the public good game (Table 4.6).

The public good game consisted of a one-shot game mirroring a commuting situation. In this game, the sustainable mobility choice functions as a signal of the participant´s willingness to cooperate with others, and vice versa, the car mobility option function as a signal of the participant´s willingness to defect. The payoff for non-cooperative choice (car use) is higher than the payoff for cooperative choice (bicycle use), regardless of what other individuals choose. However, everybody will receive a higher payoff when all individuals in the group choose to cooperate.

Table 6 Number and percentage of participants who got the control questions correct

	Correct	Incorrect	Total
Control Question 1 Prisoner Dilemma	64 62.14%	39 37.86%	103
Control Question 2 Prisoner Dilemma	63 61.17%	40 38.83%	103
Control Question 3 Public Good Game	46 44.66%	57 55.34%	103

Own elaboration

Figure 1 Example of a professor applying the online experiment

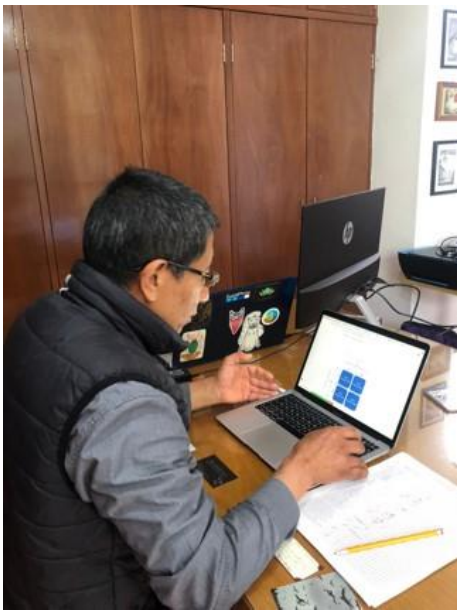
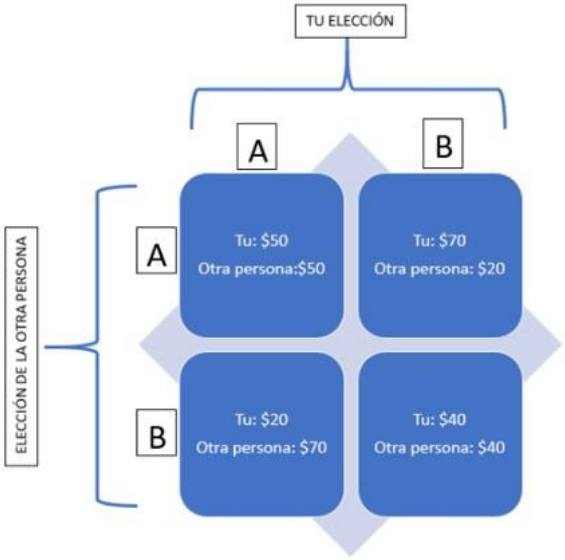


Figure 2 Prisoner's Dilemma Template Example



Own elaboration

Figure 3 Public Good Game Template Example

					Bono Total recibido por cada integrante		Total Equipo
Tú	$0	$50	Aportación a la bolsa común	Total duplicado	Tú	$100	$300
2do Integrante	$0	$50	$50 + $50 + $50 = $150	$300 / 3 = $100	2do Integrante	$100	
3er Integrante	$0	$50			3er Integrante	$100	

					Bono Total recibido por cada integrante		Total Equipo
Tú	$50	$0	Aportación a la bolsa común	Total duplicado	Tú	$50	$150
2do Integrante	$50	$0	$0	$0	2do Integrante	$50	
3er Integrante	$50	$0			3er Integrante	$50	

					Bono Total recibido por cada integrante		Total Equipo
Tú	$50	$0	Aportación a la bolsa común	Total duplicado	Tú	$50 + $66 = $116	$116 + $66 + $66 = $248
2do Integrante	$0	$50	$100	$200 / 3 = $66	2do Integrante	$0 + $66 = $66	
3er Integrante	$0	$50			3er Integrante	$0 + $66 = $66	

					Bono Total recibido por cada integrante		Total Equipo
Tú	$0	$50	Aportación a la bolsa común	Total duplicado	Tú	$0 + $33 = $33	$33 + $83 + $83 = $199
2do Integrante	$50	$0	$50	$100 / 3 = $33	2do Integrante	$50 + $33 = $83	
3er Integrante	$50	$0			3er Integrante	$50 + $33 = $83	

Own elaboration

The persuasive system consisted of the display of persuasive messages according to the social preferences of the participants. The type of strategy applied to each participant depended on his/her social preference and was chosen according to the results from Table 4.5. For cooperators, I used reciprocity messages; for free-riders, I used commitment & trust messages. The messages were designed according to some examples found in the literature, and both were designed to increase collaboration between participants (see e.g. Anagnostopoulou et al. (2017); Kaptein, de Ruyter, Markopoulos, & Aarts, (2009); Oinas-Kukkonen & Harjumaa (2008); Oyibo et al., (2018)).

To test the effectiveness of the persuasive system, I used two conditions within the experiment. For Condition 1, the persuasive system is applied in the public good game; for Condition 2, no persuasive system is applied in the public good game.

For Condition 1, the persuasive system consists of the following:

- A framework effect in the title of the public good game section. For Condition 1, the game title had the phrase "Cooperation game"; for Condition 2, the game had the phrase "Competition game".
- A personalized message in the instructions section depending on the participant´s social preference.
- A personalized message just before participant´s answer to the public good game.

Participant´s beliefs about their own social preferences, about the contribution levels of others, and their beliefs about other participants´ social preferences were elicited directly after they indicated their contribution decision in the public good game. Participants answered three questions regarding their beliefs:

- What kind of player do you think you have been?
- What kind of player do you think your other two teammates were?
- How many days of cycling do you think your other two companions have chosen?

Answers from these questions, in addition to the measure of participant´s social preferences, allow me to investigate how well this set of variables affect contribution levels in the public good game.

I also administered a post-experimental judgement task in which I asked participants to evaluate the importance of a list of individual and collective travel attributes. If relevant, attributes reflecting more-friendly environmental outcomes should correlate positively with the number of trips by bicycle in the public good game; the opposite should occur for attributes reflecting the less-friendly environmental outcomes.

A graphical representation of the sequence of tasks that the participants had to perform is provided in Figure 4.8.

Figure 4 Persuasive system display for Condition 1, if Cooperator

Own elaboration

Figure 5 Persuasive system display before the answer in the public good game for Condition 1, if Cooperator

Own elaboration

Figure 6 Persuasive system display for Condition 1, if Free-Rider

Own elaboration

Figure 7 Persuasive system display before the answer in the public good game for Condition 1, if Free-Rider

Own elaboration

4.2.2 Hypothesis Testing

Hypothesis 1. Persuasive system effectiveness. Cooperation behavior in the public good game is greater in Condition 1 than in Condition 2.

Hypothesis 2. Participants´ self-beliefs affect their contribution behavior. Those who consider themselves as cooperators will cooperate more in the public good game and vice versa.

Hypothesis 3. Participants´ beliefs about others' social preferences affect their contribution behavior. Those who consider their team members as cooperators will cooperate more in the public good game and vice versa.

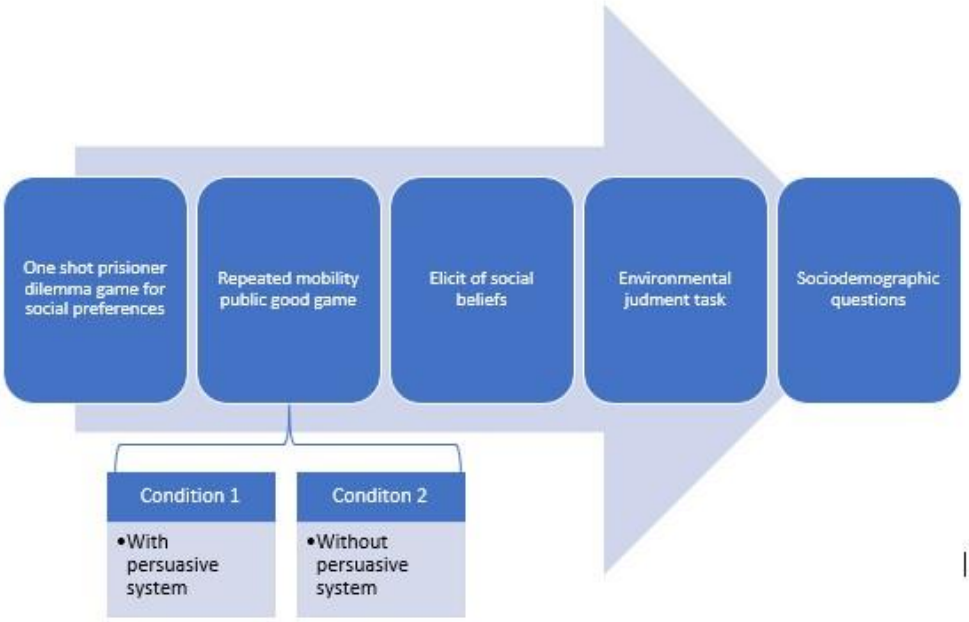
Hypothesis 4. Social preferences affect their contribution behavior. I expect that free-riders should cooperate less in the public good game.

Hypothesis 5. Social preferences correlate with environmental preferences. I expect that free-riders from the Prisoner's Dilemma game should display less environmental concern.

4.2.3 Online Economic Experiment

The economic experiment was run between May 12 and May 14 of 2021. A pilot test was realized one week before in order to practice with the professors the experiment process. The sample consists of 103 students divided into four online classrooms. Both instruments (Condition 1 & Condition 2) were applied in equal parts in each classroom.

Figure 8 Experiment Stages



Own elaboration

The sample consisted of 103 junior high students. 52 students answered the Condition 1 instrument, and 51 students answered the Condition 2 instrument. In total, 61.17% were female and 38.83% were male (Table 4.7). The average age of the participants was between 13 and 16 years old.

Table 7 Sample description

	Male	Female	Total
Cond. 1	16	36	52
Cond. 2	24	27	51
Cond. 1 %	30.77%	69.23%	100%
Cond. 2 %	47.06%	52.94%	100%
Total Sample	40	63	103
Total Sample %	38.83%	61.17%	100

Own elaboration

The online survey and the video that recorded the experiment are available in the next links:

- Online survey: https://forms.gle/SvbXR9TwHHjZt3rz6
- Experiment video: https://1drv.ms/v/s!Ar5oXupsuY_Ct0bNIBuEW2uz0a04

4.2.4 Results

For hypothesis 1 regarding the effectiveness of the Persuasive System, I expected that cooperation behavior in the public good game would be greater for Condition 1 than for Condition 2.

Table 8 Public Good Game results by Condition 1 & Condition 2

	Days of bicycle						
	0	**1**	**2**	**3**	**4**	**5**	**Total**
Condition 1							
#	3	1	5	12	12	19	52
%	5.77%	1.92%	9.62%	23.08%	23.08%	36.54%	100.00%
Condition 2							
#	4	5	10	11	5	16	51
%	7.84%	9.80%	19.61%	21.57%	9.80%	31.37%	100.00%
Total #	**7**	**6**	**15**	**23**	**17**	**35**	**103**
Total %	**6.80%**	**5.83%**	**14.56%**	**22.33%**	**16.50%**	**33.98%**	**100.00%**

Own elaboration

Table 9 T - Test for Hypotheses 1

T - Test the Public Good Game outcome by Condition 1 & Condtition 2				
Hipotheses	**Mean Condition 1 PGG outcome**	**Mean Condition 2 PGG outcome**	**Difference**	**P-Value**
1	3.653846	3.098039	0.5558069	0.07*

Own elaboration

I found that on average the number of days that students choose to travel by bicycle was 3.73. This result is consistent with what is found in the bibliography, where it is commonly observed a significant level of cooperation behavior even in anonymous games.

In Table 4.8 we can observe that the most significant difference is noted in the participants who choose 1 and 4 days of commuting by bicycle. In Condition 1, where participants were

persuaded by the Persuasive System, only 1.92% choose to travel 1 day by bicycle, and 23% choose to travel 4 days by bicycle; in the other hand, in Condition 2, 9.80% of the participants choose to travel 1 day by bicycle, and only 9.80% choose to travel 4 days by bicycle.

The average number of days to travel by bicycle for Condition 1 was 3.65 days and for Condition 2 was 3.09 days. I used an independent group t-test to compare the means between the two groups and found a positive difference between means. The corresponding p-value is 0.0681, which is less than 0.1, and therefore, the difference of means between Condition 1 and Condition 2 is different from 0 (Table 4.9). I conc6lude that due to the positive value in the difference between means, cooperation behavior is greater in Condition 1 than in Condition 2 with a confidence level of 90%.

Table 10 T - Test for Hypotheses 2-3-4-5

T - Test the Public Good Game outcome by Cooperators & Free-Riders Self-Beliefs				
Hipotheses	**Mean Cooperators PGG outcome**	**Mean Free-riders PGG outcome**	**Difference**	**P-Value**
2	3.55	2.79	0.76	0.03**
T - Test the Public Good Game outcome by Cooperators & Free-Riders Others-Belief´s				
Hipotheses	**Mean Cooperators PGG outcome**	**Mean Free-riders PGG outcome**	**Difference**	**P-Value**
3	3.56	2.96	0.59	0.07*
T - Test the Public Good Game outcome by Cooperators & Free-Riders (Social Preferences)				
Hipotheses	**Mean Cooperators PGG outcome**	**Mean Free-riders PGG outcome**	**Difference**	**P-Value**
4	3.25	3.56	-0.26	0.3863
T - Test for the Environmental Score by Cooperators & Free-Riders (Social Preferences)				
Hipotheses	**Mean Cooperators Environmental Score**	**Mean Free-riders Environmental Score**	**Difference**	**P-Value**
5	13.1	12.64	0.46	0.3165

Own elaboration

For hypothesis 2: Participants´ self-beliefs affect their contribution behavior. Those who consider themselves as cooperators will cooperate more in the public good game and vice versa. I found that those who consider themselves as cooperators, on average, chose to cycle 3.55 days. And those who consider themselves as free-riders, on average choose to cycle 2.79 days. I used an independent group t-test to compare the means between the two groups and found a positive difference between means. The corresponding p-value is 0.0332, therefore, the result is significant at 5%.

For hypothesis 3: Participants´ beliefs about others' social preferences affect their contribution behavior. Those who consider their team members as cooperators will cooperate more in the public good game and vice versa. I found that those who think his/her teammates are cooperators, on average chose to cycle 3.56 days. And those who think his/her teammates are free-riders, on average choose to cycle 2.96 days. I used an independent group t-test to compare the means between the two groups and found a positive difference between means. The corresponding p-value is 0.0709, which is less than 0.1, and therefore, the difference of means between Condition 1 and Condition 2 is different from 0.

I conclude that due to the positive value in the difference between means, those who consider themselves as cooperators cooperate more in the public good game with a confident level of 95%. And that those who consider their teammates as cooperators would cooperate more in the public good game with a confidence level of 90%.

For hypothesis 3: Social preferences affect their contribution behavior. I expect that free-riders should cooperate less in the public good game. Those who have free-rider preferences from the Prisoner's Dilemma game should cooperate less in the public good game, I analyze the outcome from the public good game and compare cooperators vs free-riders.

I found that Cooperators chose on average 3.25 days and free-riders chose on average 3.52 days. The corresponding p-value is 0.38, which is bigger than 0.1, and therefore, the difference of means between groups is not significant.

For hypothesis 4: Social preferences correlate with environmental preferences. I expect that free-riders from the Prisoner's Dilemma game should reflect less environmental concern. The higher the index, the higher his/her environmental concern. I found that Cooperators have an average of 13.1 in the environmental index and free-riders have an average of 12.64 in the index. I used an independent group t-test to compare the means between the two groups and found a

positive difference between means. The corresponding p-value is 0.31, which is bigger than 0.1, and therefore, the difference of means between groups is not significant.

I conclude that due to the positive value in the difference between means, cooperators reflect higher environmental concern compared with free-riders, but this difference is not significant.

Chapter 5

5 Conclusions

The main purpose of this work was to design a persuasive system and test its effectiveness in an online economic experiment. The work was divided into two parts; the first was focused on an exploratory analysis looking for the best design of the persuasive system, the second consisted in the application of the persuasive system within an online economic experiment and test its effectiveness in a public good game mirroring the urban social dilemma.

A hypothetical travel choice situation asked participants to contribute to the public good game as an alternative to travel by car. Hypotheses regarding the effectiveness of the persuasive system, participant´s individual behavior, and internal and external validation of the experiment also were developed and tested.

Results showed that my approach had some impact on motivating users on a personal level to change their behavior and make more cooperative choices in a social dilemma situation. The current findings provided strong evidence in support for the main hypothesis of the work: the persuasive system is effective in its goal to increase cooperation behavior in a social dilemma situation (hypothesis 1).

Regarding beliefs and how they influence cooperative behavior; we can observe that participant´s beliefs about their own social preference and other team members' social preferences are reflected in how they behave in social dilemmas. Those who consider themselves as cooperators, and those who consider their team members as cooperators, will exhibit a more cooperative behavior in the public good game (hypotheses 2 and 3).

With regard to a potential relation between social preferences and environmental judgements, I found that there was no relation between free-riders and less environmental concern (hypothesis 5). Moreover, free-riders do not exhibit less preference for commuting by bicycle in the public good game than cooperators (hypothesis 4).

My results reinforce the findings that individuals do not only construe social dilemmas exclusively in terms of their own outcomes, but they consider a significant number of broader endogenous factors derived from a general concern about the well-being of those surrounding them.

The current findings revealed strong evidence that an individual's cooperation behavior is heavily influenced by individual beliefs. Assuming that the environment in which we live has

an important impact on the way we live in society. Assuming this result, it is important to create an environment of trust among the population, if what we seek is to find an effective solution not only to the urban social dilemma but to other types of social dilemmas in society.

Beyond this, my results revealed that there is not a direct correlation between free-riders and less environmental concern. Also, I found that free-riders do not exhibit less preference for commuting by bicycle in the public good game. These results could be explained, first, by inferring that free-riders do not only consider short-term benefits for their behavior, but they could consider more long-term benefits when facing a social dilemma. In this case, free-riders could be more interested in taking care of the environment because it would be better for them to have a less polluted world in the future. Second, free-riders could change their behavior when facing different social dilemma environments. In this case, free-riders could not cooperate if they face a situation where they do not know the people they interact with; but they could cooperate in environments in which they feel part of the group. To analyze these ideas, other types of social preference measures, such as conditional cooperation, should be tested.

My study also shows that social preferences are not important determinants of cooperative behavior in social dilemmas. This could have happened due to the way social preferences were measured. Probably the simultaneous Prisoner's Dilemma is not the best way to measure social preferences, and other measurements like the Social Value Orientations should be applied and compared with the results here analyzed (see Van Vugt et al. (1996)). However, beliefs about others´ contributions are a good endogenous variable to explain cooperative behavior, reinforcing my point that in order to solve social dilemmas, it is important to create an environment of trust.

Chapter 6

6 Future Work

This work shows how online economic experiments can help to develop causal models of human behavior for real-life social dilemmas. This methodology may help academics to further design and execute more laboratory and field experiments looking to increase the external validation.

The number of participants in the online experiment was relatively small, therefore, generalization from these findings is restricted. In order to increase external validation of the findings to a wider population, it is needed to increase experimental research with different group sizes. Also, to enhance external validity, I encourage recruiting a sample of real car commuters who responded to different scenarios in which variables like travel time are travel time variability could be varied.

This experiment was based on a simulated situation which may not necessarily correspond to the real-life setting, as the factors considered are much simpler than in a real-life situation. Revealed preferences field studies could deliver more significant evidence which could confirm the findings of this work. It is also important to expand this methodology using mobility preferences and optimize persuasive interventions combining visual and verbal presentations persuasive strategies.

Students stated that they found this kind of activity fun and entertaining. I think they perceived the quality and ease of understanding of the experiment design.

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