The Effects of Knowledge and Effort on Saving Efficiency

A Senior Thesis Presented

by

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Abstract

People make tradeoffs between spending and saving every day, and they often make these financial decisions together in households, organizations, or communities. Do people save less efficiently in a partnership than they do alone? How can partners cooperate to save more efficiently? We propose two experiments using an economic game in which participants decide each turn whether to spend income to increase their health or save it for future turns. In the first experiment, we manipulate whether participants play alone or with a partner who shares the same savings account. Participants in the partner treatment have to manage their income for survival while considering their partner's behavior. In the second experiment, we examine how knowledge and effort affect participants' efficiency when saving in a partnership. We manipulate whether participants know their partner's income each turn and whether players must complete a task to earn income each turn. The results of these experiments will provide insight into how people can save more efficiently.

1 Introduction

1.1 Saving Efficiency

Do you save your money efficiently? Every day people decide whether to spend their money or save it for future purchases. People can save money by investing it in financial assets such as stocks and mutual funds, depositing it directly into a savings account, or keeping it in their wallet. Deciding between spending and saving can often be a difficult decision that is motivated by factors such as job security, age, debt, and marital status. Parents hoping to support their child through college will have an additional motivation to save money that individuals without dependents do not have. The amount of money that one person is comfortable with saving might be too little for someone else and yet too much for a third person. There is no ubiquitous saving behavior that is efficient for everyone. How can saving efficiency be defined? In a mathematical model, this might be achieved by maximizing all future streams of expected utility. In the real world, however, it is infeasible to measure the risk of financial emergencies such as losing your job, paying to repair your car, or having to buy a new roof for your house. Instead, saving behavior can be compared to a benchmark that represents an intuitive level of efficiency.

1.1.1 Short-term Saving

A benchmark for efficiency in short-term saving is being able to manage an immediate financial emergency. Between 2016 and May 2017, 52% of people in the U.S. were not able to manage a three-month financial disruption using emergency savings (Federal Reserve, 2017). When the criteria is expanded to include financial assets and borrowing, this decreases to 30%.

There is an association between education and short-term saving. Between 2016 and May 2017, adults in the U.S. were asked if they would be able to pay all of their current expenses if faced with an additional $400 expense (Federal Reserve, 2017). 21% of adults with a bachelor's degree said no, compared to 39% of adults with some college or associate degree and 48% of adults with a high school degree.

1.1.2 Long-term Saving

A benchmark for efficiency in long-term saving is maintaining a retirement savings account. Between 2018 and May 2019, 26% of non-retirees in the U.S. had no form of retirement savings (Federal Reserve, 2019). Furthermore, 44% of people in the U.S. did not think that their retirement savings were on track. The threshold for considering retirement savings to be on track varied with age.

There is an association between ethnicity and long-term saving. During the same time period, 21% of whites had no retirement savings, compared to 36% of blacks and 39% of hispanics.

1.2 Future Payoffs

A large minority of people in the U.S. save inefficiently in both the short-term and long-term. One explanation is that people discount future payoffs at various rates (Berns, Laibson & Loewenstein, 2007). This mindset can lead people to spend money on luxuries, such as fast food and designer clothes, rather than maintain emergency and retirement savings accounts. Another explanation is that people prefer spending new income to depleting their savings (Del Ponte & DeScioli, 2019). People save too much when given a low income but save too little when given a high income. Perhaps people's assessment of their ability to manage a short-term financial disruption is skewed by an unwillingness to deplete their savings. Perhaps people only discount the future when they are spending their income rather than depleting their savings. If faced with expenses that require saved money, people become less myopic and discount the present in favor of possible future expenses.

1.3 Partnerships

Would you save more efficiently if you were married or if you lived alone? People often make financial decisions that affect their spouses, children, community members or business partners. People in partnerships have to make different trade-offs than they would as individuals. Someone who lives alone might choose between eating out and saving for retirement, while parents might decide between buying

a larger house and investing in an education IRA for their child. A business partner might choose between awarding himself a higher salary or re-investing in his company, while an individual might choose between buying a new car or saving money and settling for a bicycle. The key difference is that people in partnerships often face financial decisions in which they ultimately choose between benefiting themselves or someone else.

1.3.1 Economic Games

Economic games are mathematical representations of how people make strategic decisions in scenarios such as auctions and bargaining. They are a useful tool that can be used to analyze how people make financial decisions in partnerships.

A person walking down the street might decide whether or not to give a beggar money. This scenario can be represented by a variation of the dictator game. In the dictator game, one player is endowed with money and decides how much to give a second player. The game ends after this action is taken.

A married couple might decide together how much money to save for a vacation. If they cannot come to an agreement then they will not go on a vacation. This scenario can be represented by a variation of the ultimatum game. In the ultimatum game, one player is endowed with money and must decide how much to offer second player. The second player can either accept the offer or reject it. If the second player rejects the offer, both players do not receive any money.

Someone might have to decide whether or not to lend their friend money given that they might not be paid back. This scenario can be represented by a variation of the trust game. In the trust game, one player is endowed with money and decides how much to give a second player. The second player then decides how much to send back the first player. In many variations of the game, the first player is motivated to trust the second player because every dollar that is sent back by the second player is increased in value.

1.3.2 Within Household Behavior

Spouses represent an interesting partnership because their relationship offers repeated interactions and frequently shared money. They must reconcile necessary expenditures on goods such as rent and groceries with luxury spending on goods such as sports cars and video games. Married couples can have joint bank accounts and share money between partners on a daily basis.

What happens when one partner doesn't trust their spouse to make efficient financial decisions? What if one partner keeps a secret stash of their income to gamble with? How do financial decisions change if one partner works 60 hours per week and earns a 6-figure salary while the other works a part time job? There are many unique scenarios that offer the chance for distrust between partners and motivate selfish behaviors that benefit one partner instead of the partnership as a whole. People are not always financially compatible with one another which can lead to dishonesty within a partnership. One person might not feel comfortable with a level of saving that their partner feels is more than enough.

How can two partners save efficiently and avoid selfish spending?

Spouses make larger contributions to the common pool when both are similarly educated and hold similar occupations (Iversen, Jackson, Kebede, Munro, & Verschoor, 2011). This suggests that assortative matching increases household efficiency and partners that come from the same socioeconomic class are more likely to cooperate. When spouses have a significant level of income gender has an insignificant effect on consumption patterns (Palfrey, 2013). Perhaps endowing partners with a significant amount of money can motivate efficient financial decisions and negate other effects that would otherwise influence selfish behavior. Spouses will preserve similar amounts of money for their children regardless of gender (Bjorvatn, Getahun, & Halvorsen, 2020). This suggests that giving partners a common interest increases saving efficiency within partnerships and households.

1.3.3 Motivators of Saving Efficiency

Altruism People make many financial decisions that are motivated by altruism. Donating to a local animal shelter can be motivated by a desire to help those in need. Saving money to surprise your spouse with a luxurious anniversary gift can be motivated by a desire to make someone that you care about happy. Spending and saving decisions are not only dependent on what brings the most individual satisfaction. A partner investing in their child's education IRA can be viewed as an altruistic decision. Saving inefficiencies might stem from selfishly lending to friends and family rather than saving for oneself. What factors influence these altruistic decisions and can they be manipulated to motivate efficient saving in partnerships?

People will sacrifice more than one quarter of their own wealth in an economic game to avoid taking from someone else (Razzolini, Millner, & Korenok, 2014). People dislike taking from others and are willing to make significant sacrifices to avoid doing so. Perhaps the concepts of ownership and stealing are motivators of altruistic behavior. The pressure of conforming to societal norms can repress selfish behavior (White, Laird, & Allen, 2014). Even if it is in one person's best interest to act selfishly, the threat of a bad reputation and future punishments can motivate altruistic behavior. Familiarity has a significant positive impact on altruism (Kalchev, 2017). This suggests that people are more

likely to act selflessly if their sacrifices will benefit someone that they know and trust.

Knowledge People make smaller share offers when the total amount of their wealth is private knowledge (Croson, 1996). This reinforces the idea that people associate a negative utility with being perceived as unfair or selfish. If the total amount of money that someone has to give is unknown, there are less social consequences for being selfish. Perhaps saving efficiency in partnerships can be motivated by enforcing common knowledge of wealth and financial decisions.

Effort and Ownership People develop greater trust and cooperation when they are mutually endowed with common property rather than individually given private property (Cox, Ostrom, Walker, Jaime-Castillo, Coleman, Holahan, Schoon, & Steed, 2009). Ownership decreases trust and cooperation. Perhaps partners are able to avoid selfish behavior and achieve more financially efficient outcomes if they consider their money to be owned by the partnership rather than privately owned money that is being contributed. Proper framing of financial decisions can change the question from "How much should I contribute?" to "How can we divide our money in the best way possible?".

People place a greater weight on losses than gains (Neumann, Kierspel, Windrich, Berger, & Vogt, 2018). This indicates that financial decisions can be framed to motivate saving efficiency and reinforces the idea that people are more willing to spend their new income rather than deplete their savings (Del Ponte & DeScioli, 2019). Spending income is perceived as a reduced gain while spending saved money is seen as a direct loss. Similarly, people might view contributions to their partnership as losses if they are not on good terms with their partner. Perhaps partners can be motivated to save efficiently be reducing their sense of private ownership of their money.

1.4 The Present Experiments

We will test the effects of knowledge and effort on saving efficiency in partnerships through an economic game that can be played as an individual or between two partners. Participants decide each turn whether to spend their money and restore lost health points or save it for future turns. In previous related experiments, participants were often tasked with deciding how much wealth to share with another participant or how much to contribute to a common pool. The present experiments will build upon previous research by introducing a shared savings account that participants must manage throughout the game. Participants in the partner treatment will only be able to save money for future turns in a savings account that their partner has access to. Both partners can withdraw from and deposit into the savings account at any point during the game. This forces participants to manage their money for survival while considering their partner's financial decisions with respect to their shared savings account. Participants will not be able to reserve earnings for themselves throughout the experiment and will instead be paid based on their survival performance in the game.

In the first experiment we will manipulate whether participants play alone or with a partner. The effects of partnership on saving efficiency will be measured by comparing average spending across treatments to an efficient benchmark.

In the second experiment we will manipulate whether participants in the partner treatment have common knowledge of their partner's income and if they must perform an effort task to earn income each turn. The effects of knowledge and effort on saving efficiency will be measured by comparing average spending across treatments to an efficient benchmark.

2 The Survival Game

Participants will play an economic game in which they attempt to survive in a city either alone or with a partner. Participants will begin the game with 300 health points and lose 50 each turn. This greatly reduces the risk of participants losing all of their health points due to bad luck.

Each turn, participants will look for work and have an equal chance of finding work and earning 10 dollars or not finding work and earning 0 dollars. These income values create a large disparity between high and low-income days. Participants face greater consequences for overspending than if the income amounts were 8 and 2 or 7 and 3. The income values also allow for greater variation in spending each turn.

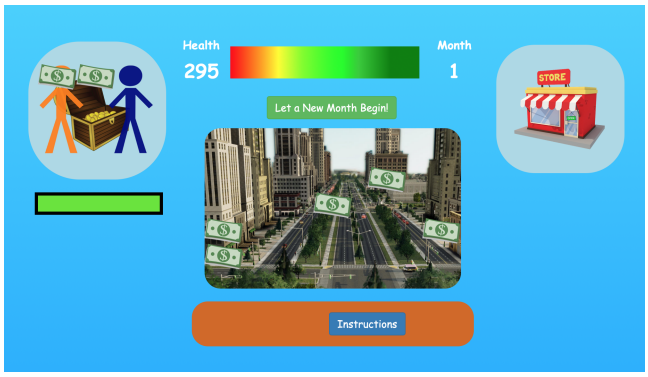

Figure 1: The survival game is programmed using JavaScript and designed using HTML and CSS. Participants save and spend money by dragging their dollars to the savings area (left) and store (right).

Participants must decide each turn whether to spend their money on health points or save it for future turns. Partic-

ipants will face decreasing returns to spending. The first dollar spent each turn will award 10 health points, the second dollar will award 9, and so on. This provides motivation for saving as otherwise participants would be best off spending all of their money immediately. Participants will play the game until their health points reach 0 or they survive the maximum amount of 30 turns. The game is designed such that participants will most likely not survive the maximum number of turns. This allows us to observe how saving efficiency between partners changes as their health points decrease and their survival becomes an immediate concern. We expect to observe unraveling of cooperation as participants scramble to keep their health points above 0.

2.0.1 Simulation

Different spending heuristics were tested using a simulation to determine the most efficient strategy in the survival game (Del Ponte & DeScioli, 2019). Each turn the simulated player spends the minimum between the heuristic value and the total dollars available. If health points would reach 0 on a given turn then the player will spend available dollars as needed to prevent the game from ending. We ran 10000 simulations for each heuristic.

Table 1: Simulated mean (SD) survival outcomes for various spending heuristics in the survival game.

Heuristic	Turns Survived
1 dollar	21.14 (10.14)
4 dollars	25.17 (12.11)
5 dollars	25.61 (13.64)
6 dollars	24.71 (13.90)
10 dollars	13.32 (4.50)
Random	13.61 (4.47)

Simulation Developed by Alessandro Del Ponte and Peter DeScioli

The efficient spending strategy for survival is to spend 5 dollars each turn, if possible, while spending as many available dollars as needed to keep health points above 0. This is referred to as the average-plus heursitic (Del Ponte & DeScioli, 2019). Survival outcomes are worse for participants that overspend rather than those that underspend. If a participant spends a small amount each turn then they accrue a large stockpile of savings by the time their health points near 0. Participants that overspend do not accrue savings and suffer the additional penalty of decreasing returns to spending each turn.

Saving efficiency will be measured by comparing average spending to the efficient benchmark given by the average-plus heuristic.

2.0.2 Strategic Analysis

Participants in the survival game have to choose between spending their money in the current turn or saving for future turns. Participants are motivated to save by decreasing returns to spending and the possibility that they receive an income of 0 dollars in the next turn. This decision is effectively between expected future payoffs and immediate satisfaction. Participants will have to weigh the risk of not receiving any money in the following turn to decide how much to save in the present turn. In the partner treatment this decision is complicated by the shared savings account. Now participants must also weigh the risk of their partner withdrawing their savings and the likelihood that they will benefit from their partner's saving on low-income days.

Participants playing the game as partners can base their decisions each turn on their partner's behavior in previous turns. If a participant watched their partner take every dollar deposited into their shared savings account last turn, they might decide to save less this turn due to their partner's recent selfish behavior. If a participant watched their partner deposit five dollars into their shared savings account, they might decide to reciprocate and save half of their income the next time they receive 10 dollars. Participants can also condition their strategies based on actions taken within turns. A participant might decide to save one dollar and only save another if their partner does not take it within the next 10 seconds.

Since participants in the survival game will not be able to communicate, they will be unable to form explicit threats and promises. Participants can attempt to punish their partner for being selfish by refusing to contribute to the shared savings account or immediately spending every dollar that their partner saves. Participants can also reward their partner for saving by not excessively withdrawing and reciprocating contribution to the shared savings account.

A Nash Equilibrium is a strategy that a player has no incentive to deviate from. Spending your entire income is one possible Nash equilibrium for partners in the survival game because a player cannot improve their payoffs by unilaterally switching to saving if their partner continues to spend everything. Looking at the entire game as a series of repeated games, there is also a cooperative equilibrium in which both players saves efficiently while their partner does the same. This equilibrium can be enforced by the trigger strategy of not saving at all. To maximize survival, participants will have to forgo the selfish Nash equilibrium and cooperate to save efficiently as per the average-plus heuristic.

2.1 Data Collection

All of the data for both experiments will be collected and stored in a database hosted on a Firebase server. Local JavaScript functions within the survival game will send data

from participants' computers to the database. The data is stored in a hierarchy of nodes which function similar to a folder system on a computer. This database allows us to download and analyze data using a JavaScript function.

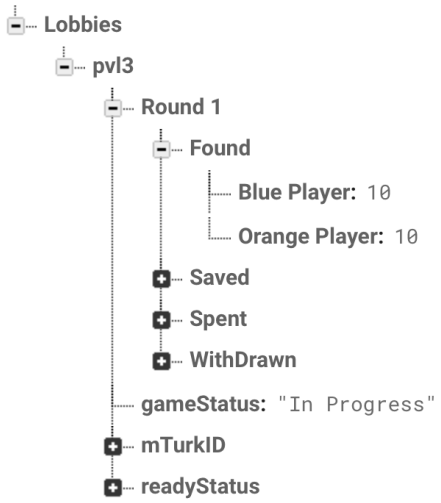

Figure 2: Hierarchy of data stored on the Firebase server. Each lobby contains all of the data for each game and its participant(s). Data can be easily retrieved using a JavaScript function.

Hypothetical Data We have not yet been able to collect data for these experiments. We offer analyses and discussions of hypothetical data to highlight our predictions and methods of data analysis.

2.2 Software Challenges

Programming the survival game to function for two partners presented several software challenges. Designing infrastructure for multi-player economic games can support future related experiments.

2.2.1 Lobbies

We developed a lobby system that will automatically sort players into open lobbies for games with two partners. When a participant enters the study a local JavaScript function looks through all of the existing lobbies that are stored in Firebase. If there are no open lobbies available then a new lobby is created, and the participant is asked to wait for their partner. If the participant disconnects during this waiting period then their lobby is closed. This prevents participants from joining an empty lobby. If an open lobby with one waiting participant exists then the participant is placed into that open lobby, which is subsequently closed. When the lobby is closed, both participants are informed that their partner is present and they begin the game.

2.2.2 Disconnection

One participant can disconnect during a game intentionally or as a result of poor connection. If one participant disconnects then their partner will remain in the game. It is also likely that partners will not lose all of their health on the same turn, so it is expected that one participant will end the game and disconnect before the other. To prevent this from ruining the format of our database, all of a participant's future node values are set to "N/A" once they disconnect from the game. Participants are alerted if their partner leaves the game or loses all of their health points, and are allowed to complete the game on their own.

2.2.3 Idling

A participant can stop interacting with the game and leave their computer for extended periods of time. This forces their partner to unfairly wait and prevents participants from completing the study in a reasonable amount of time. To prevent this from happening, we programmed a feature that will forcibly disconnect an unresponsive participant from the game after several minutes. The remaining participant will be allowed to finish the game as if their partner had disconnected or lost all of their health points.

2.2.4 Syncing

Both partners must click the next turn button for either of them to advance. This ensures partners are always on the same turn of the game. When a participant's partner clicks the next turn button, they will receive an alert that their partner is ready to go to the next turn. This reminds participants that they are playing with a human partner who might be waiting for them.

2.2.5 Dragging

The shared savings account will display the same amount of dollars at all times in both partners' games. Either player can click on a dollar and drag it to the store at any given time. This is maintained by tracking participants' deposits and withdrawals and constantly updating Firebase with the total amount in the account. To prevent participants from duplicating a dollar in the shared account by clicking on it at the same time, the dollar disappears from the account immediately when either participant clicks on it.

3 Experiment 1

In the first experiment we test the effects of partnership on saving efficiency. Participants in the individual treatment will play the survival game alone with a private savings account for a maximum of 30 turns. Participants in the partner treatment will play with another participant and a shared savings account for a maximum of 30 turns. Saving efficiency

will be measured by comparing average spending to the efficient benchmark of 5 dollars per turn. We will also examine saving efficiency for three different ranges of health points to see if partnership's effect on efficiency changes throughout the game.

3.1 Methods

Participants (N = 400) will enter the study through Amazon Mechanical Turk. This platform allows for hundreds of people to participate in the study over a short amount of time with a significantly lower cost than in-person subjects. Each participant will login to the study with a unique Mechanical Turk ID which allows us to coordinate payment afterwards and ensure nobody participates in the study more than once.

Every participant will receive a base payment of $0.50 for successfully completing the game and a bonus of $0.05 for every turn that they survive. This allows for a maximum payment of $2.00 per participant. If a participant disconnects before they complete the game then they will only receive the base payment. If one participant disconnects in the partner treatment then the remaining partner will be able to earn the base and bonus payment.

3.2 Hypothesis and Predictions

Previous research has shown that spouses are able to make more efficient financial decisions when their interests are aligned (Bjorvatn, Getahun, & Halvorsen, 2020) or when they come from similar socio-economic backgrounds (Iversen, Jackson, Kebede, Munro, & Verschoor, 2011). In the partner treatment, participants' only goal will be to survive for as many turns as possible. Since their success is not based on their partner's survival their interests are not directly aligned. Previous research has also shown that people are more willing to share resources when their total wealth is known to both parties (Croson, 1996). In this experiment participants will not be informed of each other's income. It has been found that people develop better trust and cooperation when they are not personally endowed with money (Cox, Ostrom, Walker, Jaime-Castillo, Coleman, Holahan, Schoon & Steed 2009). In this experiment participants will be directly endowed with 10 dollars on high-income days. Participants in the partner treatment will also lack familiarity, another proven indicator of altruism (Kalchev, 2017).

We propose the selfish preservation hypothesis. Many of the factors that have been shown to promote financial efficiency and altruistic behavior in partnerships are not present in this experiment. Participants in the partner treatment will not have significant motivation to trust their partners or contribute to the shared savings account. The partnership framing will not be sufficient to improve the saving inefficiency expected in the individual treatment (Del Ponte & DeScioli, 2019). We predict that partnership will decrease saving efficiency. To test this prediction we will compare the average saving each turn between treatments for both high and low-income days. In addition we will examine how saving efficiency between treatment groups changes as participants' health decreases.

3.3 Hypothetical Results

3.3.1 Overall Saving Efficiency

We found that participants in the individual treatment spent an average of 0.81 (0.13) dollars less than the efficient benchmark on low-income days, compared to 1.57 (0.14) dollars less in the partner treatment. Participants in the partner treatment spent an average of 0.76 (0.19) dollars less than participants in the individual treatment on downturn days ($t(200) = 3.99$, $p < .01$).

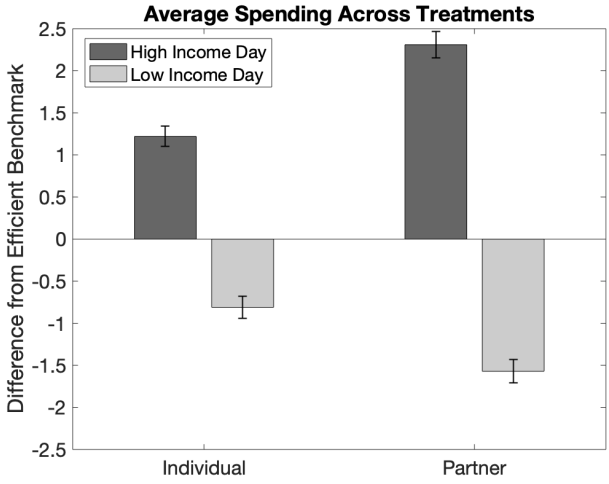

Figure 3: Average spending compared to the efficient benchmark between individual and partner treatments. All mean (SE) values are statistically different from 0 ($p < .01$).

Participants in the individual treatment spent an average of 1.22 (0.12) dollars more than the efficient benchmark on high-income days, compared to 2.31 (0.16) dollars more in the partner treatment. Participants in the partner treatment spent an average of 1.09 (0.19) dollars more than participants in the individual treatment on high-income days ($t(200) = 5.45$, $p < .01$).

3.3.2 Saving Efficiency and Health

High-Income Days Participants in the individual treatment spent 0.87 (0.18) dollars less than participants in the partner treatment when their health points were between 100 and 200 ($t(200) = 4.88$, $p < .01$) and 1.04 (0.17) dollars less when their health points were between 200 and 300 ($t(200)$

= 6.11, $p < .01$).

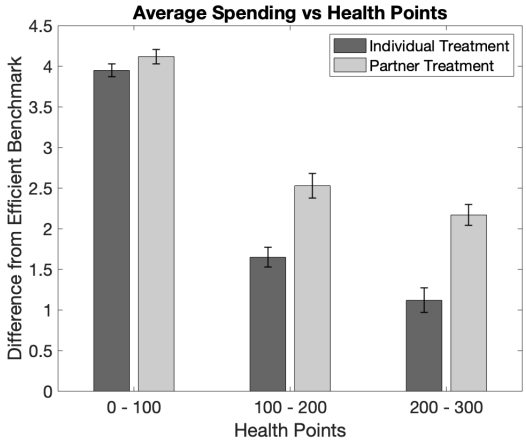

Figure 4: Average spending behavior compared to the efficient benchmark between individual and partner treatments. Data taken on high-income days across health values. All mean (SE) values are significantly different from 0 ($p < .01$).

The difference in average spending between treatments was not significant when participants had less than 100 health points ($t(200) = 1.41$, $p = .16$).

Low-Income Days Participants in the individual treatment spent 0.80 (0.18) dollars less than participants in the partner treatment when their health points were between 100 and 200 ($t(200) = 4.33$, $p < .01$) and 0.71 (0.16) dollars less when their health points were between 200 and 300 ($t(200) = 4.50$, $p < .01$).

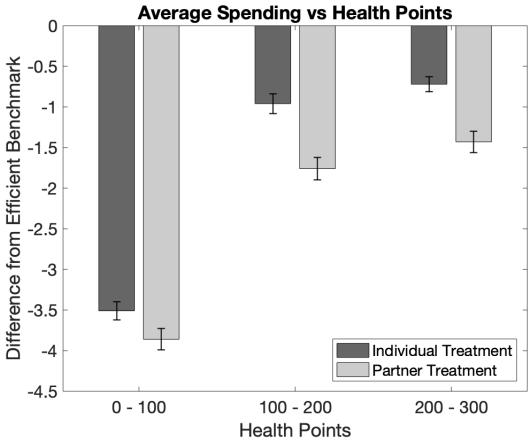

Figure 5: Average spending behavior compared to the efficient benchmark between individual and partner treatments. Data taken on low-income days across health values. All mean (SE) values are significantly different from 0 ($p < .01$).

The difference in average spending between treatments decreased to 0.35 (0.16) when participants had less than 100 health points ($t(200) = 2.06$, $p = .04$).

3.3.3 Survival

We found that participants in the partner treatment face worse survival outcomes than participants in the individual treatment.

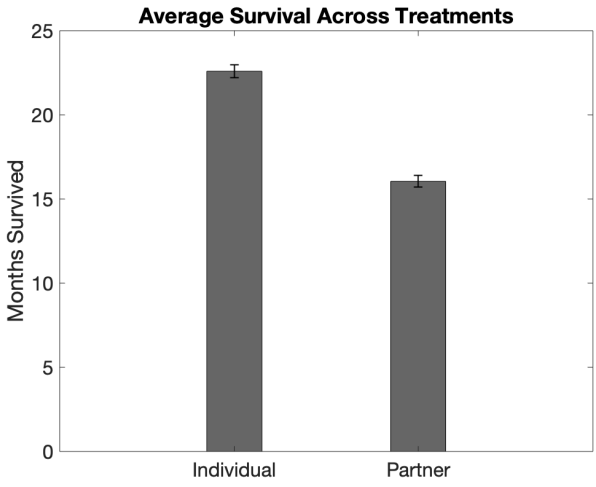

Figure 6: Average survival outcomes between the individual and partner treatments. All mean (SE) values are significantly different from 0 ($p < .01$).

Participants in the partner treatment survived for an average of 16.05 (0.35) days compared to 22.59 (0.37) for participants in the individual treatment. On average, participants in the partner treatment survived for 6.54 (0.50) days less than participants in the individual treatment ($t(200) = 12.84$, $p < .01$).

3.4 Discussion

The results for the individual treatment agree with previous research (Del Ponte & DeScioli, 2019) and show that individuals overspend on high-income days and underspend on low-income days. This behavior is further exacerbated in the partner treatment, showing that partnership significantly decreased saving efficiency for both high and low-income days and providing support for the selfish preservation hypothesis. Consistent overspending on high-income days forces participants to similarly underspend on low-income days.

When participants had less than 100 health points, the negative effect of partnership on saving efficiency became insignificant on high-income days and less significant on low-

income days. This offers an exception to the selfish preservation hypothesis and suggests that when survival becomes an immediate need, partnership no longer has a significant effect on saving efficiency or financial decisions.

Partnership also significantly decreased survival outcomes. This is a direct consequence of participants achieving more saving inefficient behavior on both high and low-income days in the partner treatment.

These results support our prediction that partnership decreases saving efficiency, barring the exception of when participants have low health points. Without external motivation, people do not save efficiently and people in partnerships save less efficiently than as individuals overall.

4 Experiment 2

In the second experiment we test the effects of knowledge and effort on saving efficiency in partnerships. Participants in the control treatment will play the survival game with one partner and a shared savings account for a maximum of 30 turns. Participants in the knowledge treatment will receive a notification each turn that informs them of their partner's income for that turn. Participants in the effort treatment will receive a pop-up task each turn that requires them to click on a minimum number of disappearing dollars before receiving their income. Participants in the interaction treatment will receive knowledge about their partner's income and be required to complete the effort task each turn. Saving efficiency will be measured by comparing average spending to the efficient benchmark of 5 dollars each turn.

4.1 Methods

Participants (N = 800) will enter the study through Amazon Mechanical Turk. The payment plan will follow the scheme outlined for the first experiment.

4.2 Hypotheses and Predictions

4.2.1 Knowledge

We will manipulate knowledge by informing participants of their partners income each turn. This information will provide common knowledge of each player's wealth throughout the game and motivate participants to contribute to their shared savings account (Croson, 1996). Furthermore, informing participant's of their partners income will eliminate any sense of doubt or deception that participants might have felt in the first experiment. This bolstered perception of trust should also motivate contribution to the shared savings account (Cox, Ostrom, Walker, Jaime-Castillo, Coleman, Holahan, Schoon, & Steed 2009). Participants might also develop a sense of familiarity through constant knowledge of each other's income which has been shown to motivate altruistic behaviors (Kalchev, 2017). We propose the information efficiency hypothesis that predicts saving efficiency will improve with common knowledge of income. We will test this prediction by measuring average spending data across the four possible income conditions between partners.

4.2.2 Effort

We will manipulate effort by requiring participants to perform a task to receive income at the start of each turn. This effort task is designed to give participants a stronger sense of ownership over their money which will decrease cooperation (Cox, Ostrom, Walker, Jaime-Castillo, Coleman, Holahan, Schoon, & Steed, 2009). As a result of their stronger sense of ownership, participants will be less willing to contribute to the shared savings account. We propose the protective ownership hypothesis which predicts that effort will significantly decrease saving efficiency. We will test this hypothesis by measuring average spending data on both high and low-income days.

4.3 Hypothetical Results

Effort We found that participants in the effort treatment spent an average of 3.39 (0.19) dollars more than the efficient benchmark on high-income days, compared to 2.54 (0.17) dollars more in the control treatment. Participants in the effort treatment spent an average of 0.85 (0.25) dollars more than participants in the control treatment on high-income days ($t(200) = 3.33$, $p < .01$).

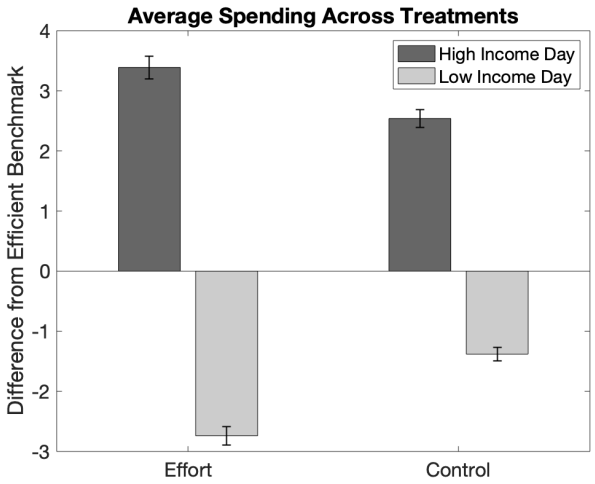

Figure 7: Average spending behavior compared to the efficient benchmark between control and effort treatments. All mean (SE) values are significantly different from 0 ($p < .01$).

Participants in the effort treatment spent an average of 2.74 (0.15) dollars less than the efficient benchmark on low-income days, compared to 1.38 (0.11) dollars less in the

control treatment. Participants in the effort treatment spent an average of 1.36 (0.18) dollars less than participants in the control treatment on low-income days ($t(200) = 7.31$, $p < .01$).

Knowledge To analyze the effects of knowledge on saving efficiency, we divide the data into four income conditions. It is no longer sufficient to only look at spending behavior on high and low-income days since participants are aware of their partner's income each turn.

Participants' average spending in the knowledge treatment is not significantly different from the efficient benchmark on mutual high-income days ($t(200) = 1.07$, $p = .29$). Participants in the knowledge treatment spent an average of 1.00 (0.20) dollars less than participants in the interaction treatment on mutual high-income days ($t(200) = 4.94$, $p < .01$). On mutual low-income days, participants in the knowledge treatment spent 1.11 (0.17) more than participants in the interaction treatment ($t(200) = 5.78$, $p < .01$).

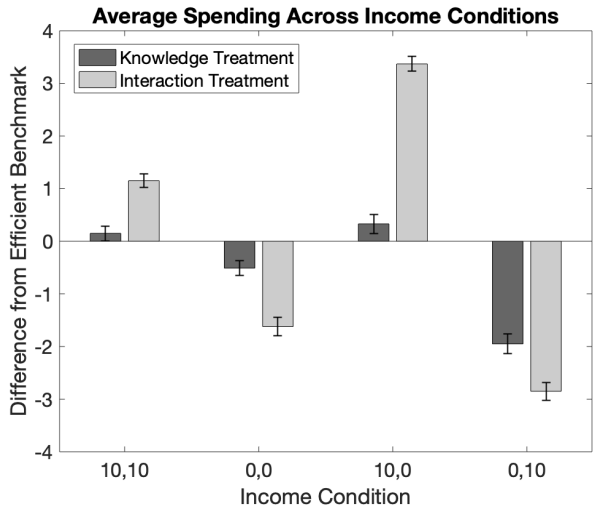

Figure 8: Average spending behavior compared to the efficient benchmark between the knowledge and interaction treatments. Data is taken across the four possible income conditions. All mean (SE) values are significantly different from 0 ($p < .01$) except for the knowledge treatment on 10,10 days ($p = .29$) and 10,0 days ($p = .07$).

Average spending on 10,0 days in the knowledge treatment is not significantly different from the efficient benchmark ($t(200) = 1.83$, $p = .07$). Participants in the knowledge treatment spent 3.04 (0.23) dollars less than participants in the interaction treatment on 10,0 days and 0.90 (0.25) dollars more on 0,10 days.

Interaction For all four income conditions, average spending in the knowledge treatment was significantly closer to the efficient benchmark than in the interaction treatment ($p < .01$ for all comparisons).

Survival We found that participants in the effort treatment faced the worst survival outcomes while participants in the knowledge treatment faced the best survival outcomes.

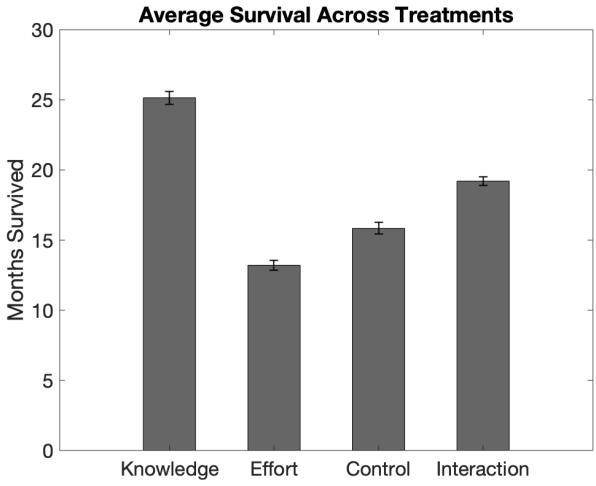

Figure 9: Average survival outcomes between the control, effort, knowledge and interaction treatments. All mean (SE) values are significantly different from 0 ($p < .01$).

Participants in the knowledge treatment survived for an average of 9.31 (0.65) days longer than participants in the control treatment, compared to 3.37 (0.51) days longer for those in the interaction treatment and 2.63 (0.53) days less for those in the effort treatment. All survival comparisons to the control treatment are statistically significant ($p < .01$).

4.4 Discussion

We found that effort significantly decreased saving efficiency on both high and low-income days. Partners save less efficiently when they have a strong sense of ownership over their money. When participants in the knowledge treatment were required to perform effort tasks their saving efficiency significantly decreased for all income conditions. This further reinforces the result that effort decreases saving efficiency and supports our prediction based on the protective ownership hypothesis.

Participants in the knowledge treatment were able to save efficiently on mutual high income and 10,0 days. This suggests that under specific income conditions partners with common knowledge of income can be motivated to save efficiently. Perhaps participants in the knowledge treatment did not save

efficiently on 0,0 days because of their preference not to deplete their savings (Del Ponte & DeScioli, 2019). The failure to save efficiently on 0,10 days can be a result of participants being unwilling to take what does not belong to them (Razzolini, Millner, & Korenok, 2014). These results provide limited support for the information efficiency hypothesis and show that our prediction was only correct under specific income conditions.

5 General Discussion

In experiment 1 we found that partnership decreases saving efficiency for both high-income and low-income days. Participants did not receive sufficient motivation to trust their partners and the saving inefficiency observed in the individual treatment was worsened by the presence of a partner. The exception to our prediction is when participants faced an immediate need for survival. Perhaps the framework of high-income and low-income days can be adjusted to include desperate times. Many of the factors that have been found to affect sharing and altruistic behaviors might fail to do so when people face a desperate need.

Partnership also decreased survival outcomes in experiment 1 which is likely a direct consequence of participants' worse saving efficiency compared to the individual treatment.

In experiment 2 we found that knowledge significantly increases saving efficiency on mutual high-income days and days on which the participant received 10 dollars and their partner received 0 dollars. This finding suggests that knowledge is a sufficient motivator of saving efficiency given specific wealth conditions. It is not clear whether participants failed to save efficiently on mutual low-income days because they were reluctant to take from their partner or preferred not to deplete their savings. This result gave limited support to our prediction as further investigation is needed to determine how income conditions affect saving efficiency.

In experiment 2 we also found that effort significantly decreased saving efficiency. This result was reinforced by the interaction treatment, which showed that even with common knowledge of income effort still significantly decreases saving efficiency for all income conditions. Further investigation is needed to understand which factors can be manipulated to reduce the negative effects of effort and ownership on saving efficiency.

Effort also decreased survival outcomes in experiment 2, which is again likely a direction consequence of participants' worse saving efficiency when required to perform effort tasks to earn their income.

6 Future Directions

There are several interesting experiments that might be considered for future studies involving the multi-player survival game. These are also effects that we would like to observe after data for the two experiments proposed in this paper can be collected and analyzed.

6.1 Mutual Income

It would be interesting to observe if saving efficiency can be motivated by endowing partners with a common income each turn instead of privately distributed incomes. Would partners be able to save efficiently if their shared savings account is endowed with income instead of each participant?

6.2 Investment

Can partners save efficiently if they share a common interest? The shared savings account in the partner treatment can earn interest each round depending on how much the partners currently have saved. This would give participants more reason to save and we might even find that participants save too much on high-income days given this condition.

6.3 More than Two Partners

The infrastructure for the survival game is programmed to support an unlimited number of participants playing together in one game. We can run basic experiments with the shared savings account and observe how increasing the number of partners affects saving efficiency. Perhaps there is a unique number of partners that has induces the opposite effect than we found with two partners.

6.4 Chat

We developed a functional chat module that can be implemented into the survival game to allow for direct communication between partners. It would be very interesting to find out if communication allows partners to save efficiently or if it furthers distrust by giving partners opportunities to deceive one another.

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A Survival Game Instructions

Appropriately labeled sections of the instructions are only shown to corresponding treatments in each experiment. Italicized instructions are only included in ubiquitous sections for corresponding treatments.

Overview – The City Survival Game

While playing this game, imagine that you are trying to survive by yourself in a regular city.

While playing this game, imagine that you are trying to survive with a partner in a regular city.

You will begin the game with 300 health points. Every turn, which is analogous to one month, you will lose 50 health points. These health points correspond to obtaining basic necessities such as food, rent, utilities and occasional luxury purchases.

Every turn, you will earn an income of either 0 or 10 dollars with equal probability. You will be responsible for deciding how much of this income to spend on health points and how much to save for future turns.

Your partner will also earn an income of either 0 or 10 dollars with equal probability each turn.

The dollars that you or your partner save each turn will be placed into a shared savings area. Both you and your partner will be able to drag and drop dollars to and from this shared savings area at any given time.

The goal of the game is to survive for 30 months while keeping your health points above 0. *Your partner has the same goal.*

You will earn an additional $.05 for every turn you survive.

Health and Earning Money

You will start the game with 300 health points.

Each turn, which equates to one month, your health decreases by 50 points due to spending on necessities.

You will perform an effort task each turn before you receive your income.

Each turn, you will receive either 0 or 10 dollars with equal probability.

In order to end your turn, your wallet must be empty.

There is no limit to how many dollars can be in your savings at any given time.

Spending and Saving

You can purchase more health points by spending your income in the store. To do so, simply drag and drop the dollar icons from your wallet to the store area.

The first dollar spent in the store on a given turn will yield 10 health points. The next dollar spent will earn 9 health points, and so on. This decreasing health points return will reset at the start of each turn.

You can save your dollars by dragging them from your wallet to the savings area.

Dollars can be dragged from the savings area to the store but may not be dragged from the piggy bank area to the wallet area. Once a dollar is spent in the store, it may not be recovered.

Any dollars that you or your partner drag and drop into the savings area can be used by either player at any given time.

Your Partner

You will play this game simultaneously with another human partner.

Your partner will be playing the same exact game and have the same goal. It is not gauranteed that your partner will earn the same income as you every turn.

Each turn both you and your partner will be informed of each other's income.

Each turn your partner will perform an identical effort task before they receive their income.

Summary

You will begin the game with 300 health points.

You will lose 50 health points each turn due to spending on basic necessities.

You and your partner will perform an identical effort task each turn before you receive your income.

Your partner will play the exact same game, but their income is also random.

Each turn, you must decide how much of your income to spend and how much to save.

Any dollars that you or your partner save can be used by any player at any given time.

Each turn both you and your partner will be informed of each other's income.

Your wallet must be empty before continuing to the next turn.

Your goal is to survive for 30 turns, or as long a possible.

B Survival Game Survey Questions

1. How did you make your decisions in this study?

2. Were there any problems during the study?

3. What is your sex?

4. What is your age?

5. What is your ethnicity?

6. Please write any other comments about the study below.