8-2013

Sharing: Social Behavior in Situations of Risk

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SHARING: SOCIAL BEHAVIOR IN SITUATIONS OF RISK

by

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A dissertation submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
Psychology
Western Michigan University
August 2013

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Western Michigan University, 2013

The present study will experimentally investigate human cooperation (sharing) in a laboratory foraging task that simulates environmental variability and resource scarcity (shortfall risk). Specifically, it investigates whether a risk-reduction model of sharing developed by evolutionary biologists (derived from a risk-sensitive optimization model known as the energy-budget rule) could predict human cooperative behavior. Participants respond to earn points exchangeable for money when point gains were unpredictable. Failures to acquire sufficient points result in a loss of accumulated earnings (a shortfall). Participants are given the choice between working alone or working with others. The difficulty of meeting the earnings requirement is manipulated across conditions to investigate the effects of economic context on sharing. The effects of social variables on sharing are also investigated to determine whether they constrain optimal decision making. Thus, the experiments investigate cooperation when: (1) participants are told the other person is a computer or another person (who is actually fictitious), (2) the correlation in earnings between the participant and partner is manipulated, (3) the earnings between the participant and partner are inequitable, and (4) the probability of reciprocity from the partner is varied. Overall, the results show that sharing is well predicted by a risk-reduction model of sharing. Sharing occurs under relatively good environmental conditions (positive budget conditions) when sharing reduces shortfall risk, but sharing does not occur under poor environmental conditions (negative budget conditions) when working alone is the only way to meet earnings requirements. Social variables have no effect on optimal decision making. These results contribute to our understanding of how economic conditions and social stimuli influence cooperation, and indicate that risk-reduction models may be useful for predicting cooperation, and failures to cooperate, among various social units, including businesses, political organizations, socio-cultural groups, and individuals. They also provide additional evidence that foraging models developed by evolutionary biologists can be useful tools for analyzing and predicting human behavior, including behavior involving monetary outcomes.

ACKNOWLEDGMENTS

I would like to thank Dr. Scott Gaynor, Dr. Alan Poling, and Dr. Maarten Vonhof, the members of my dissertation committee, for their insightful comments and support. I especially would like to thank Dr. Cynthia Pietras for guiding my graduate training and assisting in the development of this research and preparation of this manuscript. Her comments, suggestions, advice, time, and patience were an invaluable part of my graduate training. She provided an impeccable model of a graduate advisor. I would also like to thank Zach Zimmerman, David Nichol, Felicidad Zamarripa, and Jessica Cunningham for their assistance in implementing this research and Amber Watts, Adam Fox, J. Adam Bennett, Gabriel Searcy, Tomesha Manora, and Katherine Gayman for their daily support throughout my graduate training. I am forever indebted to Dr. Thomas Critchfeild for first introducing me to the field of Behavior Analysis and am grateful to my family and friends for their continuous encouragement and patience. Finally, I would like to thank the Graduate College at Western Michigan University for funding this research through a Graduate Student Research Fund.

Stephanie Theresia Stilling

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CHAPTER I

SHARING: SOCIAL BEHAVIOR IN SITUATIONS OF RISK

Cooperation has been defined in various ways, and is sometimes used to refer to social interactions that result in mutual benefits for participating individuals (Marwell & Schmitt, 1975; Nowak, 2006; West, Griffin, & Gardner, 2007a). This should be differentiated from altruism, which is defined as behavior by an individual that benefits another, but at some cost to the individual's own reproductive fitness (West et al.). Cooperative behavior is widely observed in both nonhuman and human social groups (Winterhalder, Lu, & Tucker, 1999). Because cooperation sometimes involves a cost to the actor's relative fitness, it would seem that such behavior should not be favored by natural selection. Therefore, much theoretical and empirical research has attempted to identify the environmental conditions under which cooperative behaviors would evolve and be maintained. For example, evolutionary biologists have sought to identify the ultimate, or evolutionary, causes of cooperation (Nowak, 2006), while anthropologists have focused how cooperation evolved in human social groups (Kaplan & Hill, 1985), and psychologists have tried to identify how more proximate variables contribute to a given instance of cooperation (Hackenberg, 1998).

One type of cooperative behavior is sharing resources with other individuals. Sharing involves the transfer of resources from one individual to another and can take many forms, including delayed or probabilistic reciprocal giving and intercommunity exchange (Winterhalder & Smith, 2000). Another form of sharing is pooling of resources with others and then dividing these resources among those who contributed (Winterhalder, 1986). Sharing with genetic relatives, particularly offspring, is common in both nonhumans and humans (Kaplan & Hill, 1985; Nowak, 2006; West, Griffin, & Gardner, 2007b). Although sharing does not appear to be in the self-interest of individuals because it involves a loss of resources; from an evolutionary perspective, sharing resources with genetic relatives can be adaptive if it contributes to the relative's reproductive fitness (Hamilton, 1963). Sharing with individuals who are not genetically related is more difficult to interpret, as the adaptive value of sharing with nonrelatives is less obvious. However, sharing food and other resources with individuals who are not genetically related is also observed in both humans and nonhumans (Winterhalder et al., 1999).

For example, Hames (1990) demonstrated that the Yanomamö of Venezuela share a variety of food stuffs from vegetation to large game, with the amount and frequency of sharing varying depending on the predictability of the resource, i.e., less predictable resources were shared more. The Oto and Twa, two ethnic groups from the Lake Tumba area of Zaire, often share fish both between groups and with individuals within each group (Pagezy, 1988). In addition, Bliege Bird and Bird (1997) found males of the Meriam of Australia's Torres Strait hunted sea turtles and consistently shared with older males, females, and children.

Although not as prevalent as in human societies, the sharing of food with nonrelatives has also been observed in several nonhuman species. For instance, the common raven will communicate to others when one finds a large food source like a moose carcass (Heinrich & Marzluff, 1995), and the greater nose-speared bat will communicate to others when one locates a termite swarm (Wilkinson, 1988). Thus, when one organism finds a food source, instead of feasting on it alone, the organism calls to others and enables them to feed on it as well. Social carnivores and chimpanzees engage in cooperative group hunting more often than solitary hunting and the hunting group shares the prey that is caught (Packer & Ruttan, 1988; Stanford, 1995). Furthermore, vampire bats will share provisions of regurgitated blood with both relatives and nonrelatives (Wilkinson). These incidents of sharing have been explained by evolutionary biologists with different theories, such as reciprocity (Trivers, 1971) or group selection (Nowak, 2006), all of which attempt to isolate the indirect fitness benefits that organisms accrue by engaging in these cooperative or sharing behaviors.

Evolutionary Accounts of Sharing

Human behavioral ecologists, sometimes known as evolutionary anthropologists, have also attempted to explain human sharing by identifying its adaptive value. These anthropologists have attempted to apply theories derived from research with nonhuman organisms to human food sharing. Several evolutionary-based theories have been proposed to account for human sharing with nonrelatives, including tolerated theft, trade, and risk reduction (Bliege Bird & Bird, 1997; Hawkes, 1993).

Tolerated theft involves permitting competitors to take resources because the cost of defending those resources is higher than the benefits received from retaining them. This explanation of sharing is typically applied in situations that involve a resource which can be characterized by a diminishing-returns curve wherein each additional unit of the resource is less beneficial or valuable than previous units (Bliege Bird & Bird, 1997; Hawkes, 1993; Kaplan & Hill, 1985). Food would generally fall into this category because increasing consumption of the same food item has smaller incremental value than the first few bites. The theory of tolerated theft states that because the benefits received from continual food consumption decreases, at some given point the cost of defending the food item from competitors will exceed the benefits received from continued consumption. Thus, the owner allows others to have the food. Furthermore, those who have been unsuccessful at acquiring food may be willing to pay a higher cost to take food than the owner would be willing to pay to defend it, again because the possible benefits from energy gains would be higher for the aggressor than the owner who already has consumed some of the food.

Trade involves the exchange of resources that differ in terms of their fitness currency (Bliege Bird & Bird, 1997; Kaplan & Hill, 1985). For example, an individual will exchange extra food for other goods or services which confer higher fitness benefits. The reciprocation of an exchange can occur immediately or after some time delay. If the reciprocation does not occur simultaneously, however, then it leaves open the possibility of cheating. To avoid this exploitation, it is important for the giving individual to be able to distinguish between those who will and will not reciprocate the giving act (Nowak & Sigmund, 1998). Typically, trade is used to explain sharing in situations in which successful males give food to others and the act is apparently reciprocated by indirect benefits such as allies, or direct benefits such as increased attention and access to females. Human studies that have found support these two theories are discussed in more detail below.

Risk reduction is another theory of sharing that has been investigated in several anthropological studies. One premise of this account is that when an individual forages independently, instability in food acquisition leads to variation in the mean rate of energy gains (Winterhalder et al., 1999). The larger this variation, the higher the likelihood an individual will not be able to meet his or her energy requirements. Thus, foraging independently results in variable food acquisition and, in turn, consumption. If foragers pool and share food acquisitions, however, the variability in resources is averaged across all individuals thereby reducing the risk that any one person will experience a shortfall (i.e., not meet their daily energy requirement). Winterhalder (1986) proposed that the effect of sharing on the variability of food acquisition can be expressed as:

$$\sigma = s\left[\frac{1+(N-1)R}{N}\right]^{0.5} \tag{1}$$

where σ is the variability in food acquisition after sharing, s is the variability in food acquisition experienced by individual foragers prior to sharing, N is the number of foragers sharing their acquisitions, and R is the correlation of acquisitions between foragers. Winterhalder demonstrated that when foragers are asynchronous in their success at acquiring food, either because they are foraging at different times or different locations, sharing with only a couple of individuals will greatly reduce the variability in food acquisition. Specifically, when there is a perfectly negative correlation in foragers' food acquisitions (i.e. $r = -1.0$), sharing with just one other person ($N = 2$) will reduce the variability in food acquisition to zero ($\sigma = 0$). Therefore, if individuals differ in their foraging success, then foraging independently can be viewed as a high variance option, whereas sharing reduces the variability in food acquisitions across individuals and can, therefore, be viewed as a low variance option.

The Energy Budget Model

Risk-reduction accounts of food sharing are derived from a risk-sensitive optimal foraging model known as the energy-budget rule which was developed to predict adaptive foraging choices in an unpredictable environment (Caraco, Martindale, Whittam, 1980; Stephens, 1981). Risk sensitivity refers to an organism's preference for fixed or variable options (Fantino & Romanowich, 2006). The energy budget model concentrates on the survival aspect of fitness, more specifically on starvation avoidance (Houston, 1991).

The energy budget model attempts to predict an organism's foraging choices between two alternatives, both with the same mean rate of energy-returns, but with different variances (i.e., one alternative has a high variance and the other has a low variance) (Stephens, 1981). The model assumes that the organism must obtain enough energy to survive through times when foraging is impossible (e.g., overnight). When the mean rate of food intake is sufficient to meet an organism's food requirement, the organism is experiencing a positive energy budget. This is expressed as

$$\mu n - nr + S_n > R \qquad (2)$$

where μ is the mean rate of energy gain, n is the number of time intervals the organism has to forage, r is the energy expended per time interval, S_n is the organism's initial reserves, and R is the energy requirement (Stephens). Alternatively, when the mean rate of food intake is insufficient to meet an organism's food requirement, the organism is experiencing a negative energy budget. This relation is expressed as

$$\mu n - nr + S_n < R. \qquad (3)$$

Stephens (1981) argued that when energy-budgets were positive, the chance of starvation was minimized by choosing the low-variance option. When energy budgets were negative, however, preference for the high-variance option would lead to the greatest reduction in risk that an organism would experience starvation.

The energy budget model has been tested both in the laboratory and in the wild with many different species (for reviews see Kacelnick & Bateson, 1996; Fantino & Romanowich, 2006). One of the first studies, a study by Caraco et al. (1980), manipulated the energy budgets experienced by yellow-eyed juncos by manipulating energy reserves and mean rate of food. Subjects were food deprived for 1 hr or 4 hr to put them in a positive or negative energy budget, respectively, and then repeatedly chose between two food sources. One source delivered a constant amount of food, while the other delivered a variable amount of food, both with the same mean rate. Subject's choice was risk averse in positive energy budgets and risk prone in negative energy budgets. Cartar (1991) investigated bumble bees foraging between two food sources both with similar mean rates of energy intake, but one had greater variance than the other. Energy budgets were manipulated by adding or subtracting food to the bees' nectar reserves. When the bees experienced a negative energy budget they chose the more variable option and when they were experiencing a positive energy budget they chose the constant option.

The energy budget rule, however, does not seem to predict risky decision making in all species (Kacelnick & Bateson, 1996; Fantino & Romanowich, 2006). For example, a study by Kagel, MacDonald, Battalio, White, and Green (1986) with Wistar rats found that, contrary to the predictions of the energy budget rule, subjects chose the certain alternative regardless of the energy budget. Some have argued that differences in findings across studies may be related to the type of species involved or the type of variability (i.e., variability in resource amount or delay) (Kacelnick & Bateson; Fantino &

Romanowich; Winterhalder et al., 1999). However, for a variety of species the energy budget model provides a reasonably good account of risk-sensitive food preferences.

Human Studies of the Risk-Reduction Account of Sharing

Several anthropological field studies have demonstrated that food sharing patterns among different human societies support the predictions of Winterhalder's (1986) risk-reduction account of food sharing based on the energy budget rule (Winterhalder et al., 1999). For example, Kaplan and Hill (1985) investigated sharing in the Ache of eastern Paraguay, a hunter-gatherer society. They found that unpredictable food acquisitions, such as meat and honey, were shared much more often than other, less variable food options, like vegetation. Cashdan (1985) also found that another hunger-gatherer group, the Basarwa of northern Botswana, were more likely to engage in food sharing when hunters were successful at capturing prey than when plant food was harvestedNot all anthropological field studies, however, have found support for the risk-reduction account of sharing. For example, studies of the Meriam of Australia's Torres Strait (Bliege Bird & Bird, 1997), the Kung! of northwestern Botswana (Hawkes, 1993), and the Hadza of northern Tanzania (Hawkes, O'Connell, & Blurton Jones, 1991) have all demonstrated that hunters who had better success at capturing prey did not receive more food in reciprocation than hunters who were not as successful. In addition, individuals who were successful at obtaining meat products shared these food resources with others who never reciprocated the sharing act. Thus, those who shared most experienced no risk reduction by sharing.

The sharing patterns observed in the aforementioned societies were more in alignment with the theory of tolerated theft than risk reduction. For instance, one prediction of tolerated theft is that the frequency of sharing among individuals is partially dependent on the distances between their residences (Bliege Bird & Bird, 1997; Hawkes, 1993). Those that live the closest will be the most likely to observe when individuals have been successful at acquiring food and, therefore, will be more likely to demand food from those individuals. In support of this, Bliege Bird and Bird (1997) found that the Meriam shared food significantly more with their neighbors than with other members of the group.

Findings from these studies suggest, therefore, that if risk reduction is a factor that influences food sharing, it may not be the only variable affecting sharing. Bliege Bird and Bird (1997), for example, have suggested that sharing may also produce social benefits that influence individual fitness, such as obtaining allies and increased access to mates. Indeed, Kaplan and Hill (1985) found that highly successful hunters among the Ache of eastern Paraguay had more extramarital sexual partners than less successful hunters, and that more of their children survived to reproductive age.

Although the studies described above found various degrees of support for different sharing models, no variables were manipulated to determine if behavior would change in the predicted direction. That is, in the field it is difficult to isolate any one particular variable to determine its effects on behavior. Consequently, laboratory studies, because of their ability to separate and manipulate variables independently, may be useful in the analysis of sharing. Due to ethical issues of manipulating food intake in humans, however, no laboratory study has investigated how shortfall risks affect food sharing

Human Earnings Budget Laboratory Studies

Several studies have sought to determine whether the energy budget model can predict risky choice in humans (e.g. Bickel, Giordano, & Badger, 2004; Pietras & Hackenberg, 2001). One challenge of investigating the energy-budget rule in humans is that manipulating food intake to the extreme levels required by the model is unethical. One solution to this problem is to use a currency that is analogous to energy. In optimal foraging models, the term currency refers to the variable on which costs and benefits are measured (Smith & Winterhalder, 1992; Stephens & Krebs, 1986). Because optimal foraging models are based in natural selection, they specify a currency that is related to reproductive fitness, such as energy gains or net food intake (Hackenberg, 1998; Winterhalder & Smith, 2000). Researchers have determined, however, that foraging models can also predict human behavior for other currencies, including conditioned reinforcers like money or points (Hackenberg, 1998).

A number of studies have investigated whether the energy-budget model can be used to explain human risky choice for monetary outcomes. In these studies, food intake and energy requirements were replaced by point or monetary gains and earnings requirements (i.e., an earnings budget) (Deditius-Island, Szalda-Petree, & Kucera, 2007; Ermer, Cosmides, & Tooby, 2008; Mishra & Lalumiere, 2010; Pietras & Hackenberg, 2001; Pietras, Locey, & Hackenberg, 2003; Pietras, Searcy, Huitema, & Brandt, 2008; Rode, Cosmides, Hell, & Tooby, 1999; Wang, 2002). For example, in a study by Pietras and Hackenberg (2001) three humans responded on a computer task in which they were given repeated choices between two options. One option was a fixed option, offering 2 points, and the other was a variable option, offering 1 or 3 points with a 50% chance of receiving either. The mean rate of gain (2 pts) was considered analogous to μ, or the mean rate of food intake per time interval, in Equations 2 and 3. Sessions were divided into blocks of 5 trials, analogous to *n*. If the participants gained a required number of points in a block, the money would be banked and paid at the end of the session. Otherwise, block earnings were lost. Choice was investigated across three different conditions: two negative earnings budget conditions and one positive earnings budget condition. In the negative earnings budget conditions, participants were required to earn either 12 or 13 points, whereas in the positive earnings conditions participants were required to earn 10 points. The point requirement was, therefore, used to simulate a daily energy requirement. Results indicated that the fixed alternative was preferred in the positive budget condition. In the negative budget condition, choice was either indifferent or the variable option was preferred. Choice was most risk prone in the condition with the highest requirement (13 pts). These results match the predictions of the energy budget model; participants tended to be risk averse when experiencing a positive earnings budget (i.e., point requirements were low) and risk prone when experiencing a negative earnings budget (i.e., point requirements were high) (Pietras & Hackenberg).

In the Pietras and Hackenberg (2001) study the earnings budget was manipulated by changing the earnings requirement. Other variables posited by the energy budget model to affect risky choice have been investigated as well. For example, Pietras et al. (2008) generated positive and negative earnings budgets by manipulating monetary reserves and mean monetary gain. Participant's choices varied in a manner that was consistent with the energy budget model's predictions. That is, the fixed option was preferred when participants were experiencing a positive earnings budget and the variable option was preferred when participants were experiencing a negative earnings budget.

Rode et al. (1999) used a slightly different experimental procedure to study risky choice under budget constraints but reported similar findings. Participants needed to obtain a given number of black balls out of a set number of draws from one of two boxes to win money. For one box the risk of obtaining a black ball was known and for the other the risk was unknown. The number of black balls needed was manipulated so that it exceeded, met (i.e. positive budget), or fell short (i.e. negative budget) of the mean outcome of the known-risk box. Participants chose the known-risk box when the requirement either met or exceed its mean outcome. When the requirement could not be met by the mean outcome of the known-risk box, then participants chose the unknown-risk box.

Although results of these studies provide support for the earnings budget model, there are some fundamental differences between the earnings budget and the energy budget model it tries to approximate (Hackenberg, 1998; Pietras et al., 2008). Although human earnings budget studies have investigated repeated choice for real outcomes; choices are for monetary outcomes, not food outcomes like in nonhuman studies. The possibility of starvation is a much more biologically relevant event than the possibility of not banking money. Thus, the underlying behavioral mechanisms controlling choice may be different for humans experiencing positive and negative earnings budgets and nonhumans experiencing positive and negative energy budgets. Nevertheless, that similar patterns of risky choice have been observed in both human and nonhuman studies suggests that even if the underlying processes are different, the model is still useful in predicting human risky choice (Pietras & Hackenberg, 2001; Pietras et al.).

Laboratory Analysis of Sharing Under Risk

According to Winterhalder (1986), sharing can be viewed as a strategy to minimize the chance of a shortfall, and thus can be predicted based on an organism's energy budget. The energy budget model within the context of sharing predicts that when individuals are experiencing a positive energy budget, they should share food acquisitions, and when they are experiencing a negative energy budget they should work independently. Working independently is predicted under negative budget conditions because under extreme resource scarcity sharing will not produce sufficient returns. In support of this, a recent computer simulation by Savarimuthu, Arulanandam, and Savarimuthu (2011) tested a computer simulation of sharing in which computer agents could either consume collectible resources alone or consume hunted resources which were shared with a group. They found that sharing emerged when the availability of collectible food products diminished (i.e., resources that could be acquired independently became scarce), but disappeared when its availability increased.

Only a few studies have sought to experimentally investigate a risk-reduction account of sharing in a laboratory setting (e.g. Kameda, Takezawa, Tindale, & Smith, 2002; Kaplan, Schniter, Smith, & Wilson, 2012; Pietras, Cherek, Lane, & Tcheremissine, 2006; Ward, Eastman, & Ninness, 2009). All of these studies have examined sharing when outcomes were conditioned reinforers (i.e., points or money). These laboratory studies demonstrated that sharing shifted across budget conditions in a manner consistent with the predictions of the risk-reduction account of sharing. For example, Kameda et al.

(2002) investigated the probability of sharing under conditions of certain and uncertain money gains. Participants were college students in Japan and the U.S. who were assigned to one of two payment groups. One group was told that they would receive a specified amount of money for each math problem that was correctly completed. The second group spun a game wheel to determine how much they would receive for each math problem. After completing the math problems, participants were then asked if they would share some of the money they earned with participants in another study. When the monetary outcomes were uncertain, participants were more likely to share than when the outcomes were certain.

Kaplan et al. (2012) examined sharing when participants were presented with the choice between two foraging areas, one with a high variance point outcome and one with a low variance point outcome, for 20 iterations. Participants were put in groups of eight, then independently chose between these two foraging sites. Participants were given a set amount of time to capture resources which were later exchangeable for money. Individuals were only able to bank a set number of resources, but there was no requirement that they had to meet in order to keep what they had earned. Extra resources could either be given away to other participants, or they were lost. Participants who preferred the high variance foraging area also tended to share, or give away their resources, more than those who preferred the low variance foraging site. The authors also noted that those who preferred the high variance foraging site entered into reciprocal groups with other high-variance preferring participants; sharing with the same two or three people.

The studies by Kameda et al. (2002) and Kaplan et al. (2012) showed that the probability of sharing depended on the variability or risk associated with resource gains. In both of these studies, however, the benefits obtained from sharing were not directly assessed or manipulated. They did not manipulate an earnings budget, only the variability in point or monetary earnings. To better evaluate the risk-reduction model of sharing, two laboratory studies investigated sharing in adult humans within the context of an earnings-budget paradigm (Pietras et al., 2006; Ward et al., 2009). Both examined whether risk-reduction accounts of sharing based on the energy-budget rule could predict sharing of monetary earnings.

Ward et al. (2009) presented individuals in dyads with different amounts of resources, which they used to meet a set requirement. If participants met or exceeded the requirement, their resources could be banked and later exchanged for money. However, if participants were not able to meet the requirement, then they lost their resources. Participants could either use their own resources to meet the requirement or they could give some of their resources to their partner in order to prevent their partner from experiencing a shortfall. When participants mean earnings exceeded the requirement (positive budget condition), they were more likely to share, or give resources to their partner, than when the number of resources earned did not meet the requirement (negative budget condition).

In the Pietras et al. (2006) study, participants repeatedly chose between working alone and working with others. As in the previous earnings budget studies (e.g. Pietras & Hackenberg, 2001), participants had to earn a sufficient amount of money (the earnings requirement) to keep their earnings. The earnings requirement was manipulated to create positive, negative, or neutral (i.e. no requirement) earnings budget conditions. If a participant chose to work with others, then their monetary earnings would be pooled together with the partner, which was actually a computer program. This pooled amount was then split evenly between the participant and the other person. If participants chose the work-alone option, then the amount of money they earned was how much they banked at the end of the block. Thus, working with others produced a fixed amount, whereas working alone produced a variable amount.

Pietras et al. (2006) found that participants' choices to work alone or work with others varied consistently with the predictions of the energy budget model. That is, when participants were experiencing a positive earnings budget, they chose to work with others, or share, and when they were experiencing a negative earnings budget, they chose to work alone. In the neutral requirement condition, where there was no minimum requirement, participants varied in their preference for the work-with-others option but, a common pattern was an increase in the number of work-with-others choices across exposures. However, when a work-alone option was added to the neutral condition that produced a fixed outcome, participants' preference shifted to this work-alone option. This suggests that participants preferred the work-with-others option in the neutral condition because it produced a constant amount (i.e., reduced variability). When participants were exposed to a condition in which they could choose between a constant working alone (nonsocial option), and a constant work-with-others option, the nonsocial option was preferred.

The procedure used by Pietras et al. (2006), then, has been shown to be useful for studying variables that influence sharing under risk. It establishes resource requirements within the experimental setting and the benefits for sharing and working alone can be precisely controlled. One goal of the present research was to further explore the ability of the risk-reduction model of sharing to account for human choice using monetary outcomes in a laboratory setting.

Constraints on Optimal Decision Making

The energy-budget model predicts choice based on the adaptive advantage of risky decisions (Pietras & Hackenberg, 2001; Pietras, et al., 2003). It makes no statements regarding the mechanistic or proximate variables that underlie adaptive foraging choices. That is, it does not offer any insights into the proximate physiological or psychological processes that underlie optimal decision making. Moreover, the model only makes a few assumptions about variables that affect choice, for example the variability associated with each option (Stephens, 1981). Although the simplicity of the model gives it generality, it may be important to identify other variables that limit or constrain optimal behavior.

Constraints on optimal behavior may be categorized as intrinsic and extrinsic (Smith & Winterhalder, 1992; Stephens & Krebs, 1986). Extrinsic constraints are those that exist in the external environment. For instance, temperature constrains an organism's running speed (Stephens & Krebs). Another example is time; organisms may only have a limited number of hours each day in which to capture and consume food items (i.e., during daylight). In the energy budget model, *n* quantifies the limit on the number of time intervals an organism has to forage.

Intrinsic constraints exist within the organism and can be separated into two different types: (1) constraints from an organism's biological requirements or tolerances, and (2) constraints from an organism’s behavioral abilities (Stephens & Krebs, 1986). An example of a constraint of biological requirements is the maximum length of food deprivation an organism can tolerate before it experiences starvation. An example of a behavioral constraint is pigeons’ inability to differentiate between very short delays, such as 0.2 milliseconds from 0.5 milliseconds (Stephens & Krebs).

Intrinsic constraints may also include sensory and cognitive, i.e., psychological, constraints (Smith & Winterhalder, 1992). One example of a cognitive constraint may be seen in the literature on sunk costs. The sunk cost effect occurs when an organism continues to invest time, money, or effort into an option even when doing so is costly over the long term (Arkes & Blumer, 1985; Macaskill & Hackenberg, 2012). Past investment in an alternative constrains current choice to persist on that alternative, even though it is optimal for organisms to escape or “cut their losses” (Garland, 1990). Furthermore, the probability of persistence varies as a function of the magnitude of the initial investment. Another possible example of an intrinsic constraint is ambiguity aversion, which is the preference typically observed for options with known probabilities over options with unknown probabilities, even when the options have the same expected value (McDermott, Fowler, & Smirnov, 2008; Rode et al., 1999). In situations in which an optimal foraging model would, for example, predict no preference between two equivalent options (one with a known probability and one without) this cognitive bias may lead individuals to show a preference for the alternative with the known probability.

When an organism must meet specific biological needs or other resource requirements, these requirements may make individuals less sensitive to the influence of variables which may bias or constrain behavior. For example, a risky-choice study by

Rode et al. (1999) presented participants with choices between an option with a known and an unknown probability, both with the same expected value. When there was no requirement in place, participants preferred the option with the known probability; demonstrating ambiguity aversion. However, when participants were required to earn a given amount in order have the opportunity to win money, if the amount exceeded the amount provided by the known probability option (negative budget condition), participants' preference shifted to the option with the unknown probability. Thus, when the outcomes of one option clearly failed to meet a resource requirement, participants responded optimally and choice no longer showed ambiguity aversion.

It is uncertain to what extent adaptive social behaviors (i.e., sharing and cooperation) are affected by cognitive or other psychological constraints. Thus, another goal of the present research project was to evaluate whether social variables that have been shown to negatively affect cooperation and sharing in prior research constrains optimal sharing in situations involving variability and shortfall risk. These constraints included: (a) the nature of the partner, (b) inequity in earnings, and (c) probability of reciprocity. Each of these will be discussed in more detail below.

Primary Aims

The purpose of the present research was to further explore whether a risk-reduction account of food sharing developed by behavioral ecologists can predict human cooperation. Four experiments were conducted. Experiments 1, 3, and 4 examined whether social variables influenced or constrained optimal behavior. Specifically, Experiment 1 analyzed the effects of social stimuli on sharing by comparing choice across conditions in which participants were told that they were working with a human partner and a computer. Previous research suggests that who the sharing partner is may affect one's preference to cooperate or share (Rachlin & Jones, 2008a; Sanfey et al., 2009). This experiment, then, determined how the social nature of the task affected sharing. Experiment 2 examined one prediction of the risk-reduction sharing model: that sharing should vary as a function of the correlation in earnings between foragers. Thus, Experiment 2 investigated sharing as the correlation between earnings of the participant and partner was manipulated. Experiment 3 investigated the effects of inequity in earnings on sharing. Prior cooperation research has shown that inequity in earnings between a participant and his or her partner may disrupt cooperation (Fantino & Kennelly, 2009; Kennelly & Fantino, 2007; Schmitt & Marwell, 1972; Spiga, Cherek, Grabowski, & Bennett, 1992). Thus, this experiment examined whether inequity would constrain optimal responding. Experiment 4 extended the risk-reduction model to situations involving reciprocity. Previous experiments have shown that cooperative behavior is sensitive to the probability of reciprocation and that cooperation is disrupted when the probability of reciprocation decreases (Acevedo & Krueger, 2005; Baker & Rachlin, 2001; Molm, Peterson, & Takahashi, 2001). Experiment 4 examined whether sharing would be disrupted by decreases in the probability of reciprocation when the energy-budget model predicts sharing. Together these studies sought to determine the extent to which the risk-reduction model of sharing (derived from the energy-budget rule) could predict human sharing, and analyze whether psychological variables (type of partner, inequity, probabilistic reciprocation) interfere or constrain optimal sharing responses.

CHAPTER II

EXPERIMENT 1

In the Pietras et al. (2006) sharing study, participants shared during the positive budget condition in which sharing was optimal. Thus, it is uncertain whether the social nature of the task may have influenced participants' responding. Sharing also occurred during the neutral budget condition, however, in which the mean earnings from both the work-alone and work-with-others options were identical. It is unclear whether this preference for the sharing option was observed because participants preferred the social aspect of the work-with-others alternative or because they preferred a low-variance over a high-variance alternative. That is, choosing the work-with-others option produced a constant amount each trial as opposed to a variable amount. When a second work-alone option was added (three options in total) to the neutral budget condition that also yielded a fixed monetary amount, participants' preferences shifted from the sharing option to this option; suggesting a preference for both a fixed and non-social outcome. However, when a requirement was added to the partners' earnings in the same three-option, neutral-budget condition so that sharing would benefit the partner but not the participant, preference shifted back to the sharing option. Thus, it is still unclear the extent to which social variables influence sharing behavior.

Thus, the goal of Experiment 1 was twofold. The first goal was to replicate the Pietras et al. (2006) findings that the earnings budget model can be used to account for human sharing using monetary outcomes, and secondly, to analyze whether social stimuli influence sharing in the earnings-budget task. Specifically, sharing was investigated when participants were told they were working with a computer program or working with a (fictitious) partner.

Several other cooperation studies have investigated whether social stimuli influences choice. Some have found no effect of social stimuli on responding. In a task described as “the Sharing Game,” Fantino and Kennelly (2009) and Kennelly and Fantino (2007) investigated choice when participants were told they would be sharing money with either another (fictitious) partner or a computer program. The Sharing Game presents participants with a choice between Option A, receiving X amount of money while the partner receives an amount greater than X, or Option B, receiving Y amount of money (which is less than X), while the partner receives an amount less than Y. The Sharing Game assesses whether the amount of the partner’s earnings influences the participant’s decision. These researchers found that, regardless of whether the partner was a computer or another person, participants preferred Option B. Marwell and Schmitt (1975) conducted a series of studies that investigated the effects of physical and social contact between two participants on cooperation. They found that being able to see their partner and briefly converse with them before the experimental session did not affect rates of cooperation.

Conversely, a couple of studies have demonstrated that the social nature of a task influenced people’s sharing and cooperation behavior. For example, Rachlin and Jones (2008a) showed that participants were more likely to share money with people they knew than with people that they did not know. Sanfey et al. (2003) had participants play the Ultimatum Game when participants were told they were playing with a partner or computer. In the Ultimatum game, the partner divides a monetary amount into two shares, one for the self and one for the participant. The participant must then decide to accept or reject the monetary division. If the participant accepts the division, both individuals keep the money, but if the participant rejects the offer, neither receives the money. Sanfey et al. found that, in contrast to the Fantino and Kennelly (2009) and Kennelly and Fantino (2007) studies described above, unfair offers were rejected more often when participants were working with another person than when they were working with a computer. These studies suggest that sharing and cooperation may be effected by social stimuli in some situations.

More research in this area needs to be conducted to better understand how social stimuli influence sharing. Specifically, it is important to investigate the social nature of the partner within the context of the earnings budget model. The "survive" versus "shortfall" outcomes for choices in earnings-budget conditions generate large differences in earnings for optimal and nonoptimal choices. Across budget conditions, then, there are clear predictions for when participants' responding should prefer the work alone or sharing options. Thus, if participants' responding is sensitive to social stimuli, then this may suggest that social stimuli could constrain optimal sharing behavior. For example, if participants prefer working with a partner over a computer, then they may choose the sharing option even when they are experiencing a negative earnings budget in which it would be optimal to work alone. In positive budget conditions, however, enhanced preference toward the sharing option when the partner is a person might enhance optimal responding. Such findings could have implications for understanding sharing that occurs outside the laboratory.

Method

Participants. A power analysis was conducted to determine the number of participants needed to detect a large effect size (*d* = .8) (Cohen, 1992). Data from a repeated-measures pilot study (*n* = 10) was used to determine the smallest mean of the difference scores (M_D = 3.3) and standard deviation (*SD* = 4.09). Using α = .05 (one-tailed) and 80% power, a minimum of 11 participants would be needed.

Informed consent was obtained from all participants for this and the following three experiments. Fifteen students, ages 18 yrs and older were recruited through flyers posted around the campus of Western Michigan University as well as through in-class recruitment. Participants were selected based on their availability and lack of extensive knowledge of psychology. In addition, participants had to be healthy as well as not using any drugs or psychoactive medications. Participants ranged in age from 18-39 yrs (*M* = 21.3 yrs). The majority were female (80%), and 80% identified themselves as Caucasian, 13.33% as Hispanic, and 6.67% as Middle Eastern.

Apparatus. Participants were seated in a 2.2m x 1.2m x 1.3m cubicle, alone, facing a 31.8cm x 21.6cm computer monitor and computer mouse. A Marsona TSC-330 white-noise generator was used to drown out extraneous sound and a video camera was used to observe, but not record, participants. A computer task programmed in Microsoft Visual Basic 6.0® presented all stimuli and recorded all responses.

Procedure. All procedures in this and subsequent experiments were approved by Western Michigan University's Human Subjects Institutional Review Board (Appendix A). Participants were given minimal instructions so as not to influence behavior (Appendix B). Sessions consisted of 18 blocks, 8 forced-choice blocks followed by 10 choice blocks. The earnings counter was set at $0.00 at the start of each block. As Figure 1 shows, at the start of each block participants were presented with a non-social option signaled by the letter “A” and the words “work alone” and a social option signaled by the letter “C” and the words “work with others”. During the 8 forced-choice blocks participants were only exposed to one option, either the “work alone” option or the “work with others” option. Each option was presented exactly four times in a random order. Forced-choice blocks allowed participants to experience the outcomes of both alternatives.

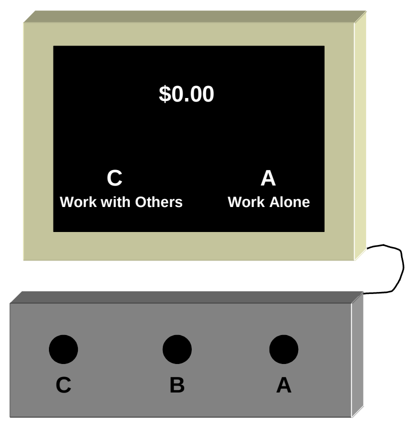

Figure 1. Diagram of apparatus.

During choice blocks participants had the opportunity at the beginning of the block to choose between the non-social “work alone” and the social “work with others” options. One response on the “A” or “C” button extinguished the alternative and the selected condition remained in effect for the remainder of the block. Within each block, participants were exposed to 5 response trials followed by a 1-20 s delay with the words “Please Wait” on the screen. This variation in the delay duration was designed to promote social deception by simulating occasions when the partner took longer than the participant to complete the block. During each trial, 5 responses on the “B” button were required to increase the earnings counter by either $0.00 or $0.12 ($p$ = .5). Figure 2 diagrams the events that occurred at the end of a block (5 trials) for “work alone” and “work with others” choices. First, the words “Your Earnings” appeared above the block counter. If the “work with others” option was selected, the participant’s and partner’s earnings were added together and split equally between them. The partner’s earnings were negatively correlated with the participants so that the total earnings always equaled $0.60 (i.e., if the participant earned $0.36 the partner earned $0.24). The words “Your Share” and “Other’s Share” appeared on the screen with two counters showing the participant’s and partner’s share of the total. The total of $0.60 was split equally so that both the participant and partner received $0.30 at the end of the block. Therefore, the sharing option produced a constant earnings amount. If the “work alone” option was selected, then the amount that the participant earned during the five trials equaled the amount the participant had earned by the end of the block, which could vary between $0.00 and $0.60. Thus, the “work-alone” option was a variable option.

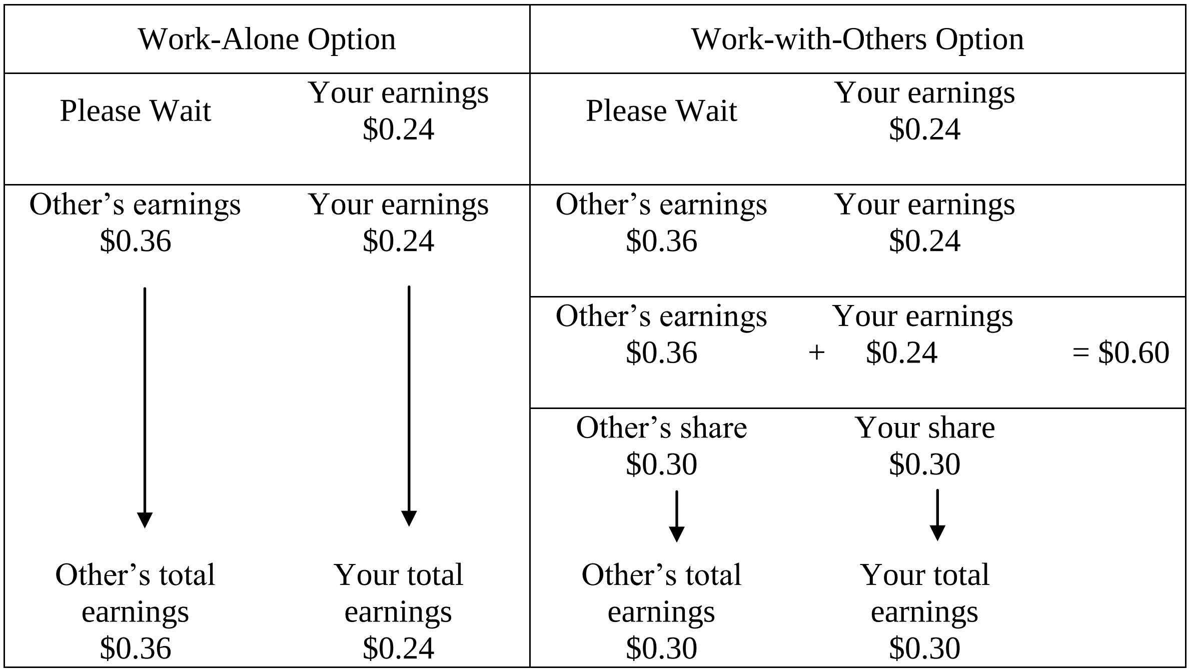

Figure 2. Illustration of events that occur at the end of the block when participants choose the work-alone and work-with-others options.

At the end of a block the participant's earnings, or share, was added to the cumulative counter only if the earnings exceeded the specified earnings requirement. If the participant did not meet the requirement, then the earnings were not added to the cumulative counter and the block counter was reset to $0.00. The earnings requirement was manipulated across conditions to generate positive, negative, and neutral earnings budgets. Specifically, in the neutral earnings budget condition the requirement was $0.00 (i.e., no requirement), in the positive budget the requirement was $0.30, and in the negative budget condition the requirement was $0.36. Thus, in a positive budget, participants could meet the requirement every block if they chose the "work with others" option and on 50% of the blocks if they chose the "work alone" option. In the negative budget, participants could not meet the requirement if they chose the "work with others" option, but could meet the requirement on 50% of the blocks if they chose the “work alone” option.

Participants came to the laboratory on two separate occasions. On each occasion participants completed 6 sessions, two sessions per earnings budget. Sessions lasted 25-30 min and were separated by 5 min breaks. Thus, participation lasted 2.5 - 3 hr each day, for a total of 5-6 hr. On one day, participants were told that they were working with a computer and on the other day participants were told that they were working with another person at a different university (see Appendix B for the instructions given to participants). To assess the social deception, participants filled out a survey at the end of each day asking them to report on the number of people they thought they were paired with and to describe their interaction with them.

Participants were compensated for their time through extra credit (if offered by their courses) and money. At the end of each day, participants drew from a prize bowl containing 32 slips of paper. For every $2.00 participants earned during the experimental sessions, they earned one opportunity to draw from the bowl. The distribution of slips was as follows: 8 (.25%) stated, “$0.00;” 4 (0.125%) stated, “$0.25;” 4 (0.125%) stated “$0.50;” 4 (0.125%) stated “$0.75;” 4 (0.125%) stated, “$1.00;” and 8 (0.25%) stated “$1.25”. Daily earnings averaged $6.00. On the last day of participation, participants were debriefed (for a debriefing script see Appendix C).

Experimental Design. The experiment consisted of a 2 X 3 within-subjects design with partner type (partner or computer) as the first factor, and budget (neutral, positive, or negative) as the second factor. Participants were exposed to the three budget conditions under one partner type before being exposed to budget conditions under the second partner type. The order of budget conditions was randomly determined. Order of exposure to partner and computer partner type conditions was counterbalanced across participants.

Data Analysis. The number of "A" (work alone) and "C" (work with others) choices during each session and mean earnings per session were the main dependent measures. Data were analyzed using a repeated measures analysis of variance. An *a priori* alpha level was set at .05. Mauchly's test indicated that the assumption of sphericity was not violated ($\chi^2[2] = .804$, $p = .669$), but the Shapiro-Wilk test indicated that the assumption of normality was violated, $S\text{-}W(12) = .855$, $p = .042$. However, Kirk (1995) noted that analysis of variance (ANOVA) tests are robust against the assumption of normality and visual inspection of a histogram suggested that the data did not show any prominent deviations from a normal distribution. Moreover, a Q-Q plot, which graphs the quartiles of a normal distribution against the quartiles of the current data, showed that the data did not depart greatly from a positive, straight line.

Results

Of the 15 participants that were recruited, three noted that they did not believe they were working with another person. Data from these participants were subsequently dropped from the analysis, leaving a total of 12 participants. Results from the second exposure to each condition are reported.

Figure 3 shows the mean number of work-with-others choices made while working with a partner and computer across all three budget conditions. A 2x3 repeated measures ANOVA test yielded a significant main effect of budget ($F[2, 53] = 14.40$, $p < .001$, $\eta_p^2 = .658$) and a significant difference among individual variation, $F(11, 53) =$

3.04, $p = .003$. However, there was no significant main effect of partner type, ($F[1, 53] = .12$, $p = .729$), nor was there a significant interaction between budget and partner type, $F(2, 53) = .84$, $p = .437$. Post hoc tests of the main effect of the earnings budget, using a Bonferroni adjusted alpha of .05/3 = .017, showed that there were significant differences between the positive ($M = 5.542$, $SD = 2.904$), neutral ($M = 3.304$, $SD = 3.611$), and negative ($M = 1.348$, $SD = 2.551$) earnings budgets. That is, when participants experienced a positive earnings budget, they preferred the work-with others option significantly more than when they experienced a neutral ($p = .001$) or negative ($p < .001$) earnings budget. Furthermore, 50% of participants preferred the work-with-others option during the positive earnings budget condition. When participants experienced a negative earnings budget, they preferred the work-alone option significantly more than when they experienced a neutral earnings budget ($p = .017$) and none of the participants preferred the work-with-others option over the work-alone option. In the neutral budget condition 8.33% of participants showed a preference for the sharing option.

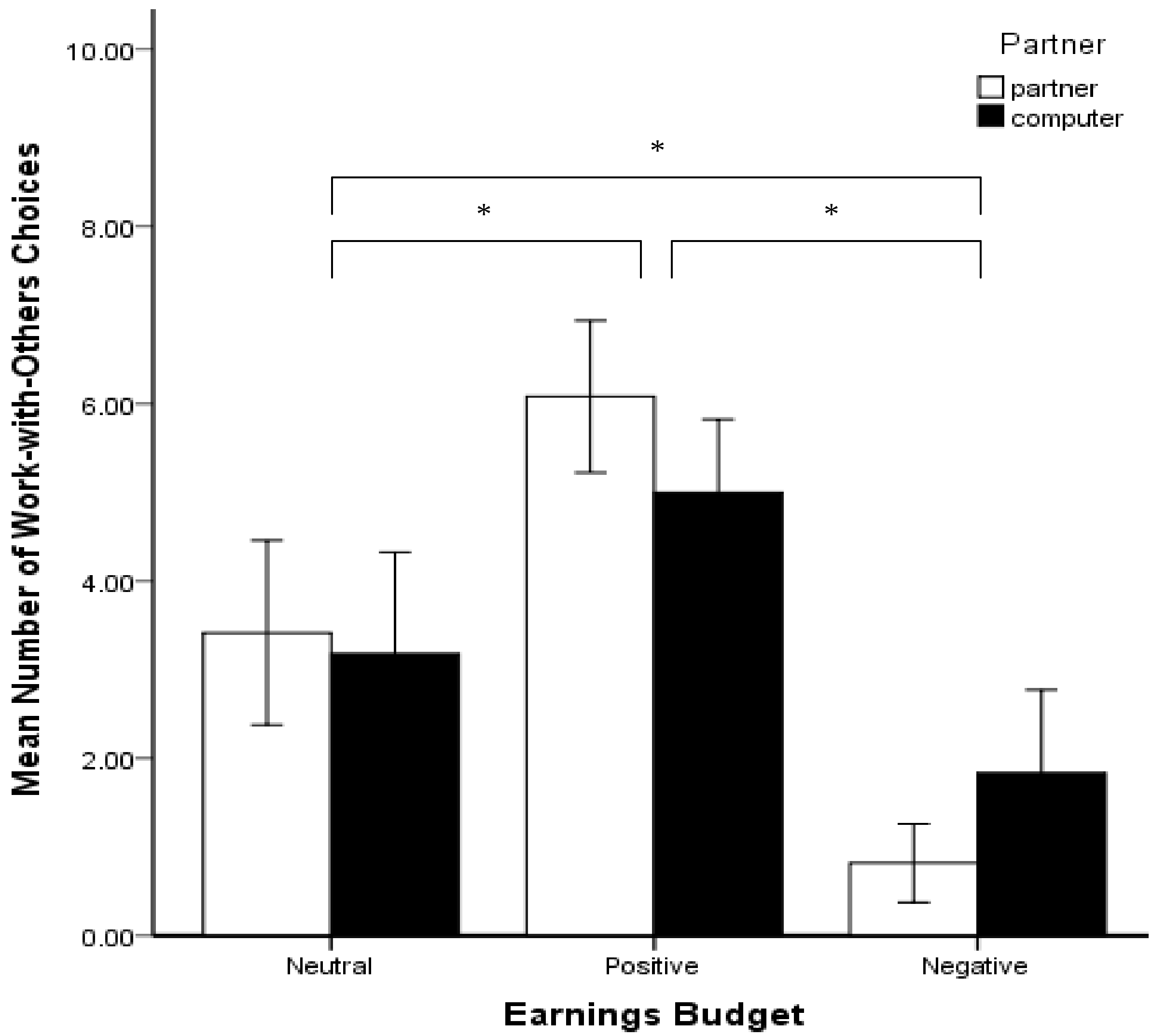

Figure 3. Mean number of work-with-others choices across three earnings budget conditions when participants were told they were working with a partner (white bars) and computer (black bars). Error bars show ± 1.0 standard error and asterisks denote statistically significant differences between groups.

Mean earnings during choice trials were near or exceeded the programmed mean for optimal choices in each budget condition (see Figure 4). Participants' mean choice earnings were highest in the neutral earnings budget in which there was no earnings requirement. Here, participants mean earnings of $3.10 slightly exceeded the programmed mean of $3.00. In the positive earnings budget condition, participants mean choice earnings were $2.37, below the optimal mean earnings of $3.00; whereas in the negative earnings budget condition, participants mean choice earnings were $1.79, close to the optimal mean earnings of $2.06. If the work-alone option was exclusively preferred in the positive earnings budget, average earnings would be $2.06, whereas if participants had an exclusive preference for the work-with-others option in the negative earnings budget, average earnings would have been $0.00. Taken together, the earnings data show that participants' responding tended to maximize reinforcement; mean choice earnings were kept near or above the programmed mean for optimal responding.

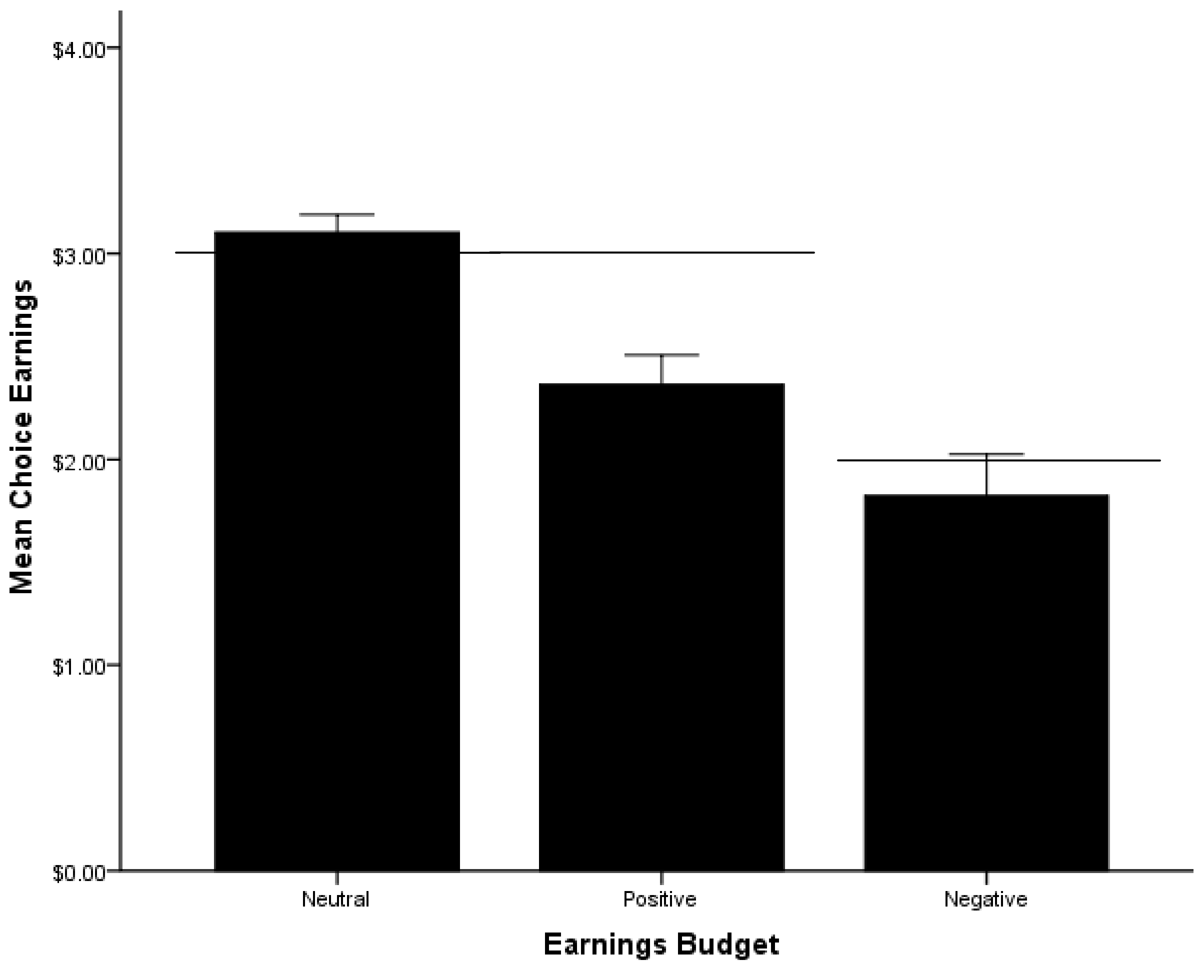

Figure 4. Mean choice earnings for each of three earnings budget conditions, with nature of partner collapsed across each condition. The black horizontal bars represent the mean programmed earnings across conditions. Error bars display 1.0 standard error.

Discussion

Experiment 1 examined whether or not the risk-reduction model of sharing based upon the energy-budget model could be used to accurately predict human sharing of monetary outcomes. Participant's responses were congruent with the predictions of the model. When participants experienced a positive earnings budget, they showed a preference for the sharing option and when participants experienced a negative earnings budget, they showed a preference for the work-alone option. In the neutral earnings-budget condition, participants preferred the work-alone option over the work-with-others option, but this preference was not as strong as when participants experienced the negative earnings budget. Participants' choice earnings fell near the maximum programmed value, showing that participants responded nearly optimally across conditions. These results are, therefore, consistent with previous research that has evaluated sharing in relation to the predictions of the energy-budget rule (Pietras et al., 2006; Ward et al., 2009).

A second goal of Experiment 1 was to investigate the effects of social stimuli on sharing by examining sharing across conditions in which participants were told they were working with a partner or computer. Participants did not show a significant difference in their choices across conditions. Rather, participants' preference for the sharing option was affected solely by the earnings budget, suggesting that this social variable did not influence responding. This finding is consistent with the results of several previous studies that have found that humans respond similarly to people and computers on a laboratory sharing task (e.g. Fantino & Kennelly, 2009; Kennelly & Fantino, 2007).

The current findings are incongruent with some previous research, however, that has shown that participants respond differently depending on social stimuli (Rachlin & Jones, 2008a; Sanfey et al., 2003). The study by Sanfey et al. had participants play the Ultimatum Game against either an actual partner or a computer and found that participants rejected unfair offers made by the partner significantly more than unfair offers made by a computer. However, there was not a significant difference in participants' responding when they were presented with fair offers by either the partner or computer. It is possible then, that the effects on sharing of the nature of the partner vary as a function of the equity or fairness in earnings between the participant and partner. How inequity effects sharing under earnings-budget conditions is further explored in Experiment 3.

In the Rachlin and Jones (2008a) study, participants made a list of 100 people they knew, starting with the people they were closest to, and then were asked to how much money they would be willing to forgo in order for the person on the list to receive a set amount of money. Participants were willing to forgo larger monetary values for those at the top of the list than for those at the bottom of the list. One possible reason for their results is that closer individuals may have aided the participant in the past, so participants were likely to reciprocate. Alternatively, it is possible that people high on the list were more often relatives (Rachlin & Jones, 2008b). From an evolutionary perspective, forgoing more money for relatives could be partly explained by kin selection. Kin selection asserts that organisms cooperate or share because giving to genetic relatives confers indirect fitness benefits (Hamilton, 1963). In the present study, no information was given to participants about the partners (i.e., they were strangers). Possibly, results would have differed if the partner was a person who the participant knew. One way to test this using the earnings budget methodology would be to explicitly manipulate the closeness or relatedness of the partner to the participant.

Another difference between the Rachlin and Jones (2008a) and Sanfey et al. (2003) studies and Experiment 1 is that in Experiment 1 an earnings requirement was established that participants needed to meet in order to bank their earnings. The presence of this earnings requirement may have made participants less sensitive to effects of social stimuli. Interestingly, no effect of social stimuli was observed in the neutral budget condition. In this condition, because there are no earnings requirements, effects of other variables, such as social stimuli, may have been most likely to be observed. Possibly, participants did not respond differently across conditions, including in the neutral condition, because they had an extensive history interacting with computers. The Computers Are Social Actors (CASA) paradigm postulates that people respond to humans and computers in a socially equivalent manner (Nass & Moon, 2000). Research in this area has found that people tend to respond politely to computers (Nass, Moon, & Carney, 1999), reciprocate “helpful” acts when a computer initiates a “helpful” act (Fogg & Nass, 1997), and engage in gender stereotyping when presented with male and female voices while working on a computer task (Nass, Moon, & Green, 1997).

In the CASA studies cited above, though, the computer partners were programmed to manipulate or display some human characteristics, such as a male or female voice (Nass et al., 1997) or making humorous comments (Morkes, Kernal, &

Nass, 1999). Conversely, in the current study there were no attempts to attribute human characteristics to the computer. That is, the only difference in partner/computer conditions was the instructions given to participants about who they were working with. Thus, the general lack of social stimuli in both Partner and Computer conditions may have produced similar choices across the two conditions. Interestingly, Marwell and Schmitt (1975) demonstrated that when participants were able to see their partner or briefly converse with them that rates of cooperation were no different compared to conditions in which they did not meet their partner. Therefore, it seems that unless participants know and have had previous interactions with their partners, then the presence of a person as a partner does not affect participants' responding.

Research has shown, however, that social stimuli can influence cooperation when cooperation aids supposedly human partners. For example, several studies have demonstrated that the earnings of the partner can affect cooperation (Pietras et al., 2006; Schmitt & Marwell, 1972; Shimoff & Matthews, 1975). Pietras et al. showed that when participants had no earnings requirement (i.e. neutral budget), but their partners had a low requirement (i.e. positive budget), participants preferred the sharing option. That is, participants chose the sharing option when it was beneficial to their partner but had no effect on their own mean earnings. Furthermore, Shimoff and Matthews found that participants cooperated "altruistically" when their partner earned less on the independent alternative than they did.

Further research needs to be conducted to determine if such "altruistic" sharing would continue if it conferred a cost to participants. Possibly, cooperation that was costly to participants would vary depending on who the partner was. If the partner was a computer, then it seems that participants would be unlikely to prefer the sharing or cooperation option. Conversely, if the partner was another person, especially a person the participant knew well, then cooperation may be more likely. Altruistic cooperation may occur if the cost is not excessive because participants may have previous experience receiving other types of benefits or social reinforcement for helping others (Rachlin & Jones, 2008b). From an evolutionary perspective, such costly sharing with nonrelatives may be expected to occur only when the participant receives benefits from sharing, perhaps even indirect benefits such as through trade, but only when those benefits exceed the costs of sharing (Bliege Bird & Bird, 1997; Kaplan & Hill, 1985).

In summary, Experiment 1 found that sharing of monetary outcomes varied as a function of budget conditions in a manner consistent with what the risk-reduction model of sharing would predict for food-related choices. Social stimuli did not constrain optimal responding. These data, therefore, further support prior research demonstrating that the risk-reduction sharing model can help predict human cooperation.

CHAPTER III

EXPERIMENT 2

One of the predictions of Winderhalder's (1986) sharing model is that sharing is most beneficial to foragers when the foraging success of sharing individuals is negatively correlated (i.e., not everyone is successful and unsuccessful at the same time). In fact, Winterhalder notes that the benefits of sharing are maximal when the correlation of energy gains between sharing individuals is r = -1.0. Conversely, if the correlation of gains is perfectly positive, i.e., r = 1.0 (such as when foraging sources are synchronized), there is no reduction in variation by sharing. Amid these two extremes lie modestly positive and negative correlations between the individuals' energy gains. As the correlation moves from positive to negative, the reduction in variation becomes larger (Winterhalder). A modest positive correlation produces less of a reduction in variation, whereas a modest negative correlation produces more of a reduction.

Several anthropological field studies have supported the assumption that correlation in gains affects sharing. For example, studies have demonstrated that plant foods are not shared as often as meat (Cashdan, 1985; Kaplan & Hill, 1985). One explanation for this finding is that one's success in acquiring agricultural products is not as variable as one's success in acquiring meat products. Moreover, the acquisition of plant foods is more likely to be synchronous (positively correlated) across individuals than meat, which reduces the benefits of sharing (Cashdan; Kaplan & Hill).

In Experiment 1, the correlation between the participant's and partner's earnings was set to r = -1.0 so that when a participant chose to work with others, the variation in earnings was reduced to zero. When the sharing option was chosen, the participant always earned $0.30 at the end of a block, regardless of how much money was earned across the five trials. Outside the laboratory, however, it is unlikely that resource acquisitions are perfectly negatively correlated. As the correlation decreases, benefits for sharing decrease, but sharing may still be a better strategy than foraging independently. Thus, it is important to assess sharing under modest positive and negative correlations. A primary goal of Experiment 2, then, was to investigate the effects of the correlation between the participant's and partner's earnings on sharing. Across conditions the correlation was manipulated and was r = -1.0, -0.43, +0.43, and +1.0. When the correlation is perfectly negative, modestly negative, or modestly positive it is optimal for participants to choose the work-with-others option. Thus, sharing was predicted. When the correlation was perfectly positive, sharing produces no reduction in the variation of earnings; making the outcomes of the work-alone and work-with-others options identical. Thus, in that condition no preference for either option was predicted.

Method

Participants. Thirteen participates were recruited. Ages ranged from 18-23 yrs (M = 19.33 yrs) and 76.92% were female, while 23.08% were male. The majority identified themselves as Caucasian (58.33%), whereas others identified as African American (25%), as Asian (8.33%), or Middle Eastern (8.33%), and one participant did not disclose her ethnicity.

Procedure. All aspects of the procedure were the same as Experiment 1, except that the correlation between the earnings of the partner and the participant following a sharing choice was manipulated across conditions. There were four correlation conditions: two negative correlations of -1.0 and -.43 and two positive correlations of .43

and 1.0. When *r* = -1.0 the participants and partner's earnings always summed to $0.60 (e.g. when the participant earned $0.12 the partner earned $0.48). When *r* = 1.0, the partner's and participant's earnings were always the same (e.g. when the participant earned $0.12 the partner earned $0.12). In the two modest correlations, partner's earnings values for each of the six possible values of the participants earnings (i.e., $0.00, $0.12, $0.24, $0.36, $0.48 and $0.60) were chosen so that Pearson product moment correlations equaled -.43 and +.43 (see Table 1). Furthermore, values were chosen so that when participants chose the sharing option, they would be guaranteed to meet the earnings requirement 97% of the time in the modest negative correlation condition and 81% of the time in the modest positive condition. This was done to ensure that the variability in earnings decreased as the correlation in earnings moved from negative to positive.

Again, participants attended the laboratory on two occasions and completed six sessions a day. Participation lasted 2.5-3 hr a day for a total of 5-6 hr. The earnings requirement was $0.30 across conditions so that participant always experienced a positive earnings budget.

Table 1

Partner's earnings and participant's share for all possible values of the participant's earnings in the -.43 and +.43 correlation conditions in Experiment 2.

	Correlation			
	-.43		+.43	
Participant's Earnings	Partner's Earnings	Share	Partner's Earnings	Share
$0.00	$0.12	$0.06	$0.24	$0.12
$0.12	$0.60	$0.36	$0.00	$0.06
$0.24	$0.48	$0.36	$0.36	$0.30
$0.36	$0.36	$0.36	$0.60	$0.48
$0.48	$0.24	$0.36	$0.12	$0.30
$0.60	$0.00	$0.30	$0.48	$0.54

Experimental Design. The experiment consisted of a repeated-measures design. Each of the four correlation conditions were experienced three times and were presented in a counterbalanced order across participants.

Data Analysis. Mauchly's test indicated that the assumption of sphericity was met ($\chi^2[5] = 8.616$, $p = .127$). Futhermore, the Shapiro-Wilk test indicated that the assumption of normality was met, *S-W*(48) = .976, $p = .414$. Thus, a one-way repeated measures ANOVA test was used.

Results

One of the 13 participants recruited stated that she did not believe she was working with another person and data from this individual was subsequently dropped from the analysis, leaving a total of 12 participants. The second and third (final) exposures to each condition were analyzed and the mean number of work-with-others choices made across all four correlation conditions is shown in Figure 5. A one-way repeated measures ANOVA test yielded no significant effect of the correlation of earnings on sharing ($F[3, 33] = 1.805$, $p = .166$). However, there was a significant difference among individual variation, $F(11, 33) = 7.42$, $p < .001$. Participants showed a weak preference for the work-with-others option across all correlations conditions: $r = -1.0$ (*M* = 6.08, *SD* = 2.40), $r = -.43$ (*M* = 7.08, *SD* = 2.03), $r = +.43$ (*M* = 6.33, *SD* = 2.16), and $r = +1.0$ (*M* = 5.87, *SD* = 2.17). Furthermore, across all four correlation conditions, the majority of participants had a preference for the work-with-others option, 66.67%, 75%, 75%, and 58.3%, respectively.

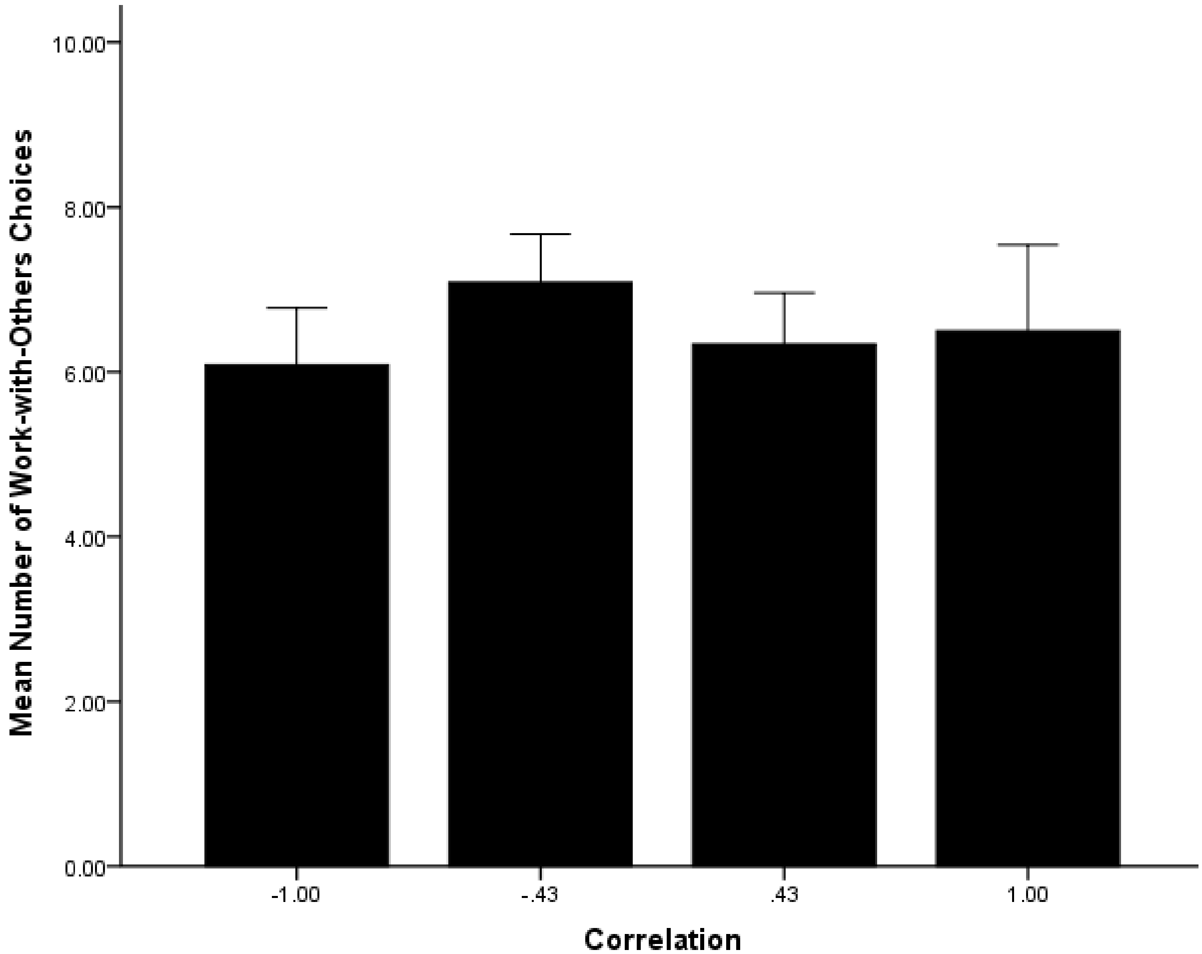

Figure 5. Mean number of work-with-others choices across four correlations of earnings between the participant and partner. Error bars show 1.0 standard error.

Participants' responding resulted in mean choice earnings that were near or above the programmed average for optimal choices in all four conditions. These earnings across each correlation condition are presented in Figure 6. Across the r = -1.0, r = -.43, r = +.43, and r = +1.0 conditions earnings were \$2.88, \$3.16, \$2.86, and \$2.39 while the programmed means were \$3.00, \$3.50, \$3.10, \$2.06, respectively.

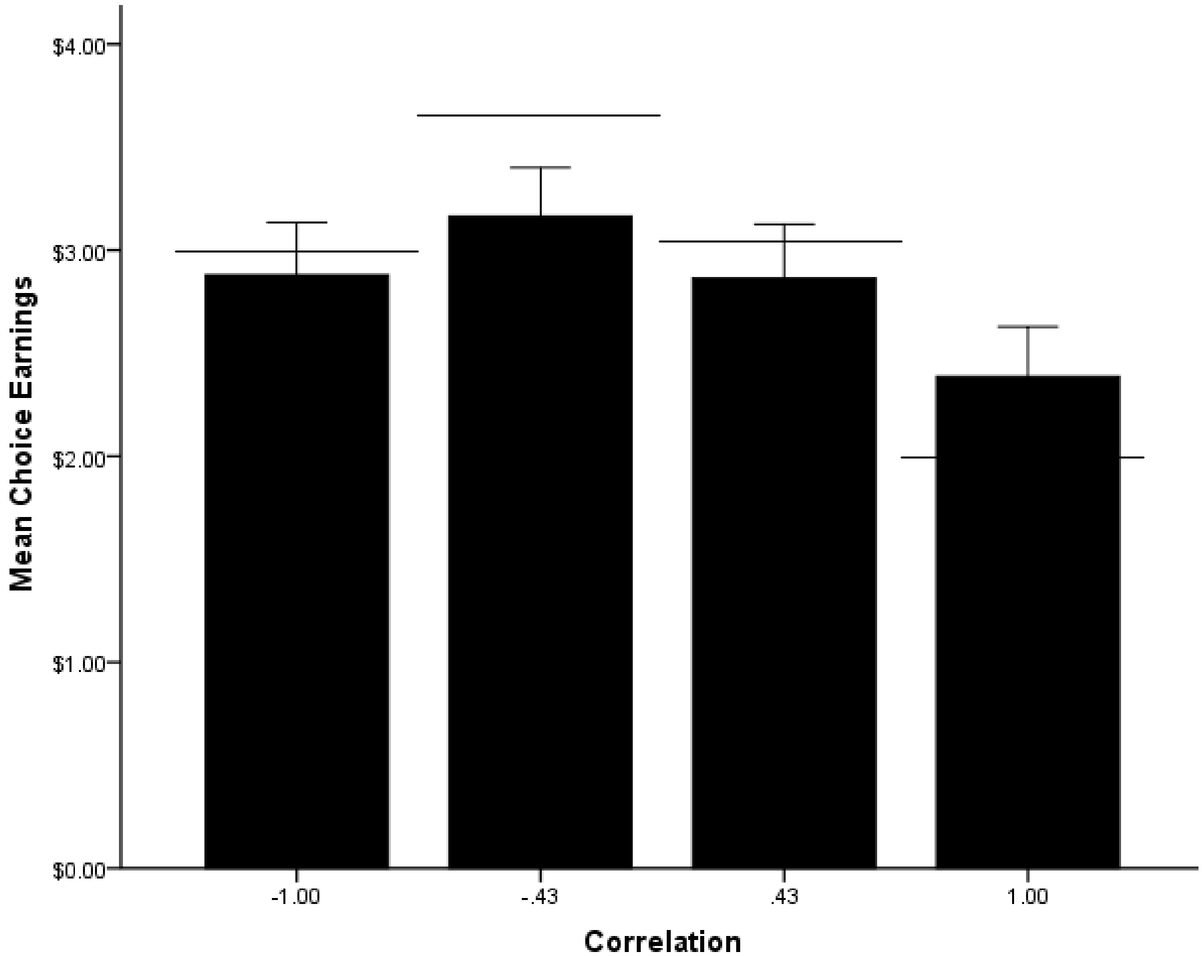

Figure 6. Mean choice earnings for each of four correlation conditions. The black horizontal bars represent the mean optimal earnings across conditions. The error bars display 1.0 standard error.

Discussion

Participants chose the work-with-others alternative in both negative correlation conditions and in the modest positive condition in which sharing was optimal. That is, when the correlation produced at least some reduction in the variation of earnings and it was more beneficial to share than work independently, participants chose the sharing option. Participants', therefore, responded optimally by reducing the risk of not meeting the earnings requirement and, as the earnings in Figure 6 showed, mean earnings were near the maximum programmed average across these three conditions.

When the correlation in earnings between the participant and partner was perfectly positive, there were no benefits to sharing over working alone. In this condition, participants still preferred the work-with-others option. It is unclear why sharing persisted in this condition. Note that in this condition the programmed mean earnings for sharing were identical to the earnings for working alone, yet participants showed a slight preference for the work-with-others option. This preference might indicate a slight preference for working with others over working alone, all else being equal, which suggests that participant's behavior was influenced by the social nature of "working-with-others." Such preference might have occurred because participants likely have a long history of reinforcement for sharing and cooperation. For example, research has shown that parents reinforce their children's sharing behavior starting at a very young age (Cook & Stingle, 1974; Shaw & Olsen, 2011). It is important to note, though, that the influence the social nature of the task has on participants' preference for the work-with-others alternative did not influence earnings. It seems more likely that the sharing that occurred in this condition was simply a carry-over effect. In most conditions, sharing was optimal. Thus, sharing may have occurred in the r = +1.0 condition because sharing was optimal in the three other conditions.

Another possible explanation for the sharing that occurred in the r = -1.0 condition is that participants were not able to distinguish differences in the variability in earnings across the correlation conditions. This explanation in unlikely, however, because participants responding was sensitive to changes in programmed mean earnings for optimal choices (see Figure 6). In the *r* = -.43 condition, earnings for exclusive choice of the work-with-others alternative were the highest ($3.50) and participants responding maximized reinforcement by showing the strongest preference for the sharing option in this condition than in any of the other correlation conditions. Conversely, optimal mean earnings were the lowest in the *r* = +1.0 condition; earnings for the sharing option and the work-alone option were identical at $2.06. Here, participants' responding had the weakest preference for the work-with-others option. Although these differences were not significant, these results suggest that participants were able to distinguish between the four correlation conditions.

Anthropological field studies that have found that asynchronous food products tend to be shared more than synchronous food products (Cashdan, 1985; Kaplan & Hill, 1985). For example, meat and honey tend to be food products that are acquired probabilistically, whereas vegetation is a resource that individuals are able to obtain on a more consistent basis. Thus, meat and honey are shared more than plant food products because they lead to the greatest reduction in the variability of acquisition. In the present study, however, participants also shared in the positive correlation condition, which is inconsistent with the findings from these anthropological studies. In the field, it is likely that sharing may not occur when resources are synchronous not only because there are no benefits for sharing, but also because there may be a small cost involved. This cost could include the effort or time required to engage in the pooling and sharing of food. If a small monetary cost was associated with choosing the work-with-others option in the present study, this likely would have produced a shift to the work-alone option when *r* = +1.0. For example, if the earnings requirement was set at $0.25 and choosing the sharing option produced a loss of $0.02 at the end of the block, then it would still be optimal to prefer the sharing option in the first three correlation conditions (*r* = -1.0, -.43, and +.43). However, when *r* = +1.0, although the earnings budget would not specifically predict a preference for one option over the other; participants would maximize earnings by preferring the work-alone option.

CHAPTER IV

EXPERIMENT 3

Previous research has suggested that when one person receives greater benefits from cooperating than the other, cooperation may be disrupted (Fantino & Kennelly, 2009; Kennelly & Fantino, 2007; Schmitt & Marwell, 1972; Spiga et al., 1992). For example, in a study carried out by Schmitt and Marwell, dyads were able to engage in either an individual task or a cooperative task. The cooperative task produced higher rewards, however, one participant in the dyad always received more than the other participant. As the magnitude of the inequity increased, cooperation decreased as the individual receiving the smaller payment opted to cooperate less. For example, when one member of the dyad received twice as much as the partner, 15 % of the dyads no longer cooperated, and when one member of the dyad received five times as much as the partner, 40% of the dyads no longer cooperated. Similarly, in another cooperation task, Spiga et al. manipulated inequity in earnings by either increasing or decreasing the reinforcement schedule experienced by the participant, relative to the (fictitious) partner. Participants made more choices to work independently when the partner experienced a richer reinforcement schedule in comparison to the participants'. In addition, two studies using the Sharing Game, described above, found that when participants were given choices between receiving high earnings that were less than the partner's (e.g. participant gets $6.00, partner gets $8.00) or receiving lower earnings that were more than the partner's (e.g. participant gets $4.00, partner gets $2.00), participants rarely chose the higher earnings option (Fantino & Kennelly; Kennelly & Fantino). Interestingly, these latter studies showed that the most frequent pattern of behavior was alternating choices between the two options, a pattern which the authors interpreted as an attempt by participants to equate the earnings between themselves and their partners.

In all of these studies, cooperation was disrupted when the participant received less than the partner. However, cooperation was not disrupted when the participant received more than the partner (Schmitt & Marwell, 1972; Spiga et al., 1992). For example, Schmitt and Marwell found that when inequity in earnings was introduced, a shift to the work alone option was always initiated by the participant who received less earnings. Furthermore, Spiga et al. demonstrated that participants who were exposed to a condition where they received more than the (fictitious) partner, they either responded more on the cooperation option or no differently than when earnings were equitable. These findings suggest that inequity per se does not disrupt sharing, but only inequity in which the participant receives a lower amount.

Research by social psychologists suggests that the disruption in cooperation caused by the inequitable distribution of resources may occur because individuals prefer outcomes that are proportional to their contributions (Messick & Sentis, 1979; Walster, Walster, & Berscheid, 1978). That is, when participants assume that the contributions made by themselves and their partners are equal, then their compensation also should be equal. When the compensation is not proportional to the contribution, then individuals perceive the outcome to be unfair and, in turn, prefer to not cooperate even if it is optimal to do so in terms of maximizing earnings.

Similar findings have been purported within the field of industrial/organizational psychology (Goodman & Friedman, 1971). Experimenters have manipulated the effort required to complete a joint task and then asked participants to allocate funds between themselves and their partners. Participants tended to distribute money proportional to each person's contribution (Leventhal, Allen, & Kemelgor, 1969; Leventhal, Weiss, & Long, 1969). Moreover, studies have indicated that when people are told they are making less money than another similarly skilled employee in the same position, they will decrease their work output in an attempt to compensate for their lower monetary pay (Goodman & Friedman).

Behaviorally, differences in reinforcement magnitude may be interpreted as an aversive stimulus that participants will work to escape or avoid by preferring options with equal reinforcement outcomes (Matthews, 1977; Schmitt & Marwell, 1972; Spiga et al., 1992; Weiner, 1977). That is, when cooperation no longer yields equal monetary outcomes, preference shifts to the work-alone option even though overall reinforcement rates may decrease. Moreover, when individuals are given the opportunity to eliminate inequity by engaging in behaviors such as giving or taking earnings from their partners, cooperation is maintained when it results in higher overall reinforcement (Marwell & Schmitt, 1975; Schmitt & Marwell). If giving was available, but not used by the partner favored by inequity, then the other partner tended to shift to the work-alone option. In addition, taking was tolerated by the higher-earning partner in the presence of inequity, but in the absence of inequity taking disrupted cooperation and participants' preferences shifted to the independent option.

Research suggests that aversion to inequity occurs in other species, such as capuchin monkeys, indicating that avoidance of inequity favoring another individual may confer organisms with evolutionary advantages (Brosnan & de Waal, 2003; Hachiga, Silberberg, Parker, & Sakagami, 2009). Brosnan and de Waal demonstrated that when capuchin monkeys witnessed another capuchin receive a high-preferred food item, they would no longer take a previously accepted low-preferred food item. Although the ultimate cause for this type of behavior is not yet known, several possibilities have been offered. For instance, Brosnan and de Waal suggested that this preference evolved through social comparisons that allowed organisms to maintain a relative advantage over others. Shaw and Olsen (2011) argue that inequity aversion signals positive, but hard to observe and costly to inspect traits, such as impartiality or fairness to others. That is, this aversion signals to others that the individual engages in fair and impartial behavior towards others; thus, engaging in cooperative behavior with the actor will not result in the other being exploited.

One difference between the methodology used in previous human cooperation experiments and the earnings budget procedure is that in the former studies participants were guaranteed to earn at least some amount of money for working alone. There is no requirement that participants had to meet and, therefore, no chance of experiencing a shortfall in earnings. Participants may be less sensitive to inequity under budget constraints in which a certain requirement needs to be met to avoid a shortfall.

The purpose of Experiment 3 was to investigate whether inequity disrupted sharing when sharing reduced the variability in earnings. It is important to assess the effects of inequity on sharing under budget constraints because the risk-reduction sharing model predicts that it is optimal to share under positive earnings budget conditions, even under a range of inequity conditions. Previous research suggests that inequity may constrain optimal responding. That is, although it may be optimal to share or cooperate in inequitable conditions, individuals' choices seem to be disrupted by receiving fewer resources than someone else.

Across conditions of Experiment 3 the participant's proportion of the total earnings accumulated through sharing was manipulated. Specifically, the division of the participant/partner earnings was $0.30/$0.30, $0.28/$0.32, $0.26/$0.34, $0.24/$0.36. In all three of the inequity conditions, inequity favored the partner. However, participants could meet the earning requirement by sharing in all but one condition (the most inequitable). Thus, it was predicted that participants would prefer the work-with-others option in the first three conditions and prefer the work-alone option in the last (most inequitable) condition, where participants could not met the earnings requirement by choosing the sharing option. Another possibility, however, was that participants would switch to the work-alone option when earnings became more inequitable.

Method

Participants. An equal number of males and females (*n* = 14) 18-21 yrs (*M* = 19.08 yrs) were recruited to participate. Of these participants, 66.67% identified themselves as Caucasian, 25% as African American, 8.33% as Hispanic, and two participants did not disclose their ethnicity.

Procedure. All details of the procedure were the same as Experiment 1 with the following exception: if the participant chose the "work with others" option, then at the end of the block the participant's and partner's totals were added together and split across conditions in the following manner, respectively: Equity ($0.30/$0.30), Inequity 4 ($0.28/$0.32), Inequity 8 ($0.26/$0.34), and Inequity 12 ($0.24/$0.36). The earnings requirement was $0.25 across all four conditions. Thus, the earnings-budget was positive in all but the last inequity condition (Inequity 12); making sharing optimal in all but the most inequitable condition. Participants completed six sessions a day for two days. Participation lasted 2.5-3 hr per day, 5-6 hr total.

Experimental Design. The experiment consisted of a repeated measures design. Each condition was presented in a counterbalanced order and was experienced three times in total.

Data Analysis. The assumption of sphericity was analyzed using Mauchly's test, which indicated equal variances across populations, $\chi^2(5) = 2.09$, $p = .837$. The Shapiro-Wilk test indicated that the assumption of normality was violated (S-W[48] = .932, p = .008), however, visual inspection of both a histogram and Q-Q plot showed that the data did not noticeably differ from a normal distribution. Consequently, a one-way repeated measures ANOVA test was used to test if there was a significant difference across the four inequity conditions.

Results

Two of the 14 total participants recruited stated that they did not believe they were working with another person. Data from these participants were subsequently dropped from the analysis, leaving a total of 12 participants. The last two exposures to each condition were analyzed. Figure 7 shows the mean number of work-with-others options chosen across all four conditions. A one-way repeated measures ANOVA test yielded a significant effect of inequity on sharing, $F(3, 33) = 16.23$, $p < .001$, $\eta_p^2 = .596$. There was not a significant difference in the variation among individuals, $F(11, 33) = 1.83$, $p = .088$. Post hoc tests using a Bonferroni adjusted alpha of .05/6 = .008 showed that participants chose the work-alone option significantly more in the Inequity 12 condition (*M* = .83, *SD* = 1.19) than in the Equity (*M* = 6.21, *SD* = 2.75, $p < .001$), Inequity 4 (*M* = 4.96, *SD* = 2.59, $p = .001$), or Inequity 8 (*M* = 5.79, *SD* = 2.45, $p < .001$) conditions. There were no significant differences across these latter three conditions. The number of participant's responding who showed a preference for the work-with-others option, varied across conditions and was 66.67% (Equity), 41.67% (Equity 4), 58.3% (Equity 8), and 0.0% (Equity 12).

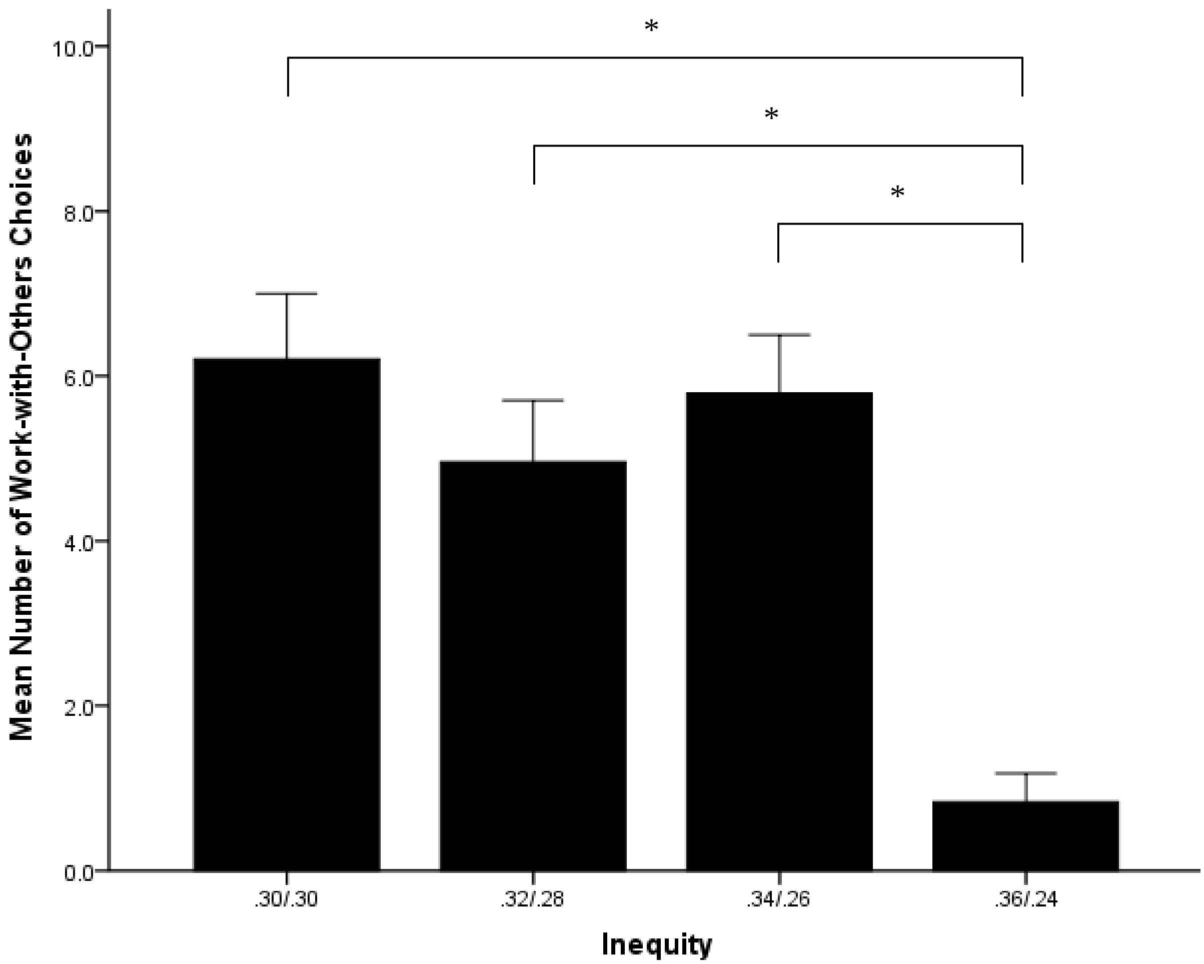

Figure 7. Mean number of work-with-others choices across four distributions of participant/partner earnings. Error bars show 1.0 standard error and asterisks denote statistically significant differences between groups.

Figure 8 shows mean session earnings from choice blocks from the last two exposures to each condition. Session earnings were highest when block earnings were divided equally and subsequently decreased as the inequity in earnings increased. On average, participants earned $2.62 (programmed mean of $3.00) when the earnings were divided equally (Equity condition). Earnings decreased to $2.50 (programmed mean of $2.80) in the Inequity 4 condition and to $2.33 (programmed mean of $2.60) in the Inequity 8 condition. In both of these inequity conditions, exclusive choice for the work-alone option would have yielded an average of $2.06. Thus, continuing to choose the work-with-others options increased session earnings during choice trials by $0.54 and $0.74. In the last inequity condition (Inequity 12), in which it was optimal for participants to choose the work-alone option, participants earned on average $1.87, which was close to the average optimal earnings of $2.06. Across all four conditions, participants mean earnings were near the average optimal earnings, indicating that choices maximized reinforcement.

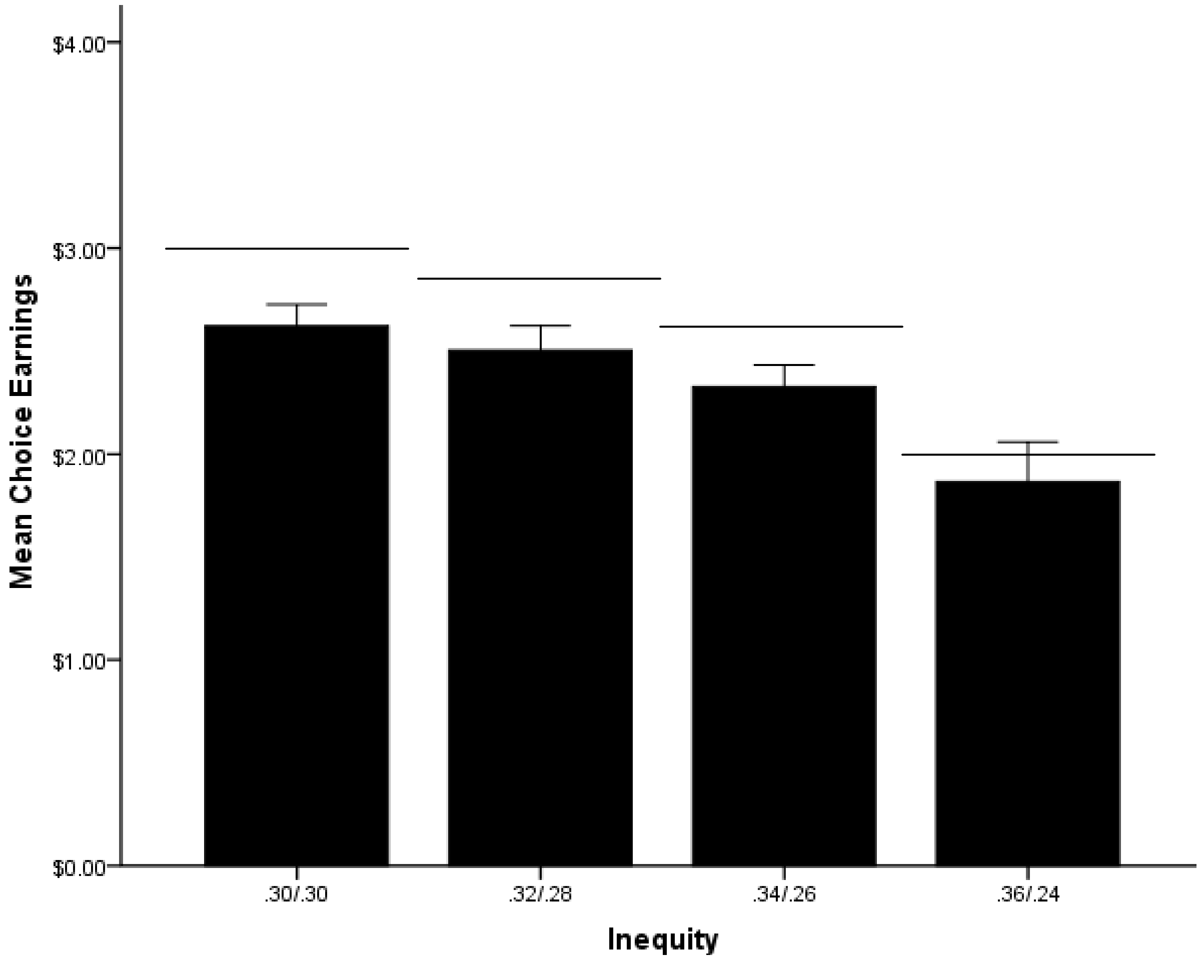

Figure 8. Mean choice earnings for each of four inequity in earnings conditions. The black horizontal bars represent the mean programmed earnings across conditions. Error bars show 1.0 standard error.

Discussion

The present experiment investigated the effect of inequity in earnings within the context of a risk-reduction model of sharing, based on the energy budget rule. Participants' responding for monetary outcomes was consistent with the predictions of the model. Specifically, when participants experienced a positive earnings budget, they showed a preference for the work-with-others option, whereas when participants experienced a negative earnings budget, they showed a preference for the work-alone option. These preferences occurred despite inequity in earnings between the participant and partner, suggesting that the social variable of inequity did not negatively affect cooperation in this study. The current findings are incongruent with previous research which has shown that participants' preferences shifted from the cooperation option to the work-alone option when the participant received less than the partner (Fantino & Kennelly, 2009; Kennelly & Fantino, 2007; Schmitt & Marwell, 1972; Spiga et al., 1992). These earlier studies have demonstrated that inequity in earnings is a social variable that constrains optimal behavior.

One key difference between the previous experiments and the present study is the presence of an earnings requirement that participants need to meet in order to bank their earnings. In previous inequity research, choosing the work-alone option produced lower earnings than cooperating, but it always produced some amount of money. In the current earnings-budget methodology, preference for the work-alone option led to a shortfall (no money) 50% of the time. Thus, the presence of the requirement made the work-alone alternative a risky option. Current results suggest, then, that the presence of this earnings requirement, which in turn allows the possibility that an individual will experience a shortfall, makes choice less sensitive to the social variable of inequity.

Another possible explanation for the results of Experiment 3 could be that the differences in earnings between the participant and the partner were too small to significantly affect preferences. That is, it is possible that discrepancies of $0.04 and $0.08 per block were not sufficiently aversive to motivate shifts towards the work-alone option. Schmitt and Marwell (1972) investigated cooperation across three inequity magnitude conditions. In the small inequity condition, in which one individual in the dyad received twice as much as the partner ($0.006/$0.003), more than half of participants (85%) continued to cooperate over work alone. When one individual made three times as much ($0.009/$0.003), the number of dyads that continued to cooperate dropped to 75%, and in the largest inequity condition, where earnings for one participant in the dyad was five times more ($0.02/$0.004), the number of dyads that continued to cooperate decreased to 60%. However, even at the largest magnitude difference, the actual monetary values used were quite small and less than those used here. Furthermore, in the present study when the sharing option was chosen, the discrepancies in earnings between the participant and the partner would have accumulated across blocks and, on average, totaled $0.67 and $0.87 across the session for Inequity 4 and 8, respectively. Thus, it does not seem likely that the small magnitude of inequity can completely account for the persistence of sharing in the present study.

To better determine whether the earnings budget made participants less sensitive to inequity, it would be necessary to replicate Experiment 3 but include neutral budget conditions in which there was no earnings requirement. If participants' responding showed a preference for the work-alone option under inequity conditions in neutral budget conditions but showed a preference for the work-with-others option in positive budget conditions, then this would provide stronger evidence that the budget conditions determined choice. To assess this, pilot data was collected from 5 additional participants. These participants were exposed to the same four conditions described above, but choice was studied under neutral budget conditions (no requirement). Participants tended to choose the work-alone option across all conditions, but preference for the work-alone option was greater in the inequity conditions. The mean number of work-with-others choices across the Equity, Inequity 4, Inequity 8, and Inequity 12 conditions were *M* = 3.7, *M* = 2.5, *M* = 2.5, and *M* = 2.4, respectively. Overall, then, although additional data is needed, these results suggest that the budget manipulation, and not simply small differences in earnings between the participant and partner, was responsible for the persistence of sharing in Experiment 3.

CHAPTER V

EXPERIMENT 4

In Experiments 1-3, and in one of the previous studies investigating risk-reduction accounts of sharing (Pietras et al., 2006), resource sharing was accomplished by pooling and then immediately dividing the accumulated resources. Under more naturalistic conditions, sharing may more often take the form of giving to others, and then receiving benefits at a later time (e.g. O'Shea, 1981; Pagezy, 1988; Wiessner, 1982). This pattern may be described as *reciprocal exchange*. Reciprocal exchange involves an individual engaging in some behavior that is beneficial to another (e.g. sharing resources) without knowing exactly when, or if, the other person will reciprocate (e.g., Molm et al., 2001). The sharing that is described in most anthropological field studies involves reciprocal exchange, rather than the pooling of resources (e.g. Bliege Bird & Bird, 1997; Cashdan, 1985; Kaplan & Hill, 1985).

Reciprocal exchange is a riskier form of sharing because typically it is not predetermined whether the other person will reciprocate the beneficial act, thereby making it possible for the recipient to exploit the person who initiates the exchange. To avoid exploitation, it is important for giving individuals to be able to distinguish between those who reciprocate and those who do not (Nowak & Sigmund, 1998). This distinction can be made by repeated interaction with the person, observing whether the person engages in reciprocal behavior with others, or by knowing the reputation that the other person has for engaging in reciprocation. Not every gift needs to be reciprocated in order for the exchange to be beneficial for the giver. As long as the occasional benefits received for engaging in the exchange outweigh the possible costs, then this exchange behavior is optimal.

Several laboratory choice studies have investigated the effects of the probability of reciprocity on cooperation. For example, both Acevedo and Krueger (2005) and Baker and Rachlin (2001) examined the probability of reciprocal exchange in the Prisoner's Dilemma game. In this game, participants and (fictitious) partners could earn more overall if both cooperated than if both defected, but participants could earn the most if they defected when their partner cooperated and the least if they cooperated when their partner defected. In both studies, when the probability of reciprocation was 100% or 75%, earnings were maximized when participants chose to cooperate, but when the probability dropped down to 50%, earnings were maximized when participants chose to defect. When the different probabilities were signaled participants behaved optimally: they preferred the cooperation option under the 100% and 75% conditions and chose the defect option under the 50% condition. However, when the different probabilities were unsignaled, participants only preferred the cooperation option when the probability for reciprocation was 100%, although it was still optimal for participants to choose the cooperation option in the 75% condition.

Other studies have looked at the effect of feedback on cooperation when the probability of reciprocation varies (Brown, 2006; Fantino, Gaitan, Meyer, & Stolarz-Fantino, 2006). In these studies participants played the same iterated version of the Prisoner's Dilemma game with a computer when the probability that cooperation was reciprocated varied between 100% and 63%, when cooperation and defection had the same expected value; and when the participants received or did not receive feedback about past (Brown) or future consequences (Fantino et al.). Preference for the cooperation option developed sooner when the probability of reciprocation was 100% than when it was lower. When the probability of reciprocation was less than 100%, then the incorporation of feedback increased participants' preferences for the cooperation option. Studies have also shown that when the partner's strategies are more predictable, such as when they play tit-for-tat, cooperation develops sooner than when the partner's strategies are more random (e.g., Bendor, Kramer, & Stout, 1991; Kunreuther, Silvasi, Bradlow, & Small, 2009).

As noted above, in previous laboratory studies investigating risk-reduction accounts of sharing partners always cooperated or pooled their earnings when participants chose the cooperation option (e.g. Pietras et al., 2006). Although this makes the outcomes for cooperating predictable, it may not be very ecologically valid. Furthermore, research that has looked at reciprocal exchange tends to do so using the Prison's Dilemma, in which defection is less risky than cooperation in terms of minimizing possible losses (Marwell & Schmitt, 1975). Within the paradigm of the earnings budget, though, the cooperation option is less risky in terms of reducing the probability one will experience a shortfall. Because the risk-averse option in the earnings-budget procedure (cooperation) is not the same as in the Prisoner's Dilemma task (defection) and reciprocal exchange seems to be a more common method of sharing than the pooling of resources, it is important to investigate reciprocal exchange within the context of the earnings budget. Thus, Experiment 4 was designed to investigate sharing when the probability that the partner shared with the participant was manipulated.

Like equity, sensitivity to reciprocation failures may constrain optimal responding. That is, as with equity, individuals may stop cooperating when the partner fails to reliably reciprocate; although it is not optimal to do so. The inability to accurately evaluate probabilities may contribute to this effect. Research has shown that individuals tend to underestimate events that have a moderate probability and overestimate events that have a very high or low probability (Kahneman & Tversky, 1979). Thus, when the probability of reciprocation decreases, individuals may judge the reciprocation probability to be lower than its actual value. This cognitive bias therefore may interfere with optimal performance (Acevedo & Krueger, 2005; Baker & Rachlin, 2001). Thus, it is important to determine whether the probability of reciprocity affects sharing in situations involving shortfall risk.

The goal of Experiment 4 was to investigate sharing across three different reciprocation probabilities. In this study, the reciprocation was not delayed, but occurred after the person chose the sharing option. That is, at the end of the block, the probability that the partner would pool earnings with the participant was manipulated. Choice was investigated across three reciprocation probability conditions: 95%, 65%, and 0%. Whenever the probability of reciprocation was above 40%, participants could maximize earnings by choosing the work-with-others alternative; whereas when the probability of reciprocation was below it, participants could maximize earnings by choosing the work-alone alternative. The 65% probability or reciprocation condition was, therefore, included to investigate sharing when the probability or reciprocation was clearly uncertain, but sharing was still optimal. Probabilities were not explicitly signaled, but participants were exposed to each probability during the forced choice blocks at the beginning of each session. It was predicted that participants would share under the 95% and 65% conditions, but work alone in the 0% condition. It was also possible that, as in the Acevedo and Krueger (2005) and Baker and Rachlin (2001) studies, sharing would decrease when the probability of reciprocity dropped below 100%.

Method

Participants. For Experiment 4, $n = 12$ participants were recruited between the ages of 18-23 yrs ($M = 19.42$ yrs). The majority were female (75%) and identified themselves as Caucasian (75%), while others identified themselves as African American (16.67%) and as Asian (8.33%).

Procedure. A primary difference between Experiment 4 and the preceding experiments was that when participants chose the "work with others" option, the partner did not always contribute earnings, or reciprocate the sharing act with the participant. At the end of a block, if the participant met the earnings requirement of $0.30 (i.e. earned $0.36 or more); then the partner always pooled earnings with the participant; but if the participant did not met the earnings requirement (i.e. earned $0.24 or less), then the probability of reciprocation varied across conditions and was either (1) $p = .95$, (2) $p = .65$, or (3) $p = .00$. The sequence of events at the end of a block is shown in Figure 9. When the partner did not share earnings, the words "Your partner did not choose the work-with-others option" appeared on the screen at the end of the five trials. Afterwards, the block concluded in the same manner as if the participant had chosen the work-alone option. The decision to program the partner to reciprocate whenever the participant earned $0.36 or more (recall that participants could only earn $0, $0.12, $0.24, $0.36, $0.48 or $0.60) was made to better model social exchange and helps maintain the social deception. That is, the partner always pooled earnings with the participant when the participant earned $0.36 or more because under those conditions the partner would benefit by doing so. The partner probabilistically shared whenever the participant earned less than $0.36 because in these conditions the partner would need to give up some of his or her earnings and receive no immediate benefit. Again, this models real-world situations in which a partner is likely to fail to reciprocate. Again, participants completed six sessions a day, which lasted 2.5-3 hr, for two days, totaling 5-6 hr.

Sequence of events when participants earned $0.24 or less		**Sequence of events when participants earned $0.36 or more**		
Please Wait	Your earnings $0.24	Please Wait	Your earnings $0.36	
Other’s earnings $0.36	Your earnings $0.24	Other’s earnings $0.24	Your earnings $0.36	
Your partner did not choose the work-with-others option		Other’s earnings $0.24	Your earnings + $0.36	= $0.60
Other’s earnings $0.36 ↓ Other’s total earnings $0.36	Your earnings $0.24 ↓ Your total earnings $0.24	Other’s share $0.30 ↓ Other’s total earnings $0.30	Your share $0.30 ↓ Your total earnings $0.30	

Figure 9. Illustration of events in Experiment 4 that occur at the end of the block when the partner did not (left column) or did (right column) share with participants when participants choose the work-with-others option. The probability that the partner shared with the participant when the participant earned $0.24 or less was p = .00, .65, and .95. The partner always shared with the participant when the participant earned $0.36 or more (see text for details).

Experimental Design. The experiment consisted of a repeated-measures design. Each of the three probability of reciprocation conditions were experienced four times and were presented in an ascending or descending order, with order counterbalanced across participants. Participants were exposed to an ascending or descending order instead of a random order because pilot participants exposed to a random order failed to show sensitivity to variability in the probability of reciprocation.

Data Analysis. Mauchly's test indicated that the assumption of sphericity was violated (χ^2[2] = 6.045, *p* = .049), but the Shapiro-Wilk test indicated that the assumption of normality was met, *S-W*(36) = .949, *p* = .099. Thus, a one-way repeated measures ANOVA test with a Greenhouse-Geisser correction was used.

Results

The mean of the last two exposures to each condition were analyzed. Figure 10 shows the mean number of work-with-others options chosen across all three reciprocity conditions. A one-way repeated measures ANOVA test, using a Greenhouse-Geisser correction, yielded a significant effect of the probability of reciprocation on sharing, $F(1.376, 15.134) = 14.813$, $p = .001$, $\eta_p^2 = .574$. There was not, however, any difference among individual variation, $F(11, 22) = 2.07$, $p = .07$. Post hoc tests using a Bonferroni adjusted alpha of .05/3 = .016 showed that participants chose the work-alone option significantly more when the probability of reciprocation was .00 (*M* = 2.5, *SD* = 2.70) than when *p* = .65 (*M* = 5.75, *SD* = 1.96, *p* = .002), or *p* = .95 (*M* = 7.0, *SD* = 2.58, *p* = .002). There was not a significant difference in the number of work-with-others choices between the *p* = .65 and *p* = .95 conditions (*p* = .067). In these two conditions, 41.67%

and 66.67% of participants preferred the work-with-other option, respectively; whereas 25% of participants in the $p = .00$ condition preferred the sharing option.

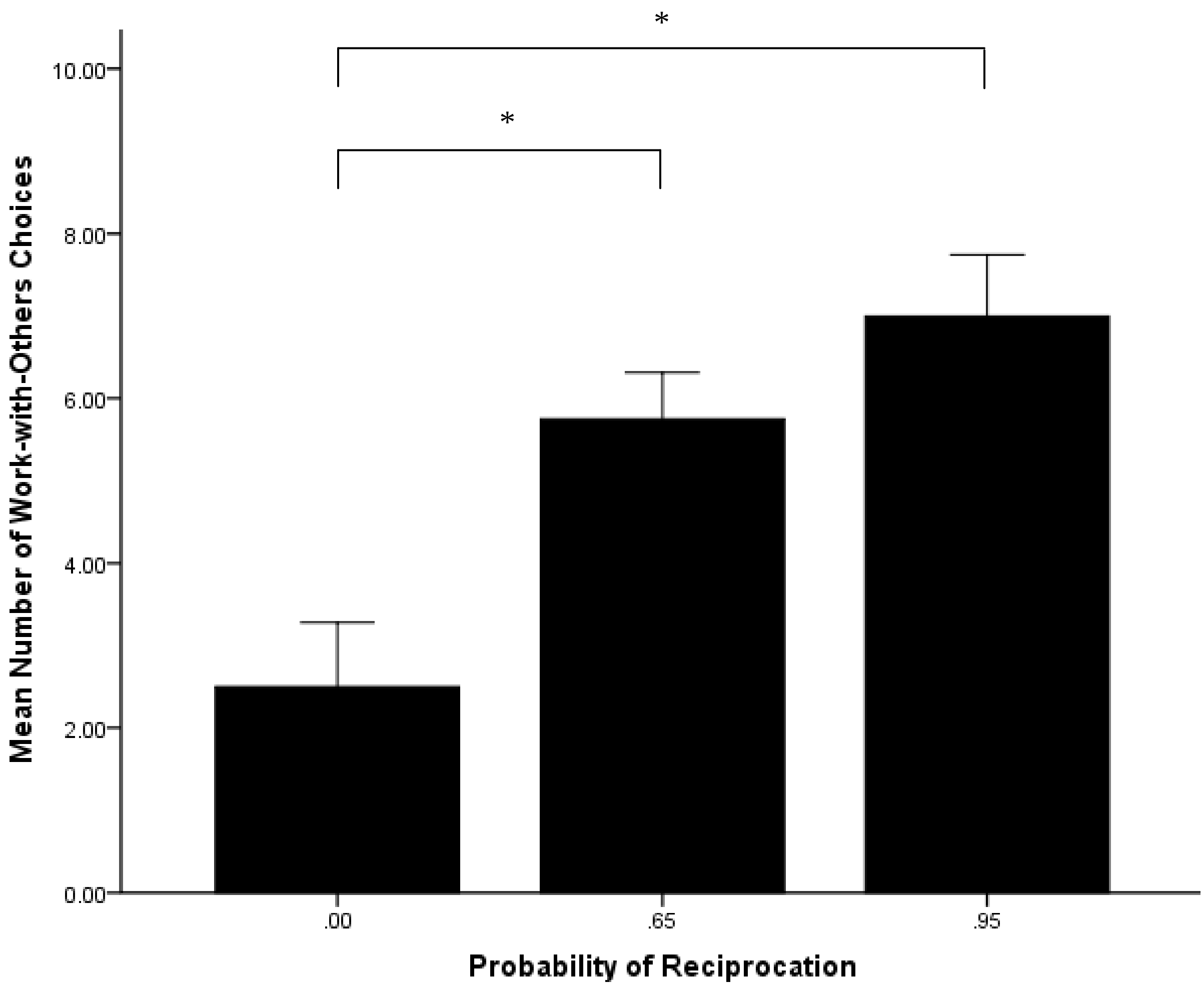

Figure 10. Mean number of work-with-others choices across four probabilities of reciprocation. The error bars show 1.0 standard error and asterisks denote statistically significant differences between groups.

Figure 11 shows mean earnings from choice trials in the last two exposures to each of the three reciprocation conditions. Participants' mean choice earnings were near the programmed mean earnings in all three conditions. Average optimal earnings were highest at $2.93 in the $p = .95$ condition, where participants averaged $2.64. When $p =$

.65, participants mean choice earnings were $2.30 and were close to the optimal mean earnings of $2.48. Choice earnings were the most variable when $p = .00$. Participants mean earnings were $1.93 (mean optimal earnings were $2.06). Exclusive preference for the work-with-others option in this condition ($p = .00$) would have yielded an average earnings of $1.50. Conversely, if the work-alone option was exclusively preferred during any of the three reciprocity conditions, average earnings would be $2.06. These choice earnings, therefore, indicate that participants' choices maximized earnings.

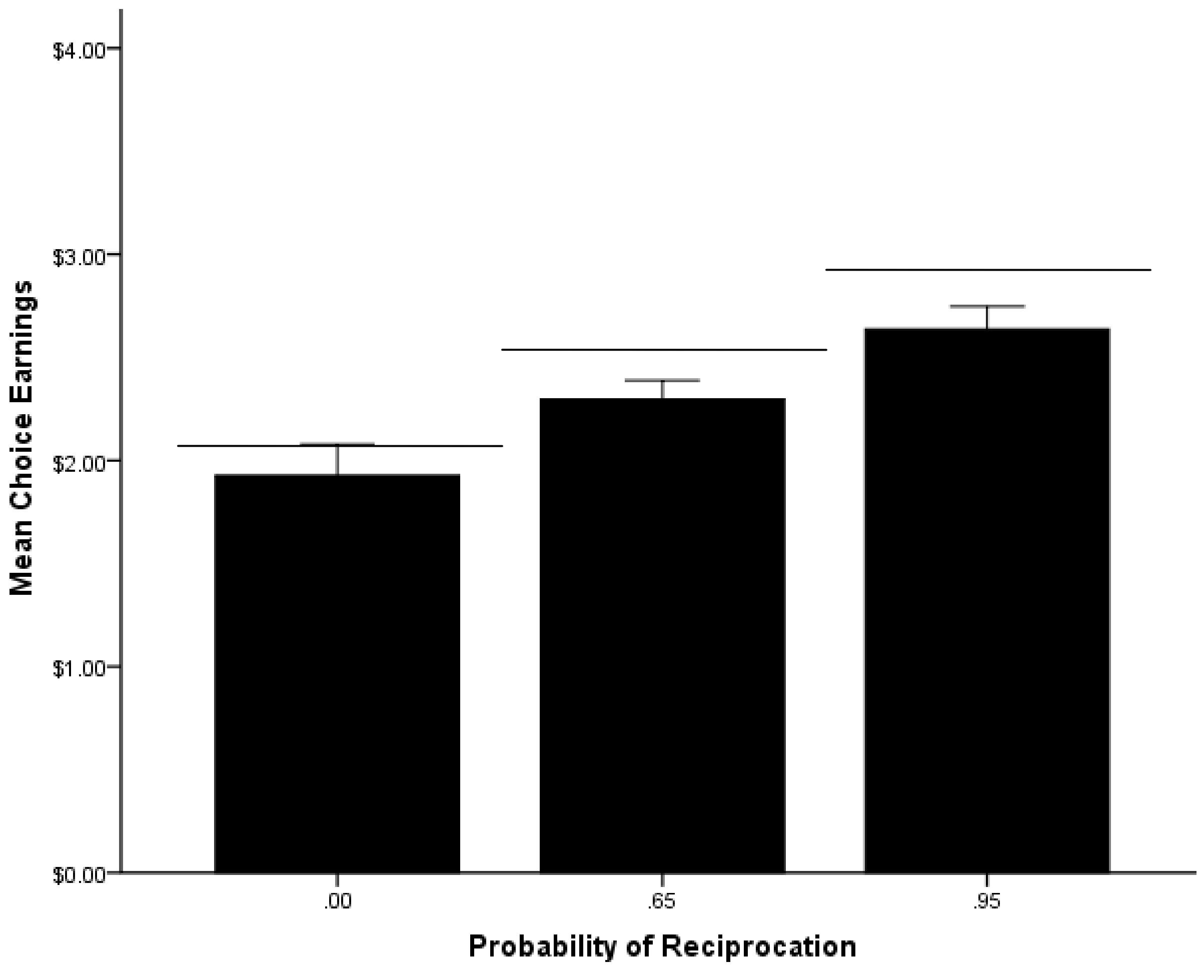

Figure 11. Mean choice earnings for each of four probability of reciprocation conditions. The black horizontal bars represent the mean programmed earnings across conditions. The error bars display 1.0 standard error.

Discussion

When the probability of reciprocation was *p* = .95 or .65, participants optimized their earnings by preferring the work-with-others option. When the probability of reciprocation was *p* = .00 participants optimized their earnings by preferring the work-alone option. If participants chose the work-with-others option in the *p* = .00 condition and earned $0.24 or less, the partner did not reciprocate. Therefore, the participant would have failed to meet the earnings requirement of $0.30. If participants chose the work-with-others option in the *p* = .00 condition and earned $0.36 or more, then the partner shared 100% of the time. Participants, then, pooled more earnings than they received back in the *p* = .00 condition, making the work-with-others option more costly than the work-alone option.

The variability in earnings when participants chose the work-with-others option was reduced as the probability of reciprocation moved from .00 to .95. When *p* = .95 and .65, choosing the sharing option reduced the variability in earnings by more than 50% and, therefore, reduced the risk that one would experience a shortfall. Conversely, when *p* = .00, choosing the work-with-others option only reduced the variability in earnings when participants had already met the earnings requirement on their own (i.e., when earnings were $0.36 or more). Thus, not only did sharing not reduce the risk that one would experience a shortfall, but it was also costly to the participant. Average earnings for exclusive preference for the sharing option when *p* = .00 was $0.56 less than the average earnings for exclusive preference for the work-alone option. Therefore, a preference for the work-alone option was optimal in this condition.

The finding that participants shared in the $p = .95$ and $p = .65$ conditions is only partially congruent with previous studies. Prior research has shown that participants continue to cooperate when the probability of reciprocation decreases when it is optimal to do so, but only when probabilities are explicitly signaled (Acevedo & Krueger, 2005; Baker & Rachlin, 2001) or when feedback on past or future outcomes are given (Brown, 2006; Fantino et al., 2006). In the current study, the probability of reciprocation was not explicitly stated nor was feedback given, yet participants still responded optimally. One reason for the persistence of sharing as the probability of reciprocation decreased was that participants were exposed to the outcomes of sharing and working alone through the forced-choice trials. This suggests that the probability of reciprocation does not necessarily have to be explicitly stated in order for participants to respond optimally. Unsignaled probabilities may better approximate real world reciprocal exchange, where one has to learn either through experience or reputation to distinguish between those who reciprocate and those who exploit (Nowak & Sigmund, 1998).

As described above, the reciprocal exchange version of the earnings budget procedure may better model naturalistic sharing conditions, as opposed to the pooling and dividing of resources (e.g. Cashdan, 1985; O'Shea, 1981; Pagezy, 1988; Wiessner, 1982). For example, Kaplan and Hill (1985) found that the Ache of eastern Paraguay engage in the reciprocal exchange of meat, like peccary and armadillos, and honey products. These resources vary both in terms of package size and synchrony of acquisition. Individuals tend to acquire a large food product one day, followed by several days of no acquisitions. Thus, reciprocal exchange allows for the reduction in the variability of consumption across days. Furthermore, pooling may turn into reciprocal exchange when different individuals are successful or unsuccessful on different days.

In prior research investigating the effects of the probability of reciprocation using the Prisoner's Dilemma task, there is some delay between the participant's choice and the reciprocation of cooperation or defection by the partner (Baker & Rachlin, 2001; Brown, 2006; Fantino et al., 2006). However, in the current study there was no delay between choice and reciprocation. Specifically, in the Prisoner's Dilemma, a choice made on trial *N* is not reciprocated until trial *N*+1; whereas in the earnings-budget paradigm, there is no delay between choice and possible reciprocation. They happen within the same block. It is possible that introducing a delay, in addition to reciprocity being probabilistic, may disrupt cooperation or sharing (Baker & Rachlin, 2002a). These conditions would better simulate realistic reciprocation where resources are given on days one is successful at acquiring food products and this giving behavior is reciprocated at a later date when others have been successful (Winterhalder et al., 1999).

Another difference between the Prisoner's Dilemma and the reciprocation version of the earnings-budget procedure is that in the latter, whether the partner shares or not depends on whether the participant has met the earnings requirement, and not, as is typically the case in the former, what the participant chose on the previous trial. Computer simulations of the Prisoner's Dilemma have found that a Pavlov strategy outperforms all others (Nowak & Sigmund, 1993). In this strategy the partner will cooperate if, on the previous trial, both the participant and the partner made the same choice. However, the partner will defect if, on the previous trial, the participant and the partner made opposing choices. Conversely, a study by Baker and Rachlin (2002b) found that participants learned to cooperate at similar rates using both Pavlov and tit-for-tat. In tit-for-tat, the partner will model the choice made by the participant in the previous trial. Generally, in both of these strategies, then, cooperation is reinforced on the next trial and defection is punished, making it possible that cooperation will increase with prolonged exposure to the task or strategy. However, this is not necessarily the case with the earnings budget methodology, in which each choice block is independent of the next. Future research in this area could manipulate whether the partner shares or not at the end of the block using similar strategies based on which option the participant chooses at the beginning of the block.

Another limitation of the present study was that sharing was investigated across only a few probabilities. There were two conditions in which it was optimal to prefer the sharing option (p = .95 and p = .65), but only one condition in which it was optimal to prefer the work-alone option (p = .00). It is possible that less optimal performance would have been obtained at more intermediate probability values, especially values near the indifference point of p = .40. Only one study has investigated choice when the probability of reciprocation was at the indifference point, where cooperation and working alone had the same expected value (Fantino et al., 2006). This study found that in this condition participants' responding eventually favored the cooperation option. Studies designed to investigate the limits of humans' ability to discriminate reciprocation probabilities would provide better information about possible constraints on optimal sharing outside the laboratory.

CHAPTER VI

GENERAL DISCUSSION

The current set of four studies investigated a risk-reduction account of sharing in humans in a laboratory setting using monetary outcomes. Across all four studies, participants reduced the risk of an earnings shortfall by sharing when they experienced a positive earnings budget and by working independently when they experienced a negative earnings budget. In addition, the presence of several social variables including the nature of the partner (Experiment 1), inequity in earnings (Experiment 3), and differing probabilities of reciprocity (Experiment 4) were examined to ascertain if they constrained optimal responding. Results indicated that these variables, in the presence of an earnings requirement, did not disrupt optimal responding. These findings therefore suggest that avoiding shortfalls, or more generally, maximizing earnings was a primary variable controlling participants' choices.

Overall, participants' choices across all four experiments were congruent with the predictions of the energy-budget model as extended to choices for monetary outcomes. These results therefore replicate the findings of previous studies that have shown that individuals' preferences in situations involving risk are sensitive to changes in monetary requirements and earnings budgets (Deditius-Island et al., 2007; Ermer et al., 2008; Mishra & Lalumiere, 2010; Pietras & Hackenberg, 2001; Pietras et al., 2003; Pietras et al., 2008; Rode et al., 1999; Wang, 2002).

Participants' responding was also consistent with the risk-reduction food sharing model that predicts that sharing should occur when it reduces the variability of resource acquisition and, in turn, the probability of an energy deficit (Winterhalder, 1986). Thus, when participants experienced a positive earnings budget, they minimized the probability of a shortfall by preferring the sharing option, and when they experienced a negative earnings budget, they minimized the probability of a shortfall by preferring the work-alone option. These results are consistent with three previous studies that have found that sharing in humans is consistent with predictions of risk-reduction models of food sharing (Kaplan et al., 2012; Pietras et al., 2006; Ward et al., 2009).

It is important to differentiate, however, between sharing behavior that is accounted for in terms of risk reduction and altruistic behavior. Altruism is typically defined as any behavior that comes at a cost or detriment to an organism, while benefitting another (Trivers, 1971; West et al., 2007a). Several theories have been purported to account for seemingly altruistic behavior, such as kin selection, reciprocity, and group selection (Nowak, 2006). The sharing behavior investigated here involved the pooling and dividing of resources in order to reduce the probability that one would experience a shortfall. In positive budget conditions, where sharing was optimal, the share that one received from this division was always beneficial in that it met the individual's earnings requirement. Therefore, the present results support theories that assume that cooperation and sharing occur, not because of altruistic reasons, but because it actually confers a benefit to the individual.

Across all experiments, participants mean choice earnings were near the mean optimal earnings. There was one positive earnings budget condition in each of the four experiments, where the correlation in earnings was -1.0 and earnings were divided evenly between the participant and the partner, and the programmed mean earnings were around $3.00. There was also one negative earnings budget condition in each experiment where the mean optimal earnings were $2.06. If the work alone option was exclusively preferred in any of the positive earnings budgets, participants would have earned an average of $2.06. Conversely, if the work-with-others option was exclusively preferred during any of the negative earnings budgets, then participants' average earnings would have been $0.00. Therefore, across experiments participants' responses maximized earnings. This finding is consistent with previous cooperation studies that have shown that, in general, participants' choice to cooperate or work independently depends on which option produces the greatest earnings (e.g., Marwell & Schmitt, 1975).

The present results further show that predictions of optimal foraging models can be applied to humans' choices in a laboratory setting for monetary outcomes (Hackenberg, 1998; Pietras & Hackenberg, 2001; Pietras et al., 2006; Winterhalder & Smith, 2000). Moreover, the current findings are consistent with other studies that have shown that social foraging models can be extended to human behavior in social contexts. For example, several studies have shown that the ideal free distribution, a model of foraging group size, is able to account for group choice in humans by predicting that the distribution of individuals at different resource sites will be proportional to the reinforcement rate available at each site (e.g., Kraft & Baum, 2001; Madden, Peden, & Yamaguchi, 2002). Several optimal foraging models have been shown to predict human economic behaviors outside the laboratory, such as on-line shopping and brand choice (e.g. DiClemente & Hantula, 2003). It is likely that the risk-reduction model of sharing may also be extended to human social behavior outside the laboratory. McDermott et al. (2008) have argued, for example, the risk-reduction model may help account for political behaviors, such as international conflict. When a leader or a country feels that their political or physical survival is being threatened by another country and low-risk responses (e.g., negotiations) appear inadequate (i.e., negative budget conditions), then that country is much more likely to go to war or engage in risky behaviors.

The ability for optimal foraging models to generalize to human's choices for monetary outcomes suggests that money may be a reinforcer that is generalizable enough to serve as a proxy for food (Hackenberg, 1998). It is important to reiterate, however, that the risk of starvation is a much more biologically relevant event than the possibility of money losses. Thus, the underlying behavioral mechanisms involved in choice in nonhumans under positive and negative energy-budget conditions may differ from those involved in choice in humans under positive and negative earnings-budget conditions. In humans, one proximate variable that may be controlling choice is the maximization of reinforcement (Pietras et al., 2008). Future research is needed to explore the behavioral processes in nonhumans (and humans) that contribute to optimal behavior. Regardless of whether the mechanisms are shown to be similar across humans and nonhumans, that similar patterns of behavior have emerged across different species implies that optimal foraging models are useful for studying choice in a variety of choice contexts.

The Energy-Budget Rule and Prospect Theory

Although participants' choices in the present studies were analyzed within the framework of risk-sensitive foraging theory, the results may also be interpreted in terms of a cognitive choice model, prospect theory (PT). PT is a model of choice which describes how varying environmental risk is framed or referenced (Kahneman & Tversky, 1979). PT explains choice behavior that would be considered biased or "irrational" from the standpoint of standard economic models, which typically assume that choices should prefer alternatives with the highest expected value. For example, one major assumption of PT is that the framing of choice options in terms of gains or losses influences risk preferences and is responsible for the apparently irrational tendency shown in individuals to be risk averse when faced with gains and risk prone when faced with losses. This assumption is generally congruent with the predictions of the energy budget model. In fact, some have argued that cognitive mechanisms responsible for risk preferences described by PT are actually the result of natural selection which has selected adaptive patterns of risk sensitivity specified by the energy-budget rule (Cosmides & Tooby, 1994; McDermott et al., 2008; Tooby & Cosmides, 1999). Specifically, these authors assert that the apparently "irrational" risk-sensitive choices predicted by PT may have evolved from the ancestral environments which favored risk aversion in situations of gains (i.e., positive energy budgets) and risk proneness in situations of losses (i.e., negative energy budgets).

This assumption is supported by recent studies that have demonstrated that capuchin monkeys, like humans, make the same risk prone choices predicted by PT when presented with gambling situations framed in terms of losses (Chen, Lakshminarayanan, & Santos, 2006; Lakshminarayanan, Chen, & Santos, 2011). For example, Lakshminarayanan et al. had capuchin monkeys trade tokens for apple pieces. They could choose to trade with one of two experimenters, both of which initially displayed three pieces of apple. However, one experimenter would only give two pieces of apple for the token, while the other experimenter gave either all three pieces or only 1 (p = .50). When presented with this choice, the monkeys preferred the risk prone choice of having a 50% chance of receiving either three pieces or one piece of apple.

Theories of Human Food Sharing

The results of the present research are congruent with anthropological field studies that have shown that individuals tend to share asynchronous, variable food products, such as meat and honey, in order to reduce their risk of starvation (e.g. Cashdan, 1985; Kaplan & Hill, 1985; O'Shea, 1981; Pagezy, 1988; Wiessner, 1982). Conversely, the preference for the work-alone alternative during a negative earnings budget is similar to studies that have found that individuals behavior tends to shift to working independently when resources are scarce (e.g. Wiessner, 1982). These consistent findings further suggest that the earnings budget procedure may be a useful method for assessing the risk-reduction theory of sharing.

Specifically, the current studies were able to precisely manipulate and control for resource variability (scarcity), resource requirements, and the correlation in resource acquisitions, which previous anthropological field studies have suggested affect sharing (Bliege Bird & Bird, 1997; Cashdan, 1985; Hawkes, 1993; Kaplan & Hill). These field studies, however, were unable to isolate the effects of these variables, making it unclear as to whether the sharing of food acquisitions that was observed occurred because it reduced shortfall risk or if it occurred for other reasons. The risk-reduction model predicts that large, asynchronous food acquisitions should be shared more frequently than small, synchronous food acquisitions; which would average resources across the sharing group, preventing any one individual from experiencing a shortfall (Winterhalder, 1986). Previous lab studies have demonstrated that variability in resource outcomes engenders sharing (Kameda et al., 2002; Kaplan et al., 2012). By adding in a resource requirement, the present studies, in conjunction with the studies by Pietras et al. (2006) and Ward et al. (2009), were able to examine choice in relation to the benefits of engaging in sharing.

As described earlier, however, not all anthropological studies have found support for risk-reduction accounts of food sharing. Researchers have therefore proposed that other theories, such as tolerated theft (e.g., Bliege Bird & Bird, 1997) or trade (e.g., Kaplan & Hill, 1985) are responsible for human resource sharing. Although the current results show that sharing can emerge if it reduces shortfall risk, the results do not indicate that these other factors do not also affect sharing. For example, the risk-reduction model of sharing predicts that those individuals who more readily engage in sharing, or resource transfer, should be reciprocated with more than those who do not (Bliege Bird & Bird, 1997; Kaplan & Hill, 1985). Otherwise, sharing would not minimize shortfall risk. Some anthropological field studies have found, though, that highly successful hunters are not reciprocated with any more food than others in the sharing groups and that some individuals receive part of the share without reciprocating (Bliege Bird & Bird; Hawkes, 1993; Kaplan & Hill). These authors suggest that one explanation for this finding is that these hunters trade food resources for other direct and indirect benefits, like increased access to females. Thus, it may be possible that instead of one model of resource sharing accounting for all behavior, different theories better explain sharing behavior in different environmental contexts (Winterhalder & Smith, 2000).

Similarly, sharing is not the only strategy that hunter-gatherers may use to minimize shortfall risk. For instance, in environments where food is synchronous and follows a seasonal pattern of being bountiful then scarce, storage or hoarding may be a better strategy to reduce the risk of starvation (Testart et al., 1982). In these situations individuals must be able to efficiently acquire large quantities of food within a given time period and properly store their acquisitions to survive through seasonal periods where food is scarce. Sharing under these environmental conditions would not result in the reduction of shortfall risk because food acquisitions would not be highly variable between individuals. During bountiful seasons, everyone would be somewhat successful at obtaining food items and during scarce seasons everyone would be unsuccessful. Whether sharing emerges in human social groups who experience shortfall risk may, therefore, depend on whether alternative strategies are less costly or are better able to minimize risk.

Effects of Social Stimuli on Sharing

A second goal of the current research was to investigate whether certain social variables that have been shown to negatively affect cooperation and sharing in prior research constrain optimal behavior in situations involving the risk of a shortfall. Experiment 1 examined whether participants responded differently when they thought they were working with a computer or a (ficitious) partner. Experiment 3 investigated whether participants' responding was affected by inequity in earnings, whereas Experiment 4 manipulated the probability of reciprocity from the partner. In all three experiments, participants' responded optimally in accordance with the respective earnings budget. Thus, the present results indicate that these social variables did not constrain optimal responding. This stands in contrast with previous research which has suggested that each of these variables may shift participants' preferences from the sharing or cooperation option to the independent option, even when it is still optimal to prefer the cooperation option (e.g., Acevedo & Krueger, 2005; Baker & Rachlin, 2001; Fantino & Kennelly, 2009; Kennelly & Fantino, 2007; Sanfey et al., 2003).

It is likely that methodological differences between the current study and previous studies are responsible for the different findings. The earnings-budget procedure includes an earnings-requirement (i.e., a shortfall risk) which was not present in prior research. Typically cooperation or sharing has been studied using procedures such as the Sharing Game (e.g. Fantino & Kennelly, 2009; Kennelly & Fantino, 2007), the Ultimatum Game (e.g. Sanfey et al., 2003), or the Prisoner's Dilemma (e.g. Acevedo & Krueger, 2005; Baker & Rachlin, 2001; Brown, 2006; Fantino et al., 2006). In all of these methodologies, there are no monetary requirements that participants need to meet in order to bank the money they have earned, which allows participants the opportunity to always earn some money. The presence of shortfall risk seems, then, to override the influence that these social variables have on behavior. The findings of Rode et al. (1999), that participants' responding no longer showed ambiguity aversion once a resource requirement was present, further supports the proposition that behavior is less sensitive to psycho-social variables when they are experienced within the context of needing to meet a resource requirement.

One way to test whether or not the presence of a requirement makes individuals less sensitive to social variables is to investigate these same variables under neutral budget conditions (no requirement). If similar results are obtained when a requirement is present and absent, then this would suggest that a requirement is not the principal variable controlling behavior. This was done, for instance, in Experiment 1, where participants were told they were working with a partner and a computer during positive, negative, and neutral budget conditions. The findings from that study demonstrated that participants' responding was similar across the partner/computer conditions within each budget condition. Similarly, Pietras et al. (2006) investigated the effects of the presence and absence of the partner's earnings across the same three budget conditions and again did not find systematic differences in responding when the partner's earnings was present or absent. For these variables, then, it seems that the presence of a requirement does not make participants responding more or less sensitive to them. However, these variables did not bias or constrain choice behavior in any way. In addition, based on the current findings, social or psychological variables may only influence behavior when they impact overall outcomes in earnings.

That social stimuli did not constrain optimal responding in these experiments suggest that the predictions of the risk-reduction model of sharing are not influenced by social variables that do not translate to different net outcomes. For example, the model may accurately predict sharing in more real world situations where earnings may not be divided evenly across the group or when a sharing act is not always reciprocated, as long as sharing continues to be significantly more profitable than not sharing. In support of this, several anthropological field studies have found that shared food products are not evenly distributed among everyone in the sharing group and that individuals who do not always reciprocate the sharing of food products continually receive part of the share (e.g. Bliege Bird & Bird, 1997; Hawkes, 1993; Kaplan & Hill, 1985).

Limitations

One limitation of the present research is that choice was measured only on a few occasions and, therefore, there was substantial individual variability in responding.

Interestingly, the variability in participants' responding tended to be lower in negative earnings-budget conditions than in positive earnings-budget conditions. The range of responding was most likely higher in positive budget conditions than negative budget conditions because participants could still meet the earnings requirement half the time when they chose the work-alone option in positive budget conditions, whereas participants could never meet the earnings requirement by choosing the work-with-others option during negative budget conditions. In addition, participants were only exposed to each condition two to four times, which may not have been enough to capture stable responding. For instance, Pietras et al. (2006), who also investigated choice under differing budget conditions, did not change conditions until participants' responding was stable, which took an average of 7.5 sessions per condition. In the present study, participants completed a maximum of 4 sessions per condition. Despite this individual variability, the current studies yielded statistically significant results. Thus, longer exposures to conditions probably would not have generated qualitatively different results than those reported here.

This limited experience may explain, however, why participants, on average, only showed a moderate preference for the work-with-others option across positive budget conditions. Participants in Pietras et al.'s (2006) study showed a stronger preference for the work-with-others option, and some displayed an increase in their choice preferences across exposures. This suggests that if the current participants were allowed longer contact with each condition, they may have exhibited stronger preferences for the sharing option. On the other hand, other earnings budget studies conducted by Pietras et al. (2003; 2008) which have run participants under differing budget conditions to stability have not always found exclusive preference for one option over another, suggesting that some sampling of both options may be expected.

Another limitation of the present research is that the procedure did not model all of the variables likely to influence sharing, such as the costs associated with engaging in a sharing act. For example, as described above, Experiment 2 found that participants continued to prefer the work-with-others option even when the correlation in earnings was perfectly positive. This preference may dissipate if participants incurred a cost when choosing the sharing option. Furthermore, in the present studies sharing produced a certain outcome. It is unlikely that outside the laboratory sharing completely eliminates variability in resource acquisitions. Searcy and Pietras (2011) investigated human's choices in positive and negative earnings-budget conditions when all choice options were associated with some variability and found that choice was still consistent with the predictions of the energy-budget rule. However, there were some differences in local choice patterns. It also may be valuable to investigate sharing when sharing reduces but does not completely minimize resource variability.

Future Research

There are several other social variables that could affect sharing that could be investigated within the context of shortfall risk. Some variables are natural follow-ups to the present four studies. For example, the presence of an actual partner would aid in determining any effects the partner has on sharing. Although there does not seem to be a difference between working with a computer or a (fictitious) partner, some previous research has demonstrated that if an individual were to work with a close friend or spouse sharing would increase (Marwell & Schmitt, 1975; Rachlin & Jones, 2008a). Having participants work with other people would also affect the benefits of sharing by making the benefits of choosing the sharing option less predictable. Adding in a cost component to the sharing option might also better model sharing in naturalistic conditions. Recall that in Experiment 2 participants' responding showed a slight preference for the sharing option when the correlation was +1.0. The presence of a cost when choosing the work-with-others alternative would help determine whether the sharing occurred simply because of carry-over, or whether participants preferred the social option. In addition, other variables in Winterhalder's (1986) model, such as the number of sharing partners, could be explicitly manipulated to examine if participants' behavior would match the predictions of the model.

Other variables have been shown to influence sharing behavior in the absence of shortfall risk. Differences in gender, for instance, have been found (Fantino & Kennelly, 2009; Kennelly & Fantino, 2007; Marwell & Schmitt, 1975; Walters, Stuhlmacher, & Meyer, 1998). Generally, these studies suggest that while males tend to maximize earnings, females tend to be more equitable. Although the sample size in the present studies was too small to analyze gender effects, future studies could explore gender differences in the earnings-budget procedure more systematically. Delays in reciprocation have also been shown to inhibit cooperation (e.g., Komorita, Hilty, & Parks, 1991; Locey & Rachlin, 2012; Parks & Rumble, 2001). Thus, future studies could investigate sharing under shortfall risk when partners delayed their reciprocation, such as by one choice block. Again, it is possible that examining these variables within the context of the presence of a resource requirement, may override their effects on behavior. All of these variables will further evaluate the generality of the risk-reduction model of sharing and better determine the conditions under which optimal behavior will be maintained.

The risk-reduction model of sharing could also be used to examine the sharing of other currencies besides food and money, such as information. The sharing of information can take many forms, for example writing a review for a service or a product, or communicating hazardous events like traffic jams (Rochenbach & Sadrieh, 2012). The sharing of this information is costly to the provider in terms of the time and effort it takes to communicate to others and the provider typically does not receive any direct benefits for doing so; although they may receive indirect benefits through others reciprocating the communication act. However, it is also possible that providing information about a product, service, or event may decrease risk. In support of this, Rochenbach and Sadrieh found that extreme outcomes (positive and negative) are communicated and shared much more often than moderate ones. Thus, in alignment with the risk-reduction model, information is shared more often with high-variability outcomes than low-variability outcomes.

Conclusions

The present research has improved our understanding of how resource variability and scarcity, along with shortfall risk influence sharing. These studies provided additional evidence that an adaptive model of food sharing based on a risk-sensitive optimization model can be used to predict human sharing, including sharing of monetary resources. These findings suggest that the risk-reduction model may be used to explain or predict conditions outside the laboratory that might generate sharing (or failures to share) in humans and better interpret instances of sharing. For instance, when a natural disaster devastates an area, individuals' survival may become threatened and the availability of resources becomes highly variable (Ward et al., 2009). In situations like these, the risk-reduction model would predict resource transfers to occur. Indeed, right after a national disaster, the donation of resources such as money, food, or clothing increases. Furthermore, the risk-reduction model of sharing may be useful for understanding a variety of human social interactions in politics (e.g., the formation of coalitions and alliances), economics (e.g., business partnerships, information sharing, resource sharing), and society (e.g., carpooling, communal living, file sharing).

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Appendix A

Human Subjects Institutional Review Board Approval

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: September 27, 2012

To: Cynthia Pietras, Principal Investigator
Stephanie Stilling, Student Investigator for dissertation
Zachary Zimmerman, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 12-09-40

This letter will serve as confirmation that your research project titled "Social Behavior in Situations of Uncertainty and Risk" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: September 27, 2013

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix B

Instructions

You will be able to earn points by using a mouse to click letters on a computer screen.

[Today you will be participating with other people in this study. These other people also have response panels and monitors. These other people are located at another facility. When the session starts the computer will connect to the other participants' computer.]

[Today you will be participating in the study by yourself. The computer will simulate other people in the study]

When the session starts, the letter B, the words "Press Now," and a counter will appear on the computer screen. The counter will be at zero. Clicking on the letter B will cause the letter B and the words "Press Now" to go off the screen and will cause other letters to appear. Either the letter A, the letter C, or both letters A and C will appear. The words "Work Alone" will appear beneath the letter A and the words "Work with Others" will appear beneath the letter C. When only one letter is on the computer screen, using the mouse to click on the letter on the screen will add money to the counter. When both letters A and C are on the computer screen, you can click on either letter A or letter C. The letter you have selected will remain on the screen and the other letter will disappear. Clicking on the letter on the screen will add money to the counter. Several counters may appear on the computer screen during the session. The amount of money shown on the counter labeled "Your total earnings" is the amount you have earned during the session. Every $2.00 you earn will be exchangeable for a draw from the prize bowl. Please remain seated. When you see the words "Session Over" appear on the screen you may return to the waiting area.

Appendix C

Debriefing

The purpose of this study is to investigate choice between working with others or working alone in situations involving uncertainty and risk. We aimed to relate choice patterns to theoretical models of choice and social behavior. The study also examined how motivational variables influenced choice. You were presented with choices between working alone or working with others in blocks of 5 trials. The amount of money you earned per block varied. The motivational variable that was investigated was the earnings requirement, or the amount of money you needed to earn every 5 trials to be able to keep the earnings or prevent a loss in earnings. These target amounts were designed to model monetary requirements that people face in everyday life, such as money amounts needed to pay bills, eliminate debt, purchase items, beat competitors, etc. We sought to determine how variables that influenced the chance of meeting this requirement influenced your choice between working with others or working alone. Sometimes you could meet the earnings requirement by working alone; sometimes you could meet the earnings requirement by working with others; and other times it did not matter which one you chose. There was no right or wrong way to respond on this task. The study did not determine whether you are more likely to work independently or work with others, and your performance on this task does not indicate how you will respond in other situations.

All data that we have collected from you will remain confidential. The results of this study will contribute to our understanding of variables that influence choice and social behavior, particularly in situations involving uncertainty and risk, and may be published in scientific decision-making or psychology journals. If you have any other questions about the study, please ask. We thank you for your participation.