# The Effects of Uncertainty and Communication on Cooperation in Commons Dilemmas

by

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Abstract

A sample of 55 female and 41 male university students ($N = 96$) enrolled in introductory psychology courses participated in a 2 by 2 (uncertainty by communication) factorial between-subjects ANCOVA design investigating the independent and joint effects of uncertainty and communication on cooperation rates in a simulated commons dilemma. Participants' self-efficacy and risk perceptions (pertaining to resource management) were also examined as covariates to investigate each of their relations to cooperation rates. Participants were randomly divided into groups of three and "fished" in a computer simulation of ocean fishing (FISH 3.1), and completed a short questionnaire. As predicted, the presence of group communication was associated with higher rates of cooperation; the presence of uncertainty was associated with lower cooperation rates; and higher levels of resource management self-efficacy were associated with higher cooperation rates. The prediction that the detrimental effect of uncertainty would be more pronounced when there is no communication present received partial support: a marginally significant interaction was found between communication and uncertainty. Contrary to expectations, higher levels of resource management risk perception were associated with lower cooperation rates. Limitations of the current investigation are outlined and possible directions for future research are discussed.

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# Acknowledgements

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# The Effects of Uncertainty and Communication on Cooperation in Commons Dilemmas

Because of over-consumption of natural resources, environmental problems and concerns are growing rapidly. Social scientists are attempting to learn more about both individual and group contributions to ecological degradation (Budescu, Suleiman & Rapoport, 1995). Humans extract, refine, use, and dispose of many natural resources. Thus, individuals make many decisions about resource management everyday in their homes, work, or leisure activities (Gifford & Gifford, 2000). The most crucial aspect of individual-level resource management decisions is that they sum across billions of individuals' actions to affect societal-level management (Gifford & Wells, 1991).

*Social dilemmas* are defined as situations in which individuals face complicated choices in which the rewards for noncooperation (defecting) are greater than the rewards for cooperation, yet if all fail to cooperate (defect), then all receive lower rewards than if all cooperate (Dawes, 1980). The original example used in research on social dilemmas is the prisoner's dilemma, in which two people are faced with a choice to cooperate (refuse to turn evidence against the other prisoner) or defect (try to escape by turning the evidence against the other prisoner). *Social traps* are a type of social dilemma in which short term pleasure or reinforcement over time leads to pain or loss (Messick & McClelland, 1983). Some classic examples of social traps include smoking, overeating, and the use of pesticides or DDT (Gifford & Gifford, 2000). *Public goods dilemmas* are a type of social dilemma in which individuals must decide whether to self-sacrifice for public good through activities such as donating to charity, or volunteering (Chen, Au, & Komorita, 1996). *Commons dilemmas* or *resource dilemmas* focus on valuable, limited, common pool resources and individuals must make the decision whether to cooperate (harvest little, resulting in modest short term gain but long-term conservation of the resource) or defect (harvesting a large amount, resulting in large short term gain but endangering or even extinguishing the common resource; Dawes, 1980; Gifford & Gifford, 2000; Jager, Janssen, & Vlek, 2002).

The "commons" originally referred to a central open space in the heart of a small village or town which was undivided and owned in shares by citizens of higher standing who shared its grass and open space to graze their animals (Gifford & Wells, 1991). As long as enough grass exists in the commons for all the shareholders, there is no conflict, however, in most commons, eventually some users of the commons develop motives to use more grass than the others (perhaps for more animals or to sell to other villages) or the number of users of the commons increases (Gifford & Wells, 1991). External influences can also influence the availability of the commons such as weather conditions or climate changes. Consequently, the demand for the limited common resource increases, as does the conflict over its partitioning and usages (Hardin, 1968). In a desirable but limited commons, some individuals act out of self-interest to maximize personal gain and the "tragedy of the commons" then begins in which each person is compelled to increase his/her harvesting without limit in a world that is limited, thus rushing toward destruction and ruin (Hardin, 1968). Many resources besides pasture and land are common resources (desirable resources jointly held by a group of individuals) such as fish, forests, oil, whales, water, and fresh air (Gifford & Gifford, 2000).

Various resources regenerate at different rates. The danger of resource exhaustion arises when resources regenerate at a slower rate than individuals harvest them (Gifford & Wells, 1991). Harvesters of such limited resources then face a crucial decision to either increase their wealth quickly at the expense of other users and the commons, or to restrain harvesting to preserve the commons and increase their wealth slowly (Gifford & Gifford, 2000). A *commons* is a pool of desirable resources that may be harvested by a number of individuals and organizations that share access to it and *commons dilemmas* occur when improved technology or increased person-power ("effort") enables the harvesting of resources faster than they can regenerate. Harvesters must decide whether to maximize personal gain in the short term or maximize collective gain over the longer term (Gifford & Wells, 1991; Gifford & Gifford, 2000). When studying commons dilemmas, the main broad question explored by social scientists is: Under which conditions will stakeholders act in self-interest to the detriment of the resource and other harvesters?

*Uncertainty*

One variable that has received substantial attention over recent years is uncertainty, specifically how it affects harvesters' decisions to cooperate or defect under simulated commons dilemma conditions. In resource dilemmas, two types of uncertainty may exist, social uncertainty, and environmental uncertainty (Garling, Biel & Gustafsson, 1998). *Social uncertainty* refers to uncertainty about how other individuals are acting or responding to the situation. It may be reduced by developing trust in the other participants based on perceived predictability, controllability and reciprocity (Garling et al., 1998). *Environmental uncertainty* generally refers to uncertainty about the size or the replenishing rate of a common resource (Biel & Garling, 1995; Garling et al., 1998). Such uncertainty generally results from a lack of knowledge about the resource. When environmental uncertainty is high, this may lead to a "big pool" illusion, which means that when the size of a resource is unknown, it is typically overestimated and may even seem endless (Messick & McClelland, 1983). Feedback about the state of the resource (e.g. size, regenerating rate, depletion) is the best way to decrease environmental uncertainty (Biel & Garling, 1995).

The general finding in this line of research is that in simulated resource dilemmas as environmental uncertainty (commonly defined as uncertainty about resource size) increases, individuals tend to increase the size of their requests of the resource, thus leading to over-harvesting (e.g., Budescu, Rapoport, & Suleiman,1990; Budescu, Rapoport, & Suleiman, 1995; Chen et al., 1996; Hine & Gifford, 1996; Roch & Samuelson, 1997; Wit & Wilke, 1998; Gustafsson, Biel and Garling 1999; Gustafsson, Biel & Garling, 2000; Rapoport & Au, 2001).

For example, in a simulated resource dilemma, Budescu et al. (1990) found that as environmental uncertainty (defined here as uncertainty about pool size) increased, participants tended to 1) overestimate the size of the resource, 2) increase the size of their requests of the resource, and 3) expect others to increase their requests. In another study, using a computerized commons dilemma simulation (FISH 3), Hine and Gifford (1996) investigated the independent and joint effects of pool size uncertainty and regeneration rate uncertainty. Both types of environmental uncertainty significantly increased harvesting (as indicated by declines in restraint) and decreased cooperation (as indicated by decreased group efficiency). Therefore, environmental uncertainty tends to be conducive to defection rather than cooperation. Gifford (2002) notes that environmental uncertainty regarding the resource outcomes may be the single most important factor affecting individuals' decisions to either cooperate or defect in commons/resource dilemmas.

Because the over-harvesting effect of uncertainty is significant and reliable, it is crucial that we develop an understanding of the psychological aspects of this effect. Gustafsson, Biel and Garling (1999; 2000) outline three explanations for the over-harvesting effect of environmental uncertainty. First is the perceptual bias, which is based on the tendency to optimistically overestimate resource size (Jager, Janssen & Vlek (2002) call this "environmental optimism"). The second is the outcome-desirability bias, which is based on the tendency to judge desirable outcomes as more likely than undesirable ones. Finally, the constrained egoism-bias, which asserts that although individuals are greedy and try to maximize their own rewards, their greed may be constrained by motives to maintain the resource and to increase fairness among group members (Gustafsson et al., 2000). More recently, Jager, Janssen and Vlek (2002) discussed two additional explanations. The first asserts that the overestimation of resource size is not an environmental optimism effect, but rather a post-experimental cognitive defense strategy, which is used merely to justify one's selfish behavior. The second is that uncertainty stimulates an imitation effect (increased imitative behavior resulting from social comparison), which in turn, promotes over-harvesting.

Gustafsson, Biel, and Garling (1999) investigated the effects of environmental and social uncertainty on harvesting requests from a common pool and found that, regardless of the level of social uncertainty, as environmental uncertainty increased participants tended to overestimate resource size and to over-harvest the resource. Results suggest that the over-harvesting effect of environmental uncertainty is in itself so strong that it is generally unaffected by social uncertainty (Gustafsson et al., 1999). These findings support an outcome-desirability bias explanation for the over-harvesting effect of uncertainty and do not support a constrained egoism-bias explanation (Gustafsson et al., 1999).

In another study conducted by Gustafsson, Biel and Garling (2000) size estimates and requests from an uncertain resource as well as contributions in a public good dilemma were investigated in relation to information about other participants' pessimistically biased estimates of resource size. In line with previous findings, under conditions of environmental uncertainty participants tended to request large amounts of the resource and to contribute small amounts. Neither requests nor contributions were dependent on information about the requests or contributions of others (social uncertainty). These findings support an outcome-desirability bias explanation for the over-harvesting effect of uncertainty and do not support a perceptual-bias or a constrained egoism-bias explanation (Gustafsson et al., 2000). Therefore, the environmental uncertainty effect may arise from the tendency to judge desirable outcomes as more likely than undesirable ones.

Jager, Janssen and Vlek (2002) investigated the effects of uncertainty and satisfaction on the harvesting behavior of simulated agents in a commons dilemma simulation. Not surprisingly, uncertainty once again promoted over-harvesting. Results of the study also suggest that uncertainty results in increased optimism regarding the outcome of events ("optimism effect"), increased rates of imitative behavior ("imitation effect"), and a decrease in adaptation in harvesting behavior during resource depletion ("adaptation effect").

*Solutions*

Although the over-harvesting effect of environmental uncertainty is well researched and increases our understanding of the reasons why individuals may defect rather than cooperate, this effect is deleterious to the common resource. Therefore, in addition to studying environmental uncertainty, more attention must be dedicated to variables that are conducive to cooperation, which may provide solutions to such resource dilemmas. According to Messick and Brewer (1983), the two general classes of solutions to social dilemmas are individual solutions and structural solutions.

*Individual solutions* are dependent on independent changes in the behavior of individuals in order to produce increased cooperation (Messick & Brewer, 1983). Some research has been conducted in attempts to identify some of the individual differences that are conducive to such solutions. For example, using a replenishable resource dilemma paradigm, Roch and Samuelson (1997) investigated the relations between environmental uncertainty and social value orientation. Social value orientation influences motives, strategies, and choice behavior in mixed-motive experimental games (Roch & Samuelson, 1997). The three major social value orientations are: 1) cooperative, 2) individualistic, and 3) competitive (Messick & McClintock, 1968). It was found that 1) under conditions of high environmental uncertainty participants harvested more resources than when under low uncertainty, 2) noncooperators harvested significantly more resources than cooperators, and 3) noncooperators responded to environmental uncertainty by increasing their harvests (defected), while cooperators continued to use self-restraint (cooperated). These findings suggest that individual differences may moderate the environmental uncertainty effect (Roch & Samuelson, 1997).

Although individual differences are an important aspect of resource-sharing situations, it is important to note that some individual difference variables have proven to be somewhat irrelevant in social dilemma contexts. For example, Caldwell (1976) examined sex effects within a prisoner type social dilemma and found no differences between males and females. Additionally, in his review of the research on the effects of participant characteristics on cooperation rates in social dilemmas, Gifford (2002) concludes that gender and age are less influential variables and that cooperative behavior depends largely on other factors. Thus, researchers would benefit from focusing on more powerful individual difference variables as individual solutions to social dilemmas.

*Structural solutions* require coordinated group action to alter the pattern of incentives or to change the decision-making structure of the group as a whole (Messick & Brewer, 1983). Research has also been dedicated to understanding these types of solutions. For example, Rapoport and Au (2001) examined the effects of rewards (bonus) and punishments (penalty) on the requests of individuals in a CPR dilemma under uncertainty. In the bonus treatment, rewards were given to those who requested the least and in the penalty treatment a charge was imposed on those who requested the most. It was found that both the bonus and the penalty treatments considerably decreased the amount of resource requested and therefore increased cooperative behavior. However, the penalty treatment was more effective in reducing individual requests than the bonus treatment. These results draw attention to the possibility of using reward and/or punishment to curb the harvesting behaviors of individuals and to hopefully increase cooperation in real world resource dilemmas (Rapoport & Au, 2001). Additionally, Wit and Wilke (1998) investigated the effects of both environmental and social uncertainty in a public goods dilemma and found that environmental uncertainty decreases cooperation only under conditions of high social uncertainty, but not under conditions of low social uncertainty. This finding is promising because it implies that the detrimental effects of environmental uncertainty can be counteracted by reducing perceived social uncertainty by supplying information about the actions of other participants (Wit & Wilke, 1998).

Of these two types of solutions, group decisions regarding structural solutions are typically more difficult to understand and are based on an evaluation of the existing resource allocation system regarding a number of criteria (Samuelson & Messick, 1986). These criteria include: the capacity of the allocation system to provide efficient management of the resource, the degree of fairness in the distribution of the resource among group members, the perceived degree of individual freedom afforded by the allocation system, and the extent to which one's self-interest is affected by a system change. Communication between individual harvesters allows group members the opportunity to agree on an appropriate allocation system and to develop consensual rules regarding resource partitioning (Hackett, Schlager, & Walker, 1994). Generally, allocation systems that are perceived as being both efficient and fair tend to be preferred by group members (Samuelson & Messick, 1986).

*Communication*

Communication has had substantial effects on cooperation rates in social dilemma simulation experiments. The general finding in this area of research is that a period of group discussion tends to increase cooperation among participants and is therefore conducive to conservation of the common resource (e.g., Liebrand, 1984; Orbell, van de Kragt & Dawes, 1988; Hackett et al. 1994). Given that the effect of communication in increasing cooperation is so substantial and reliable, understanding its psychological underpinnings is important (Orbell et al., 1988).

Three main explanations for the effect of communication on cooperation have been proposed (Orbell et al., 1988). The first explanation is that the content of communication or discussion may move individuals toward the collective desirability of cooperative behavior and therefore may persuade individuals to act contrary to their egoistic preferences. Second, discussion provides an opportunity for participants to make promises to one another and such commitments, along with the expectation that others will keep their commitments, encourage individuals to cooperate. Finally, in-group bias (the belief that one belongs to a group that is distinct from other groups), along with the social identity (aspects of the self image that are derived from the social categories that one perceives oneself to belong to) created by communication, may induce cooperation based on individuals striving for a positive social identity (cf. Orbell et al., 1988). The salience of a collective social identity may encourage individuals to place a greater weight on collective gains over individual gains by reducing the social distance among group members and thus, making it less likely that they will make sharp distinctions between their own interests and the interests of others (Brewer & Kramer, 1986).

Orbell, van de Kragt and Dawes (1988) conducted two experiments intended to explain discussion-induced cooperation. Results of experiment one did not support the hypothesis that discussion triggers norms in favor of cooperation. However, promises to cooperate (commitments) were found to be an important aspect of discussion-induced cooperation. Experiment two demonstrated that promises were only conducive to cooperation as long as everyone in the discussion group promised. Based on these findings Orbell and associates (1988) discuss two models, which can be used to explain discussion-induced cooperation. First, consensual promises during discussion promote group identity, which leads individuals to focus on group benefits rather than egoistic preferences and therefore, leads to cooperative decisions. Second, discussion provides an opportunity for making promises to cooperate which, when unanimous, explain the effect of discussion independent from group identity. Orbell et al. (1988) conclude that both the consensual promise-making and the group identity that result from group discussion have independent effects on cooperation rates and may as well interact to enhance cooperation further than either one would produce separately.

Although communication reliably increases cooperation in resource dilemmas, situations may exist in which communication may actually decrease cooperation rates, and therefore, support defection. Given that the rule structure of communication, as well as the complexity of the social dilemma setting, affect the effectiveness of communication, not all individuals who are permitted to communicate will achieve optimal outcomes regarding resource management (Hackett et al., 1994). One situation in which this may be expected to happen involves the combination of high environmental uncertainty and communication. Jager and associates (2002) state that uncertainty increases individual's reliance on social comparison and tends to increase imitative behavior that generally leads to over-harvesting. Furthermore, Jager et al. (2002) expect that when participants are allowed to communicate, they will engage in more social processing (e.g. social cognition, social comparison), thus leading to increased rates of imitative behavior, and further contributing to resource depletion. However, it must be recognized that this is simply what would be *expected* given the reasoning behind *one* possible explanation of the environmental uncertainty effect and, to date, has not been confirmed by research.

Additionally, Brewer and Kramer (1986) found that feelings of social identity (produced by communication) were only influential on individual harvesting decisions when depletion of the common resource had become severe. This is not surprising given that the conflict between individual self-interest and collective well-being is not as salient when an ample supply of the common resource exists (or is believed to exist; Brewer & Kramer, 1986). On the other hand, social identity does increase self-restraint under collective conditions relative to individual identity conditions, in which the collective good is not as salient. In a large group setting, this effect holds even when expectations of reciprocity and confidence in one's own ability to influence outcomes ("criticality") are both low (Brewer & Kramer, 1986). Therefore, it appears that individuals in a large group setting may in fact be responding more to the salience of collective loss than to diffusion of risk or their own (temporarily less salient) egoistic preferences (Brewer & Kramer, 1986).

A final situation in which communication may not be effective in increasing cooperation is when the shareholders of the common resource are heterogeneous in their endowments (e.g., some are initially "better off" than others). Hackett et al. (1994) found that in group settings involving communication, such heterogeneity creates conflict over the distribution of and access to common pool resources, and that this conflict may cause the self-governance of the group to fail, thus leading to defection and inefficient management of the resource. In such cases, participants simply can not agree upon what would constitute a fair distribution and thus, do not cooperate on the adoption of certain "sharing rules" that are established during discussion (Hackett et al., 1994). Therefore, in order for communication to enhance cooperation, the participants must be able to agree on a set of resource allocation rules, and depending on the characteristics of the group members and the decision setting, this is not always guaranteed. Although heterogeneity decreased the strength of the communication effect relative to fairly homogeneous groups, Hackett et al. (1994) also found that even when the participants were heterogeneous, the dominant effect of communication persisted by increasing cooperation and efficiency of resource management relative to the absence of communication.

*Self-Efficacy*

Self-efficacy is conceptualized as one's perceptions about one's competency and capability to organize and execute courses of actions in order achieve a given outcome or result with respect to performance on specific tasks or activities (Bandura, 1986). One's level of self-efficacy is thought to relate to his/her task choices as well as his/her effort and perseverance in those activities (Bandura, 1977; Bandura, 1986). Through its impact on behavioral choice, effort, and persistence, self-efficacy influences thought patterns, stress reactions, and performance (Bandura, 1977; Bandura, 1986). Research has demonstrated that self-efficacy is related to performance across a wide variety of activities including, athletic performance (Moritz, Feltz, Fahrbach, & Mack, 2000), academic performance (Wood & Lock, 1987), health functioning (Holden, 1991), career choices, coping with fears, recovering from life-threatening illnesses or events, smoking cessation, pain tolerance, and sales performance (cf. Bandura, 1986).

In the context of social dilemmas, self-efficacy can be defined as the degree of influence individuals perceive they have on the provision of public goods or the management of a common resource (Foddy, Smithson, Schneider, & Hogg, 1999). For quite some time, self-efficacy has been considered to be an important variable influencing individuals' behavior in public goods dilemmas (e.g., Komorita & Parks, 1994; Messick, 1973; Olson, 1965). Specifically, feelings of self-efficacy have been shown to strongly influence individuals' tendency to free ride. Those with low self-efficacy are more likely to free ride and less likely to contribute than individuals with high self-efficacy (Kerr & Bruun, 1983). Through a series of three studies, Kerr (1989) also demonstrated that feelings of self-efficacy (belief in their ability to affect the group's outcome) and collective-efficacy (the perception that one's group can effectively perform a given task) are affected by group size. Specifically, individuals' self-efficacy as well as collective-efficacy decreased as the size of the group increased, and surprisingly, they maintained their belief in these group size effects even when their actual level of objective self-efficacy (the probability that one can actually affect the group's outcome) remained constant across varying group sizes. From these results, Kerr (1989) asserted that these findings illustrate an *illusion of efficacy*, meaning that individuals overgeneralize their experiences to groups of varying sizes and thus, maintain the belief that they have little effect on the outcome of a large group, even when there is evidence against this notion.

Komorita and Parks (1994) assert that the effects of self-efficacy may be related to the concept of criticalness or the fact that individuals are less likely to free ride and more likely to contribute in public goods dilemmas if they perceive their actions to be critical to the group outcome (e.g., Stroebe & Frey, 1982; Van de Kragt, Orbell, & Dawes, 1983; Rapoport, Bornstein, & Erev, 1989). Feelings of self-efficacy in public goods situations are influenced by expectations about the behavior of other group members or the idea that one's contribution would just be wasted if one does not believe that anyone else will contribute (Van de Kragt et al., 1983). Kerr and Kaufman-Gilliland (1997) found that in the context of social dilemmas individuals tended to minimize the efficacy of their cooperative behaviors as a justification for defection (i.e., "I couldn't have made a difference anyway"). Although self-efficacy has clearly been investigated in the context of public goods type social dilemmas, it has yet to be investigated within the realm of commons dilemmas or resource dilemmas.

Bandura (1977) asserts that self-efficacy is best conceptualized and measured as a multidimensional construct and researchers should match a given activity or task with self-efficacy as it pertains to that specific activity, rather than using a global measure of self-efficacy to predict performance on a specific activity. Thus, Bandura (1990) developed a set of scales called the Multidimensional Scales of Perceived Self-Efficacy (MSPSE) that measure perceived self-efficacy in nine domains of performance (enlisting social resources, academic achievement, self-regulated learning, leisure-time skills, self-regulatory efficacy, self-efficacy to meet others' expectations, social self-efficacy, self-assertive self-efficacy, and enlisting parental and community support). No scale was found that specifically measures self-efficacy with respect to resource management in a commons dilemmas context. Therefore, for the purposes of the current investigation, a resource management self-efficacy scale was developed based on Bandura's (1990) method of assessing self-efficacy.

*Risk Perception*

When attempting to predict under which conditions individuals will take precautions against negative consequences such as illness or injury, one must take into account the nature of the threat by considering factors such as the perceived probability that harm will occur if no action is taken and the perceived severity of that harm, or in other words, the perceived risks involved (Weintsein, 2000). The concept of risk perception has typically been applied to health-protective behavior and the adoption of precautions against perceived risks (e.g., Weinstein & Nicolich, 1993; Weinstein, 2000). All of the dominant theories of health-protective behavior assume that 1) the anticipation of a negative outcome and the desire to avoid the outcome or reduce its impact create a motivation for self-protection, which contributes to the adoption of health-protective behavior and 2) the expected benefits associated with risk reduction must be weighed against the expected costs of acting in order to predict behavioral changes (Weinstein & Nicolich, 1993). There are four main assumptions of Weinstein and Nicolich's (1993) precaution adoption model; 1) perception of high personal risk increases the likelihood of precaution adoption, or in other words, risk perception is assumed to play a causal role; 2) behavior change is determined by the sum of the factors that encourage action oriented behavior, and when the sum is great enough, people adopt precautionary behavior; 3) changes in behavior give way to changes in risk perception, specifically, when people adopt precautions they perceive their personal risk to be lowered; 4) some of the factors that influence action fluctuate, so an individual who does not take action at one point in time may decide to act at another point in time (Weinstein & Nicolich, 1993).

Similar to the theories of health-protection and precaution adoption, a rational choice based approach to solving resource dilemmas emphasizes contextual and social factors that structure the preferences that individuals have, which frame and structure their decisions, behaviors and lives and focus on what a reasonable decision may be for an individual or group given the situation (McCay, 2002). The situational factors considered by this approach include; the knowledge available to individuals or groups, its quality and level of uncertainty, the risks that they face (or they perceive they face), the resources to which they have access, the people with whom they interact, and many more factors such as institutions, norms, rules, values, organizations, and patterns of behavior (McCay, 2002). Thus, risk perceptions are also considered an integral part of resource dilemmas and their potential solutions. Risk perceptions are an important factor in predicting behavioral intentions and have their own unique power to account for behavioral intentions that is separate from environmental beliefs or knowledge (O'Conner, Bord, & Fisher, 1999). Additionally, risk perceptions have been found to significantly predict behaviors such as willingness or intention to support personal and governmental behaviors that address climate change with respect to global warming

(O'Connor et al., 1999), motivation to engage in health-protective behavior (Weinstein, 2000), motivating undecided individuals to decide to participate in home radon testing (Weinstein, Lyon, Sandman, & Cuite, 1998), and increasing automobile seat belt use (Weinstein, Grubb, & Vautier, 1986). Similarly, Flache (2001) found that individual risk aversion favors rational cooperation ongoing or repeated interaction of dyadic exchanges.

McCay (2002) asserts that the study of risk perception and human behavior (e.g., Chess, Salomone, & Hance, 1995; Gardner & Stern, 1996) is particularly relevant to the study of common-pool resources and that many common-pool resource issues are classic examples of risk based scenarios (i.e., risk of losing access to or the use of something considered valuable). The concept of risks can be applied to changes in the condition of renewable natural resources and how individuals or groups are affected by and perceive these risks is crucial to whether and how they decide to respond to reduce or prevent such risks (McCay, 2002). For example, the risks associated with exposure to natural or man-made sources of the gas radon and whether people take precautions to protect themselves by deciding to test their homes or to make changes to reduce their exposure (Weinstein & Sandman, 1992). This line of research demonstrates the responses of people to perceived risks to their health or their lives. Some individuals are not aware of or do not understand the risks; others are aware of the risks, but do not perceive them to be serious to themselves; others seek or assess information about the risks and what can be done to prevent or diminish them; yet others conclude that they can or cannot afford to take precautionary action with the resources and knowledge that they may have (Weinstein & Sandman, 1992). Therefore, depending on the characteristics of specific situations individuals are in, they may be unaware of risks; they may be aware of risks, but do not believe that they can affect the situation; they may not have the resources required to address the risks or they may feel as though the effort, costs, or obligations involved in addressing such risks are not worth it; others may have the interests and resources to affect their decisions about whether to participate in or support collective action (Stern, Dietz, Abel, Guagnono, & Kalof, 1999; McCay, 2002). It is logical to assert that this process may generalize to research that is interested in discovering what leads individuals to change their behavior in situations of environmental problems and resource dilemmas and thus, this research would also require an analysis of the situations individuals are in and the severity of the risks that they may or may not perceive (McCay, 2002).

Because risk perception is multifaceted and rooted in the subjective weights and preferences of the individual (depending on their perception of probable or expected harms/losses or benefits/gains), it is important to consider the factors that comprise the perception of risk that is associated with a given activity or event (Palmer, Carlstrom, & Woodward, 2001). Holtgrave and Weber (1993) designed a simplified conjoint expected risk model (SCER), which postulates that the perceived risk of any given activity is a function of five dimensions; 1) the subjective probability of harm; 2) the subjective probability of benefit; 3) the subjective probability of neither harm nor benefit (status quo); 4) the subjective expected harm; and 4) the subjective expected benefit. This framework allows one to assess the relative weight associated to subjective probability and expected outcome information, as well as the perceived harms, benefits, and risks involved in specific activities (Palmer et al., 2001). Exploring and identifying the bases for differences that may exist in perceived risks may provide a richer understanding of conflicts over environmental issues, and more specifically resource management issues, and hopefully aid in the development of more effective strategies for communicating about risks and negotiating solutions to important problems (Palmer et al., 2001). Therefore, for the purposes of the current investigation, a resource management risk perception scale was developed based on Holtgrave and Weber's (1993) method of risk perception analysis.

*The Current Study*

Given that uncertainty is conducive to defection and communication tends to encourage cooperation, it is logically compelling to argue that communication may, to some extent, counteract the over-harvesting effect of uncertainty. The purpose of the current study is to investigate the independent and joint effects of uncertainty and communication on cooperation rates in a simulated commons dilemma. Individuals' resource management self-efficacy and resource management risk perception were also examined as covariates to investigate their relation to cooperation rates within a complex commons dilemma context. Based on the previous research and theory reviewed above, the following predictions were made:

P1. The presence of group communication will be associated with higher cooperation rates (main effect of communication).

P2. The presence of environmental uncertainty will be associated with lower cooperation rates (main effect of uncertainty).

P3. The detrimental effect of uncertainty will be more pronounced when there is no communication present than when group communication is present (interaction between uncertainty and communication).

P4. Higher levels of resource management self-efficacy will be associated with higher cooperation rates.

P5. Higher levels of resource management risk perception will be associated with higher cooperation rates.

# Method

## *Participants*

Participants were a sample of 55 (57.3 %) female and 41 (42.7 %) male university students ($N = 96$) enrolled in introductory psychology courses at a Canadian university. Their ages raged from 17 to 40 years ($M = 19.68$, $SD = 3.55$). Participants were randomly divided into groups of three, because age and gender tend to have insignificant influences on cooperation rates within a commons dilemma context (cf. Gifford, 2002), the composition of these groups in terms of participants' age and gender was also random. As part of the standard recruitment process of the university, participants received 2 bonus course credits for their participation in the study. Additionally, because most real world resource-sharing situations offer the opportunity for personal profit, participants were individually paid 5 cents per fish caught.

Demographic information regarding participants' intended university major and extent of previous knowledge of commons dilemmas also was collected to provide additional background about the participants. Of the 96 participants, 35.4 % identified their probable or intended major to be in the social sciences (e.g., psychology, sociology, anthropology, etc.), 27.1 % intended to major in the physical sciences (e.g., biology, chemistry, physics, etc.), 17.7 % were planning to major in business or economics, 1.0 % identified their intended major as engineering or computer sciences, 12.5 % intended to major in some area of humanities (e.g., English, history, linguistics, etc.), and the remaining 6.3 % indicated that they were not yet sure what they intended to major in. Participants were also asked to identify on a likert-type scale (1 = not at all familiar to 5 = very familiar) how familiar they were with commons dilemmas or related concepts such as "tragedy of the commons", resource dilemmas, or social dilemmas prior to participating in this study. Of the 96 participants 36.5 % indicated that they were not at all familiar with the concepts, 30.2 % had heard of the terms but were still not very familiar with them, 20.8 % reported being somewhat familiar with the concepts, 7.3 % were familiar with the concepts, and the remaining 5.2 % reported being very familiar with the concept prior to their participation in the study.

*Instruments*

*FISH 3.1* (Gifford & Gifford, 2000) is a microworld used for studying social dilemmas (commons dilemmas) and resource management. A micro-world is a dynamic, computer-based environment that exists in laboratories, but reasonably simulates real-world conditions (cf. Gifford & Gifford, 2000). The FISH 3.1 program uses ocean fishing as a metaphor which participants (fishers) experience through the use of graphics (fish seen on screen) and text (providing information such as resource replenishment "spawning"). The program may be used in stand-alone or networked modes with either all human or a mixture of human and computer simulated "fishers". Fifteen parameters may be varied including: number of resource units (fish), participants (fishers), trials (seasons), payoff values, rate and period of resource regeneration (spawning), computer fishers' level of harvesting greed, awareness of other harvesters' actions (social uncertainty), uncertainty in the amount of the resource (environmental uncertainty), operating costs, and whether the resource is visible to harvesters. The program is very flexible and automatically collects, aggregates, and stores information about each fisher's harvesting behavior each season as well as computes four different cooperation formulae that measure both harvest restraint and harvest efficiency at both the individual (Individual Restraint and Individual Efficiency) and group (Group Restraint and Group Efficiency) levels for each season and over all seasons. From this information, the rates of defection and cooperation can be easily determined (Gifford & Gifford, 2000). Cooperation can also be measured in terms of the number of seasons individuals are able to make the resource last without causing depletion.

*Resource Management Self-Efficacy* (based on Bandura, 1990). Because self-efficacy is often viewed as a domain specific concept, the 11 item resource management self-efficacy scale was developed for the purposes of the current investigation based on the format of Bandura's Multidimentional Scales of Perceived Self-Efficacy (MSPSE). However, Bandura's (1990) MSPSE scales recommend the use of a 1-100 rating response format and the current scale uses a 5 point Likert-scale ranging from 1 = strongly disagree to 5 = strongly agree, to assess individual's judgments of how effectively they believe they are able to influence the state or outcome of the common resource. Sample items include: "I can influence the state of the resource (i.e., how many fish are in the ocean at any given time)."; "I can manage my resource use so that I obtain the results or goals that I desire.", and "I can coordinate my resource use behavior with the behavior of others who are using that resource." Scores can range from 11 – 55 with higher scores denoting a higher level of self-efficacy. Several items are reverse-keyed to control for response-set biases. Bandura, Pastorelli, Barbaranelli, and Capara (1999) and Choi, Fuqua, and Griffin (2001) provide evidence attesting to the psychometric properties of the MSPSE scale format. Additionally, Maurer and Pierce (1998) and Maurer and Andrews (2000) provide evidence supporting the use of a likert-type response format for self-efficacy scales as an acceptable and reliable alternative method for measuring self-efficacy. In the current investigation, reliability analysis revealed that the reliability of the resource management self-efficacy scale was adequate (Cronbach's $\alpha = .75$).

*Resource Management Risk Perception* (Holtgrave & Weber, 1993). Because the perception of risks associated with specific activities as related to individuals' behavioral choices regarding those activities, the 15 item resource management risk perception scale was created for the purposes of this study from Holtgrave and Weber's (1993) Simplified Conjoint Expected Risk (SCER) model-based approach to measuring perceived risk of activities. The resource management risk perception scale consists of 15 activities and individuals' must rate 1) the probability of the activity being beneficial to them (Pr.benefit), 2) the probability of the activity being harmful to them (Pr.harm), 3) the probability of the activity being neither beneficial nor harmful to them (Pr.status quo), 4) the expected benefit from the activity for them (E.benefit), 5) and the expected harm from the activity to them (E.harm), and 6) how risky they perceive the activity to be (R.X). All six ratings are done on a scale from 0 – 100, with higher ratings indicating higher probabilities, expectancies, and overall riskiness. Sample items include: "Take all of the resource that you can as soon as possible."; "Coordinate your resource-using behavior with that of other resource users for the benefit of the resource"; and "Try to take more of the resource than other resource users to ensure that you make the most profit." The SCER model can be expressed as the perceived riskiness, R, of activity X, in the equation R(X) = A0 Pr(status quo) + A+ Pr(benefit) + A- Pr(harm) + B+ E(benefit) + B- E(harm), which is an additive linear combination of the perceiver's subjective judgments about the harms and benefits associated with the activities. Scores can range from 15 - 1500 with higher scores indicating greater risk perception. Holtgrave and Weber (1993), Palmer (1996), Carlstrom, Woodward, and Palmer (2000) and Palmer, Carlstrom, and Woodward (2001) provide substantial evidence attesting to the psychometric soundness of SCER model format for a variety of activities. In the current investigation, reliability analysis revealed that the reliability of the resource management risk perception scale was adequate (Cronbach's $\alpha = .81$).

*Fishing Experience Questionnaire.* This questionnaire was created for the purposes of the current investigation in order to explore participants' subjective experiences of the fishing simulation. It is a post-procedure qualitative measure consisting of 8 open-ended questions about various aspects of the fishing simulation, including the uncertainty and communication manipulations. Sample items include "Did you find the fishing experience to be frustrating? If so which aspects frustrated you the most?"; "Did you find it difficult to coordinate your fishing with that of others in your ocean in order to obtain your desired outcome? If so, what aspects do you think made it so difficult?"; "If your group was allowed to communicate did you feel this hindered or helped your fishing efforts and in what ways?" and "If there were mystery fish in your ocean (fish outlines) did you feel this hindered or helped your fishing efforts and in what ways?". This questionnaire should increase our understanding of the way in which participants interpret various aspects of the fishing simulation experience.

*Procedure*

Following ethical guidelines, prior to beginning the study procedures participants received consent forms and the details of which were reviewed. Specifically, prospective participants were told that: a) participation in the study was strictly voluntary; b) the information they provided would be completely anonymous and confidential; and c) they had the right to omit any steps of the procedure or questionnaire items they wished or to withdraw from the study at any time without penalty or consequence.

Each group was randomly assigned to one of the four experimental conditions created by the 2 (communication) by 2 (uncertainty) factorial two-way between-subjects design. There were 8 groups in each cell. The communication groups were seated side by side and were encouraged to engage in open, unrestricted group discussion throughout all fishing seasons. The no-communication groups were separated by one seat and were not permitted to communicate at all (they could not see one another's computer screens and were faced forward at their own computers with a substantial amount of distance between them). Using the FISH 3.1 program, the environmental uncertainty (operationalized here as uncertainty regarding how many fish there were) was varied. All conditions began with 100 real or certain fish in their ocean. The no-uncertainty groups just had these certain fish in their ocean and were aware of the exact number of fish at all times. When uncertainty was present, a maximum of 40 of the fish were uncertain "mystery fish" outlines which may or may not exist. The resource management self-efficacy and risk perception scales were included as covariates to investigate their relation to cooperation rates within a complex commons dilemma context.

Except for the two manipulations (uncertainty and communication), all fishers participated in the same resource dilemma scenario, which was set up with the FISH 3.1 parameters. Departures from port did not cost the participants, there were no operating costs, there was no limit on number of casts, the probability of catching a fish was set at 1 for each cast made, each catch was worth 5 cents, 30 seconds elapsed between seasons for spawning to occur, the spawning rate was set at 2, and the number of seasons was set at 10. It is important to note that although the maximum number of seasons was set at 10, participants were not told how many seasons the simulation was set for because their knowledge of this information could influence their fishing behaviour. Fishers were provided with feedback about pool size, their own harvests, their own profits, but were not shown the harvests and profits of other fishers.

Participants were seated in rows of three at individual computers in a computer lab at the university. Each row of three participants was considered an "ocean" as each group of three was fishing against each other and sharing the fish in their "ocean". Detailed instructions for the program were carefully reviewed and were also provided on the opening screen of the program.

A screen shot of the FISH 3.1 program is provided in Figure 1 below. Please note that it is only an example screen shot and that the specific FISH parameters on the screen shot in Figure 1 do not necessarily match the parameters used in the current study.

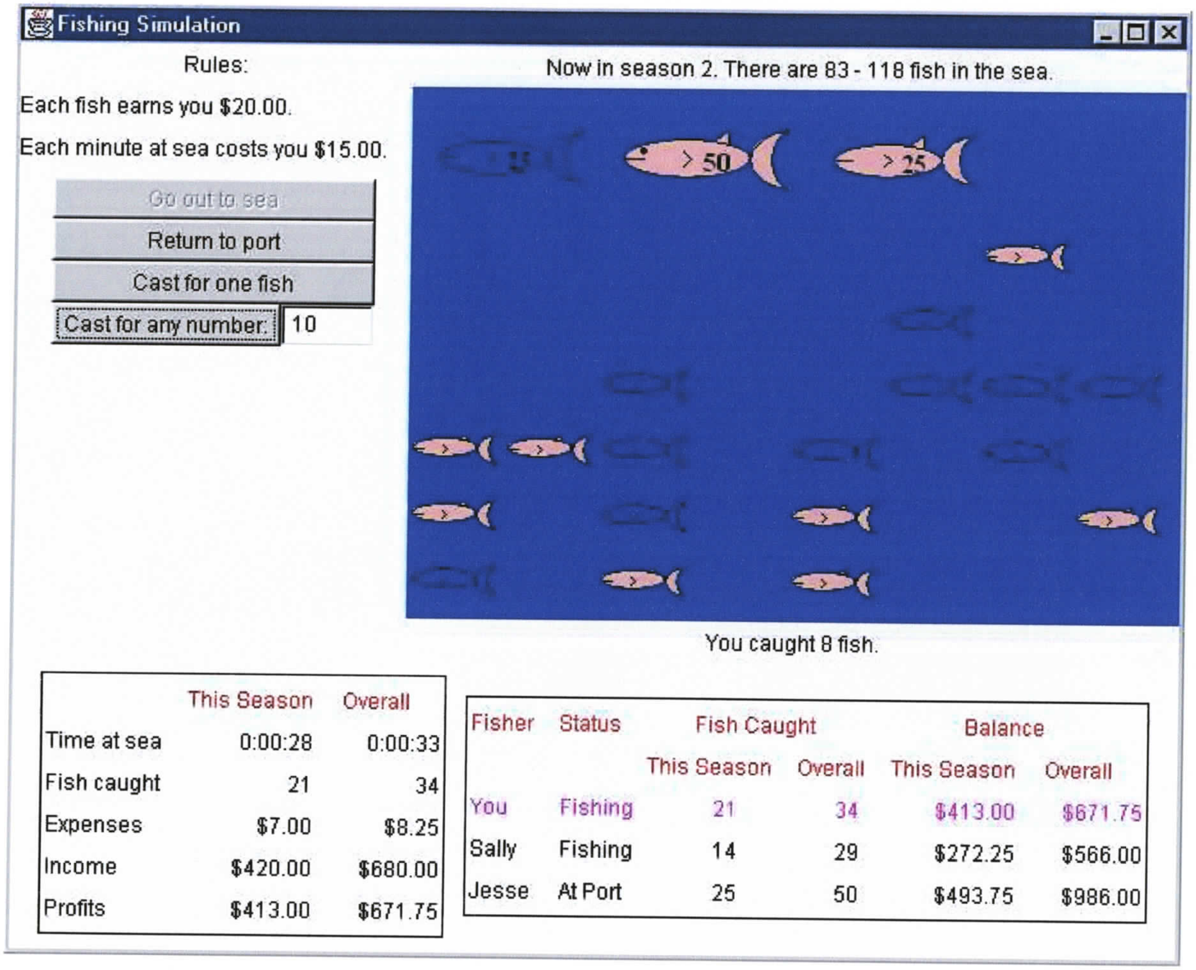


*Figure 1.* Example screen shot of the FISH 3.1 program.

Participants were first allowed a short practice trial of two fishing seasons with the program to ensure that everyone understood how to use the fishing simulation. Then participants engaged in the real fishing simulation, which lasted 10 fishing seasons. When all groups were finished the simulation, participants completed a short questionnaire containing demographic information and the 11-item resource management self-efficacy scale, the 15-item resource management risk perception scale, and an 8 item qualitative questionnaire about their fishing experience. Once the questionnaire was complete participants were individually paid for their fishing performance. The entire procedure was about one hour in duration.

Cooperation was measured by the Individual Restraint and Individual Efficiency rates that are automatically calculated by the FISH 3.1 program after each simulation. These cooperation rates are based mainly on the number of fish taken, the number of fish left to spawn, group profit, and the equality of the number of fish caught between group members. Individual restraint ranges from 1 (if this harvester was totally restrained i.e., took no fish) to 0 (if this harvester took 1/Nth of the entire pool), to 1 - N (a negative number, if this harvester took 100% of the pool), where N is the number of fishers. Scores less than 0 indicate very little restraint (i.e., this harvester was taking enough fish to rapidly deplete the pool by him/herself). Individual efficiency is computed in one of two ways, depending on whether the stock was endangered or not (see Hine & Gifford, 1996 for details). Perfect efficiency or sustainability (i.e., this harvester took just enough fish so that, once spawning occurs, the resource would regenerate to its original size) receives a score of 1. A score of 0 means the harvester took 1/Nth of the whole existing pool, far too much for the pool to regenerate. Scores below 0 indicate even greater inefficiency or greed. Because the program gives Individual Restraint and Individual Efficiency values for each fishing season, the average of each individual's restraint and efficiency scores over all seasons was used. The number of seasons that the resource lasted (without depletion) was also used as a measure of cooperation as it is also an important indicator of cooperation and is not captured by the averaged scores of the other cooperation measures.

## Results

### *Intraclass Correlations*

Because individuals were fishing in groups, intraclass correlations were calculated to explore the extent to which their behaviour could be considered empirically independent from the behaviour of their group members. The intraclass correlation coefficients for the restraint and efficiency measures were extremely low ($r = -.03, p = .60$ and $r = .10, p = .17$, respectively), indicating that individuals can empirically be considered to be relatively independent regardless of their group membership (refer to table 1). Therefore, the analysis was performed at the individual level ($N = 96$) rather than the group level (using individual restraint and efficiency instead of group restraint and efficiency).

Table 1

*Intraclass Correlations*

| | Intraclass Correlation | 95% Confidence Interval | | F Test with True Value | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | Df1 | df2 | Sig |
| Individual Restraint | -.03 | -.20 | .20 | .92 | 31 | 62 | .60 |
| Individual Efficiency | .10 | -.10 | .34 | 1.33 | 31 | 62 | .17 |

*Scale Reliabilities*

The resource management self-efficacy scale and the resource management risk perception scale were both created for the purposes of the current investigation. Therefore, their reliabilities within this study are important. As can be seen in table 2, reliability analysis revealed that the reliability of the resource management self-efficacy scale was adequate (Cronbach's $\alpha = .75$) and the reliability of the resource management risk perception scale was quite strong (Cronbach's $\alpha = .81$).

Table 2

*Reliability Analysis*

| Scale | Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|---|
| Resource Management Self-Efficacy | .75 | .75 | 11 |
| Resource Management Risk Perception | .80 | .81 | 15 |

*Descriptive Statistics*

Descriptive statistics including means and standard deviations for each of the four conditions are provided in tables 3 to 6. Overall cooperation rates (on all cooperation measures) of all four conditions were somewhat high, as were the average scores on the resource management self-efficacy and risk perception scales (above mid-points). Although they were not included in the analyses at all, for interest, individuals' mean profits for each of the four conditions are provided as well.

Table 3

*Descriptive Statistics for the No Uncertainty by No Communication Condition*

| | | Seasons Lasted | Individual Restraint | Individual Efficiency | Self-Efficacy | Risk Perception | Total Profits |
|---|---|---|---|---|---|---|---|
| N | Valid | 24 | 24 | 24 | 24 | 24 | 24 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 6.13 | .30 | .42 | 34.88 | 820.38 | 3.13 |
| Std. Deviation | | 4.04 | .41 | .65 | 5.85 | 284.11 | 2.58 |
| Minimum | | 1.00 | -.80 | -1.60 | 24.00 | 15.00 | .60 |
| Maximum | | 10.00 | .84 | 1.66 | 49.00 | 1150.00 | 12.15 |
| Midpoint | | 5 | 0 | 0 | 33 | 757.50 | _ |

Table 4

*Descriptive Statistics for the No Uncertainty by Communication Condition*

| | | Seasons Lasted | Individual Restraint | Individual Efficiency | Self-Efficacy | Risk Perception | Total Profits |
|---|---|---|---|---|---|---|---|
| N | Valid | 24 | 24 | 24 | 24 | 24 | 24 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 7.63 | .51 | .93 | 40.79 | 761.42 | 5.86 |
| Std. Deviation | | 3.10 | .16 | .36 | 5.58 | 160.93 | 2.73 |
| Minimum | | 1.00 | .19 | .26 | 27.00 | 467.00 | .15 |
| Maximum | | 10.00 | .91 | 1.82 | 50.00 | 982.00 | 8.35 |
| Midpoint | | 5 | 0 | 0 | 33 | 757.50 | _ |

Table 5

*Descriptive Statistics for the Uncertainty by No Communication Condition*

| | | Seasons Lasted | Individual Restraint | Individual Efficiency | Self-Efficacy | Risk Perception | Total Profits |
|---|---|---|---|---|---|---|---|
| N | Valid | 24 | 24 | 24 | 24 | 24 | 24 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 2.63 | .31 | .47 | 33.92 | 898.96 | 1.79 |
| Std. Deviation | | 1.53 | .51 | .92 | 6.83 | 146.98 | 1.33 |
| Minimum | | 1.00 | -.56 | -1.12 | 22.00 | 569.00 | .00 |
| Maximum | | 5.00 | 1.00 | 2.00 | 47.00 | 1190.00 | 4.50 |
| Midpoint | | 5 | 0 | 0 | 33 | 757.50 | _ |

Table 6

*Descriptive Statistics for the Uncertainty by Communication Condition*

| | | Seasons Lasted | Individual Restraint | Individual Efficiency | Self-Efficacy | Risk Perception | Total Profits |
|---|---|---|---|---|---|---|---|
| N | Valid | 24 | 24 | 24 | 24 | 24 | 24 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 6.63 | .45 | .79 | 38.63 | 704.83 | 3.57 |
| Std. Deviation | | 3.57 | .56 | 1.10 | 5.27 | 294.33 | 2.26 |
| Minimum | | 1.00 | -1.70 | -3.40 | 31.00 | 15.00 | .00 |
| Maximum | | 10.00 | 1.00 | 2.00 | 51.00 | 1260.00 | 7.70 |
| Midpoint | | 5 | 0 | 0 | 33 | 757.50 | _ |

*Univariate Analyses of Variance and Covariance (ANCOVAs)*

In order to asses the effects of uncertainty, communication, self-efficacy, and risk perception on each of the cooperation measures used (number of seasons lasted, individual restraint, and individual efficiency), the data were analyzed using three univariate 2 x 2 (uncertainty by communication) between subjects factorial analysis of variance and covariance (ANCOVAs). The results of these analyses are displayed in tables 7 through 13. Additionally, to add a qualitative perspective to the results, participants' responses to the fishing experience questionnaire are discussed where appropriate.

*Cooperation in Terms of Number of Seasons Lasted*

A 2 x 2 (uncertainty by communication) between subjects factorial analysis of variance and covariance (ANCOVA) revealed a significant main effect of communication on cooperation rates (as measured by number of seasons lasted), $F(1, 90) = 5.86, p = .017$ (refer to table 7). Specifically, relative to individuals who were not permitted to communicate ($M = 4.38, SD = 3.50$), those who were involved in communication ($M = 7.13, SD = 3.35$) were significantly more cooperative. The presence of communication accounted for approximately 6.1 % of the variation in cooperation rates (partial $\eta^2 = .061$).

The effect of communication is also reflected in participants' answers to the questions in the qualitative fishing experience questionnaire. The most frequent comments given by participants in the communication conditions emphasized the advantages that communication provided in terms of coordinating their behavior with others in their ocean, facilitating their personal fishing goals, and increasing their enjoyment of the experience. Additionally, the most frequent comments provided by participants in the no communication conditions emphasized the disadvantages they experienced as a result of not communicating. These disadvantages included: experiencing frustration over the harvesting behavior of others, feeling distrust for the other fishers, difficulty coordinating one's behavior with others, and feeling that their personal fishing goals were hindered by the lack of communication.

A significant main effect was also found for environmental uncertainty on number of seasons lasted, $F(1, 90) = 9.87, p = .002$. This finding indicates that individuals who fished out of a certain resource pool ($M = 6.88, SD = 3.64$) were significantly more cooperative than those who fished out of an uncertain resource pool ($M$ = 4.63, $SD$ = 3.39). Uncertainty regarding the resource size accounted for approximately 9.9 % of the variation in cooperation rates (partial $\eta^2 = .099$).

The effect of uncertainty is also reflected in participants' answers to the questions in the qualitative fishing experience questionnaire. The most frequent comments about the uncertainty manipulation emphasized the disadvantages participants experienced as a result of not knowing how many fish there were. These disadvantages included: increasing the risks by creating a "false sense of security" in the assumption that the mystery fish were in fact real, experiencing confusion and difficulty over how many fish there might be, and feeling that their personal fishing goals were hindered by the presence of uncertainty. Additionally, the most frequent comments provided by participants in the no uncertainty conditions emphasized the advantages that a certain resource pool provided in terms of knowing how many fish to catch each season, knowing when to stop fishing for the season or how many to leave for spawning, and facilitating their personal fishing goals.

These significant main effects are however, qualified by a marginally significant communication by uncertainty interaction, $F(1, 90) = 3.84$, $p = .053$, which accounted for approximately 4.1 % of the variation in cooperation rates (partial $\eta^2 = .041$). Although the interaction is only marginally significant, it is considered an important aspect of the study and is, therefore reported and interpreted.

As can be seen in table 7, of the two covariates, the resource management self-efficacy covariate evidenced a significant effect on cooperation rates ($F(1, 90) = 8.61$, $p = .004$), accounting for approximately 8.7 % of the variation in the number of seasons the resource lasted (partial $\eta^2 = .087$). However, the resource management risk perception covariate did not significantly affect cooperation rates in terms of seasons lasted, $F(1, 90) = 1.23$, *n.s.*

Table 7

*Two by Two Between-Subjects ANCOVA using Number of Seasons Lasted*

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Self-Efficacy | 81.02 | 1 | 81.02 | 8.61 | .004 | .087 | .827 |
| Risk Perception | 11.60 | 1 | 11.60 | 1.23 | .270 | .014 | .196 |
| Uncertainty | 92.80 | 1 | 92.80 | 9.87 | .002 | .099 | .874 |
| Commun-ication | 55.13 | 1 | 55.13 | 5.86 | .017 | .061 | .668 |
| Uncertainty * Commun-ication | 36.11 | 1 | 36.11 | 3.84 | .053 | .041 | .491 |
| Error | 846.62 | 90 | 9.41 | | | | |
| Total | 4458.00 | 96 | | | | | |
| Corrected Total | 1284.00 | 95 | | | | | |

Note: Computed using alpha = .05; R Squared = .341 (Adjusted R Squared = .304)

Although the communication by uncertainty interaction was marginally significant ($F$ (1, 90) = 3.84, $p$ = .053), it supports the predicted pattern and thus, was explored in further detail. Simple main effects tests were performed using the Bonferroni alpha adjustment (.05 / 2 = .025; adjusted $\alpha$ = .025) and independent samples t-tests (see tables 8-11). There are two different ways the interaction can be interpreted and thus, to provide a complete and unbiased picture, it was explored from both perspectives.

As can be seen in table 8, within the no uncertainty condition, the effect of communication on cooperation was not significant ($t$ (46) = -1.44, *n.s.*); indicating that those who did not communicate ($M$ = 6.13, $SD$ = 4.04) did not differ from those who did communicate ($M$ = 7.63, $SD$ = 3.10). Table 9 indicates that within the uncertainty condition, those who did communicate ($M$ = 6.63, $SD$ = 3.57) had significantly higher cooperation rates ($t$ (46) = -5.04, $p$ < .001) than those who did not communicate ($M$ = 2.63, $SD$ = 1.53). See figure 1 for a visual display of the interaction from this perspective. From this interpretation it appears that as predicted, communication was in fact instrumental in counteracting the detrimental effect of uncertainty.

Table 8

*Effect of Communication Within the No Uncertainty Condition*

| Levene's Test for Equality of Variances | | t-test for Equality of Means Within the no uncertainty condition (communication vs. no communication) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | T | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | Lower | Upper |
| 12.18 | .001 | -1.44 | 46 | .156 | -1.50 | 1.04 | -3.59 | .59 |

Table 9

*Effect of Communication Within the Uncertainty Condition*

| Levene's Test for Equality of Variances | | t-test for Equality of Means Within the uncertainty condition (communication vs. no communication) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | T | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | Lower | Upper |
| 77.47 | .000 | -5.04 | 46 | .000 | -4.00 | .79 | -5.60 | -2.40 |

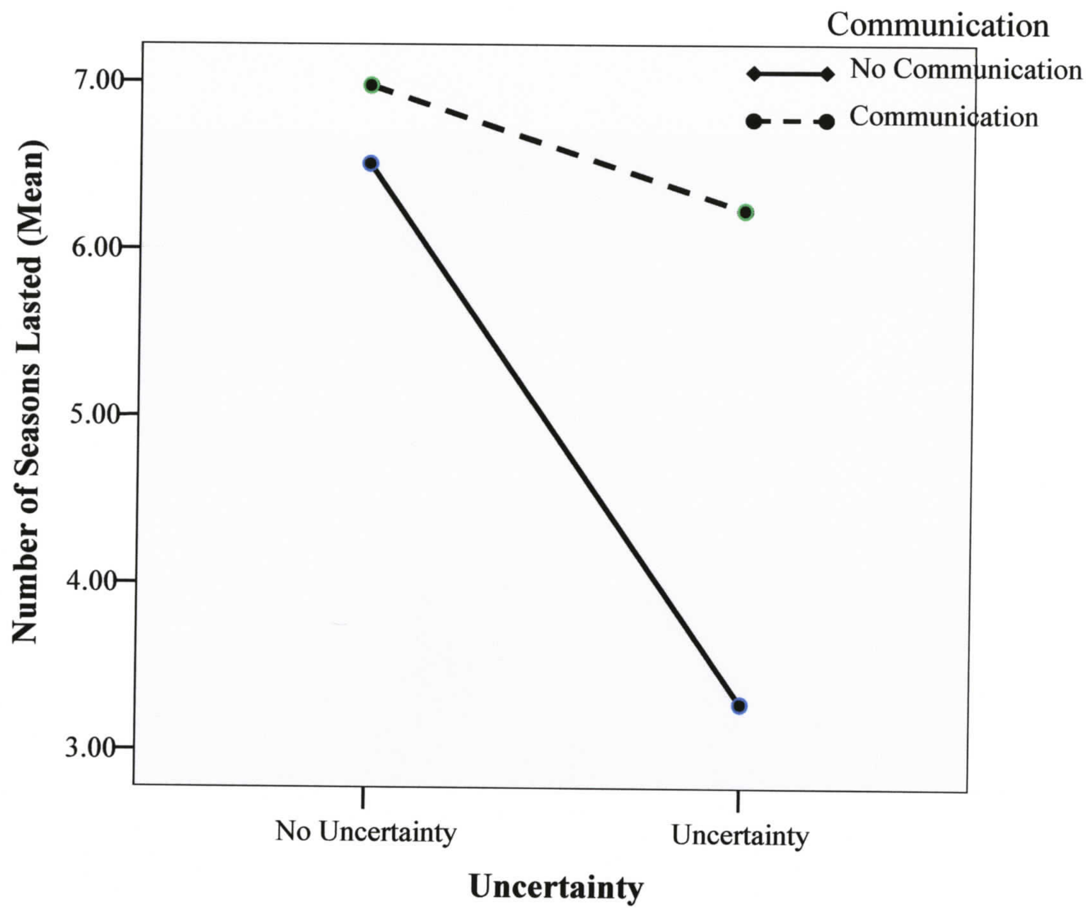


*Figure 2.* Communication by Uncertainty Interaction

From another perspective, table 10 shows that within the no communication condition, those who were certain of the resource size ($M = 6.13$, $SD = 4.04$) had significantly higher cooperation rates ($t\ (46) = 3.97$, $p < .001$) than those who were uncertain about the resource size ($M = 2.63$, $SD = 1.53$). However, as can be seen in table 11, within the communication condition, no significant effect was found for uncertainty on cooperation rates ($t\ (46) = 1.04$, *n.s.*); indicating that those who were certain of the resource size ($M = 7.63$, $SD = 3.10$) did not differ from those who were uncertain about the resource size ($M = 6.63$, $SD = 3.57$). See figure 2 for a visual display of the interaction from this perspective. This perspective supports the prediction that the detrimental effect of uncertainty would be more pronounced when there is no communication than when communication is present.

Table 10

*Effect of Uncertainty Within the No Communication Condition*

| Levene's Test for Equality of Variances | | t-test for Equality of Means Within the no communication condition (uncertainty vs. no uncertainty) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | T | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | Lower | Upper |
| 153.33 | .000 | 3.97 | 46 | .000 | 3.50 | .88 | 1.73 | 5.27 |

Table 11

*Effect of Uncertainty Within the Communication Condition*

| Levene's Test for Equality of Variances | | t-test for Equality of Means Within the communication condition (uncertainty vs. no uncertainty) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | T | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | Lower | Upper |
| 4.74 | .035 | 1.04 | 46 | .306 | 1.00 | .966 | -.944 | 2.94 |

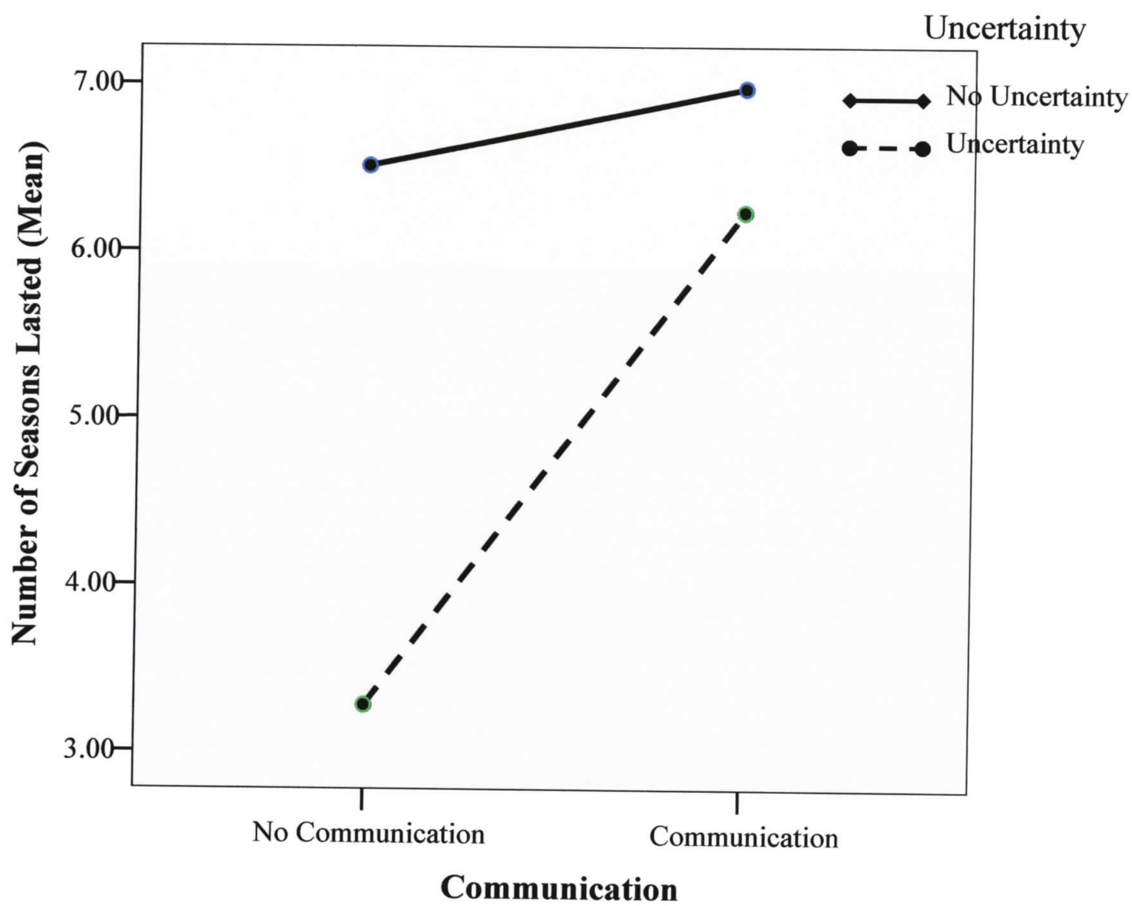


*Figure 3.* Uncertainty by Communication Interaction

*Cooperation in Terms of Individual Restraint*

As displayed in table 12, a second 2 x 2 (uncertainty by communication) between subjects factorial analysis of variance and covariance (ANCOVA) using individual restraint as the measure of cooperation did not reveal a significant main effect for either communication ($F$ (1, 90) = .1.37, *n.s.*) or environmental uncertainty ($F$ (1, 90) = .05, *n.s.*). These findings indicate that no significant differences were found between individuals who were permitted to communicate ($M$ = .48, $SD$ = .41) and those who were not ($M$ = .30, $SD$ = .46) or between individuals who fished out of a certain resource pool ($M$ = .41, $SD$ = .33) and those who were uncertain of the resource size ($M$ = .38, $SD$ = .54). Similarly, the analysis did not reveal a significant communication by uncertainty interaction, $F$ (1, 90) = .46, *n.s.* Of the two covariates, the resource management self-efficacy covariate did not significantly effect cooperation rates, $F$ (1, 90) = .07, *n.s.* However, the resource management risk perception covariate was marginally significant ($F$ (1, 90) = 3.75, $p$ = .056) accounting for approximately 4.0 % of the variation in cooperation rates (partial $\eta^2$ = .040).

Table 12

*Two by Two Between-Subjects ANCOVA using Individual Restraint*

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Self-Efficacy | .01 | 1 | .01 | .07 | .792 | .001 | .058 |
| Risk Perception | .71 | 1 | .71 | 3.75 | .056 | .040 | .482 |
| Uncertainty | .01 | 1 | .01 | .05 | .827 | .001 | .055 |
| Commun-ication | .26 | 1 | .26 | 1.37 | .245 | .015 | .212 |
| Uncertainty * Commun-ication | .09 | 1 | .09 | .46 | .498 | .005 | .103 |
| Error | 16.97 | 90 | .19 | | | | |
| Total | 33.27 | 96 | | | | | |
| Corrected Total | 18.50 | 95 | | | | | |

Note: Computed using alpha = .05; R Squared = .083 (Adjusted R Squared = .032)

*Cooperation in Terms of Individual Efficiency*

Nearly identical results were obtained when a third 2 x 2 (uncertainty by communication) between subjects factorial analysis of variance and covariance (ANCOVA) was conducted using individual efficiency as the measure of cooperation (refer to table 13). Again the analysis did not reveal a significant main effect for either communication ($F$ (1, 90) = 2.78, *n.s.*) or environmental uncertainty ($F$ (1, 90) = .03, *n.s.*); indicating that no significant differences were found between individuals who communicated ($M$ = .86, $SD$ = .81) and those who did not communicate ($M$ = .45, $SD$ = .79) or between individuals who fished out of a certain resource pool ($M$ = .67, $SD$ = .58) and those who fished out of an uncertain resource pool ($M$ = .63, $SD$ = 1.02). Similarly, the analysis did not reveal a significant communication by uncertainty interaction, $F$ (1, 90) = .76, *n.s.* Of the covariates, resource management self-efficacy did not significantly effect cooperation rates, $F$ (1, 90) = .02, *n.s.* However, the resource management risk perception covariate did evidence a significant effect on cooperation rates, $F$ (1, 90) = 4.31, $p$ = .041, accounting for approximately 4.6 % of the variation in cooperation rates (partial $\eta^2$ = .046).

Table 13

*Two by Two Between-Subjects ANCOVA using Individual Efficiency*

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Self-Efficacy | .01 | 1 | .01 | .02 | .883 | .000 | .052 |
| Risk Perception | 2.74 | 1 | 2.74 | 4.31 | .041 | .046 | .537 |
| Uncertainty | .02 | 1 | .02 | .03 | .856 | .000 | .054 |
| Commun-ication | 1.76 | 1 | 1.76 | 2.78 | .099 | .030 | .378 |
| Uncertainty * Commun-ication | .48 | 1 | .48 | .76 | .386 | .008 | .138 |
| Error | 57.23 | 90 | .64 | | | | |
| Total | 105.29 | 96 | | | | | |
| Corrected Total | 64.33 | 95 | | | | | |

Note: Computed using alpha = .05; R Squared = .110 (Adjusted R Squared = .061)

*Zero Order Correlations*

Simple or raw correlations were also calculated between all variables and the three cooperation measures (see table 14). All correlations were two-tailed because this investigation was largely exploratory in nature and any associations observed were of interest, regardless of their direction. Uncertainty was negatively related to number of seasons lasted, $r = -.31$, $p = .002$. Therefore, those who were uncertain of the resource size evidenced lower cooperation (as indicated by seasons lasted) than those who were certain of the resource size. Communication was positively associated with all three cooperation measures. Specifically, communication was associated with greater number of seasons lasted ($r = .38$, $p < .001$), higher individual restraint ($r = .20$, $p = .05$), and higher individual efficiency ($r = .25$, $p = .01$). Resource management self-efficacy was positively correlated with number of seasons lasted ($r = .42$, $p < .001$), indicating that higher levels of self-efficacy were associated with greater number of seasons lasted. Resource management risk perception was negatively correlated with all three cooperation measures. Specifically, higher levels of risk perception were associated with lower number of seasons ($r = -.24$, $p = .02$), lower individual restraint ($r = -.24$, $p = .02$), and lower individual efficiency ($r = -.26$, $p = .01$). The demographic information collected on the participants (gender, age, probable or intended major, and familiarity with commons dilemmas) were not significantly related to any of the three measures of cooperation rates.

Table 14

*Zero Order Correlations Between all Measures*

| | | Individual Restraint | Individual Efficiency | Seasons Lasted |
|---|---|---|---|---|
| Uncertainty | Correlation | -.03 | -.03 | -.308(**) |
| | Sig.(2-tailed) | .77 | .81 | .002 |
| Communication | Correlation | .20(*) | .25(*) | .38(**) |
| | Sig.(2-tailed) | .05 | .01 | .000 |
| Gender | Correlation | .03 | .01 | .03 |
| | Sig.(2-tailed) | .79 | .97 | .75 |
| Age | Correlation | -.03 | -.02 | .07 |
| | Sig.(2-tailed) | .81 | .85 | .50 |
| Intended Major | Correlation | .04 | .04 | -.12 |
| | Sig.(2-tailed) | .73 | .68 | .26 |
| Familiarity | Correlation | -.03 | -.03 | -.07 |
| | Sig.(2-tailed) | .80 | .80 | .52 |
| Self-Efficacy | Correlation | .12 | .14 | .42(**) |
| | Sig.(2-tailed) | .23 | .19 | .000 |
| Risk Perception | Correlation | -.24(*) | -.26(*) | -.24(*) |
| | Sig.(2-tailed) | .02 | .01 | .02 |

Note: ** Correlation is significant at the 0.01 level (2-tailed);

* Correlation is significant at the 0.05 level (2-tailed).

The simple correlations amongst the three cooperation measures used were also calculated and can be seen in table 15. The individual restraint and individual efficiency cooperation measures were strongly correlated ($r = .95, p < .001$). Number of seasons lasted evidenced moderate correlations with both individual restraint ($r = .28, p = .006$) and individual efficiency ($r = .24, p = .017$).

Table 15

*Raw Correlations Between Cooperation Measures*

| | | Individual Restraint | Individual Efficiency | Seasons Lasted |
|---|---|---|---|---|
| Individual Restraint | Correlation | 1 | .95(**) | .28(**) |
| | Sig. (2-tailed) | | .000 | .006 |
| Individual Efficiency | Correlation | .95(**) | 1 | .24(*) |
| | Sig. (2-tailed) | .000 | | .017 |
| Seasons Lasted | Correlation | .28(**) | .24(*) | 1 |
| | Sig. (2-tailed) | .006 | .017 | |

Note: ** Correlation is significant at the 0.01 level (2-tailed);

* Correlation is significant at the 0.05 level (2-tailed).

# Discussion

This study makes a unique contribution to the research on commons dilemmas by assessing the interaction between communication and uncertainty and by exploring the concepts of resource management self-efficacy and resource management risk perception. Although it is largely exploratory in nature, the current investigation provides preliminary support for the existence of an interaction between uncertainty and communication and highlights the importance of including more individual difference measures such as self-efficacy and risk perception in investigations of how individuals behave in resource sharing situations. It is recommended that the concepts of resource management self-efficacy and resource management risk perception be examined in future investigations in order to further validate their measurement and increase understanding of their contributions to behavior in commons dilemma contexts.

To summarize the main findings of this study, the results are reviewed in relation to the aforementioned predictions.

*Communication will be Associated with Higher Cooperation*

The prediction that the presence of group communication would be associated with higher rates of cooperation was supported by the finding that communication had a significant main effect on cooperation in terms of number of seasons lasted. This finding is consistent with the general finding that a period of group discussion tends to increase cooperation among participants and is therefore conducive to conservation of the common resource (e.g., Liebrand, 1984; Orbell, van de Kragt & Dawes, 1988; Hackett et al. 1994).

Some of the comments that participants in the communication conditions made to one another while fishing demonstrate the effectiveness of communication as instrumental in promoting cooperation. For example, some comments that were recorded during experimental sessions include: "I'll take seventeen fish, do you want to take turns who takes what because we can only take fifty each season"; "How many do you have now?...We'll stop fishing then to let you catch up to us"; "I'll take fifteen…you guys should take the same"; "You have to return to port now, we're waiting for you to finish so they can spawn"; and "Let's set a limit on how many you can catch at once".

Additionally, communication was positively correlated with all three cooperation measures. However, the main effect of communication was not significant on cooperation when it was measured by individual restraint or individual efficiency. The observed power of both of these analyses ($1 - \beta = .212$ and $1 - \beta = .378$, respectively) was however, much lower than that of the analysis employing number of seasons lasted as the cooperation measure ($1 - \beta = .668$).

*Environmental Uncertainty will be Associated with Lower Cooperation*

The prediction that the presence of environmental uncertainty would be associated with lower cooperation rates was supported by the finding that uncertainty had a significant main effect on, and a negative correlation with, number of seasons lasted. This finding is consistent with the general finding that in simulated resource dilemmas as environmental uncertainty (commonly defined as uncertainty about resource size) increases, individuals tend to increase the size of their requests of the resource, thus leading to over-harvesting (e.g., Budescu et al., 1990; Budescu et al., 1995; Chen et al., 1996; Roch & Samuelson, 1997; Wit & Wilke, 1998; Gustafsson et al., 1999; Gustafsson et al., 2000; and Rapoport & Au, 2001).

However, environmental uncertainty was not correlated with, and nor did it have a significant main effect on, cooperation as measured by individual restraint or individual efficiency. The observed power of both of these analyses ($1 - \beta = .055$ and $1 - \beta = .054$, respectively) was, however, much lower than that of the analysis employing number of seasons lasted as the cooperation measure ($1 - \beta = .874$). This lack of power and partial failure to replicate may also be attributable to the limitations to the methodology of this specific design which are discussed in some detail below.

*The Uncertainty by Communication Interaction*

The prediction that the detrimental effect of uncertainty would be more pronounced when there is no communication present than when group communication is present did receive partial support as a marginally significant interaction was found between communication and uncertainty on number of seasons lasted. Specifically, within the no uncertainty condition, the affect of communication on cooperation was not significant, but within the uncertainty condition, those who did communicate evidenced higher cooperation rates than those who did not communicate. Thus, it appears that communication was in fact instrumental in counteracting the detrimental effect of uncertainty to some extent.

However, the uncertainty by communication interaction was not significant when cooperation was measured by individual restraint or individual efficiency. Again, the observed power of both of these analyses ($1 - \beta = .103$ and $1 - \beta = 138$, respectively) was much lower than that of the analysis employing number of seasons lasted as the cooperation measure ($1 - \beta = .491$).

*Higher Self-Efficacy will be Associated with Greater Cooperation*

The prediction that higher levels of resource management self-efficacy would be associated with higher cooperation rates was supported by the finding that resource management self-efficacy evidenced a significant affect on cooperation rates in terms of number of seasons lasted. Specifically, higher levels of self-efficacy were associated with greater number of seasons lasted. This finding is consistent with previous theory and research demonstrating that self-efficacy is an important variable influencing individuals' behavior in social dilemmas (e.g., Olson, 1965; Messick, 1973; Kerr & Bruun, 1983; Kerr, 1989; Komorita & Parks, 1994). However, previous studies have focused on public goods dilemmas, whereas, the current study extends the concept of self-efficacy by applying it to a commons dilemma context.

*Higher Risk Perception will be Associated with Greater Cooperation*

The prediction that higher levels of resource management risk perception would be associated with higher cooperation rates received no support. As a covariate, resource management risk perception did evidence a significant affect on cooperation rates in terms of individual efficiency and a marginally significant affect on cooperation in terms of individual restraint. However, contrary to the predicted effect of risk perception, higher levels were actually associated with lower cooperation rates. Similarly, resource management risk perception was negatively correlated with all three cooperation measures. Specifically, higher levels of risk perception were associated with lower number of seasons, lower individual restraint, and lower individual efficiency.

This finding is not consistent with the general finding in previous research that risk perceptions increase motivation to engage in proactive behaviors against negative consequences (e.g., Weinstein et al., 1986; Weinstein et al., 1998; O'Connor et al., 1999; Weinstein, 2000). However, the findings from the current investigation do support the notion that risk perceptions are an important factor in predicting behavioral intentions and thus, should be considered an integral part of resource dilemmas and their potential solutions (O'Conner et al., 1999).

One possible reason why higher levels of risk perception were not associated with higher levels of cooperation is because the extent to which individuals actually desired to avoid such risks was not examined. Individuals' perceptions of the risks involved in resource sharing situations can be differentiated from individuals' risk aversion (i.e., the extent to which they feared such risks or desired to avoid them). Therefore, while individuals perceived the risks involved in various resource management-related activities, they may not have necessarily been motivated to avoid such risks.

It is important to note that the examination of the last three predictions (regarding the uncertainty by communication interaction, resource management self-efficacy, and resource management risk perception) was exploratory in nature, and thus, methodology improvements and replications are necessary in order to minimise limitations and to advance social scientists' knowledge of the potential interactions and associations between various factors affecting commons dilemma behavior.

*Limitations and Recommendations for Future Research*

There are several limitations to the design of the current investigation that warrant mention. First, the sample used in this investigation was somewhat small ($N = 96$). As using a small sample has negative implications for statistical power, future research on commons dilemma situations should attempt to use larger numbers of participants wherever possible.

Another limitation, which is common to many social scientific studies (see Sears, 1986) was that participants were young college students enrolled in introductory psychology classes. Thus, findings of this study may have over-represented this group and under-represented others. This limits the external validity, and thus, the generalizability of the results to different age groups, cultures, ethnic groups and socio-economic statuses. As a result, researchers do not know whether the associations observed, or lack there of, would be of comparable magnitude outside a college setting. Researchers should target non-college student samples and larger numbers of participants by recruiting participants from the community or city at large.

A large percentage of participants intended to major in some area of social sciences. Consequently, they may have been more knowledgeable about, and/or more sensitive to the social psychological constructs of interest and may have censored their responses according to their previous knowledge. Inspection of participants' mean scores provides some evidence in support of this concern (i.e., mean scores on measures of cooperation and on the resource management self-efficacy and resource management risk perception scales were above the mid-points). While it is certainly possible that participants in this study were genuinely more cooperative, efficacious, and sensitive to risks; it is equally compelling to argue that involvement in these studies may have triggered self-presentational concerns. Thus, the current investigation may have been limited by the use of self-report data, which may have introduced some response biases. I recommended that researchers investigate the possible association between scores on the resource management self-efficacy and risk perception scales and social desirability bias (or, more specifically, its dimensions of self-deception and other deception - see Meston, Heiman, Trapnell, and Paulhus, 1998).

Additionally, the resource management self-efficacy and risk perception scales that were used were created for the purposes of this investigation and have not yet proven to be reliable and valid. Although in this particular study they both evidenced adequate reliability, additional validation of these scales is required in order to demonstrate their psychometric soundness.

It is important to acknowledge that participants in all conditions completed the study questionnaire after having participated in the fishing simulation. The procedure was set up in this order because if the questionnaire was given prior to the simulation, it is likely that some content in the questionnaire could affect participants' behavior during the simulation. However, order effects can be confounding regardless of whether the questionnaire is completed before or after the study procedure. Consequently, participants' scores on the resource management self-efficacy and risk perception scales may have been affected by the experimental condition that they were in during the simulation. Therefore, subsequent studies using these scales should control for order effects by including the order of the questionnaire presentation as a variable in their investigations.

If replicated, this particular study could improve in both complexity and methodology in various ways. First, perhaps some of the parameters of the FISH program need to be modified so that the study better represents real-world fishing situations. For example, in their study of the effects of two types of environmental uncertainty, Hine and Gifford (1996) found relatively strong effects for both pool size uncertainty and regeneration rate uncertainty. In their investigation, the FISH parameters were set so that there were costs for departure and operation, the probability of catch was set at .5, and fishers were not provided with feedback about others harvests and profits. As opposed to the current investigation in which the FISH parameters were set so that there were no departure costs or operating costs, the probability of catching a fish was set at 1 for each cast made, and fishers were provided with feedback about pool size, their own harvests and profits, and whether the other fishers were fishing or at port. The parameters used by Hine and Gifford (1996) may have more accurately simulated real world fishing because in reality there are usually costs to fishers, less than 100% confidence that a catch will result from each cast, and full disclosure of others harvesting behavior is not always readily available. Therefore, perhaps the current study should be repeated with the use of more realistic FISH parameters.

The extent of environmental uncertainty used in the current study was comparable to that used by Hine and Gifford (1996). Additionally, in the current investigation an effect of uncertainty was found on number of seasons lasted. Thus, the failure to find an effect of uncertainty on cooperation in terms of individual restraint and individual efficiency does not seem to be due to insufficient levels of uncertainty. However, while it appears that the current study did use enough environmental uncertainty, perhaps the design of the study could be modified so that several different levels of uncertainty are included. This may help to distinguish between the lack of sufficient uncertainty to produce an effect and the lack of sufficient power to detect an effect. For example, in a study investigating the impact of environmental uncertainty in commons dilemmas, Budescu et al. (1990) used three levels of uncertainty (high, moderate, and none) and found that as uncertainty increased, the overharvesting effect became more pronounced. Specifically, as environmental uncertainty (defined here as uncertainty about pool size) increased, participants tended to 1) overestimate the size of the resource, 2) increase the size of their requests of the resource, and 3) expect others to increase their requests. If a follow-up investigation is conducted from this study, perhaps the effect of uncertainty will be easier to detect and interpret if varying levels are used in the uncertainty manipulation.

As mentioned earlier, *Individual solutions* to social dilemmas are dependent on independent changes in the behavior of individuals in order to produce increased cooperation (Messick & Brewer, 1983). While resource management self-efficacy and resource management risk perception proved to be useful individual difference variables in the current investigation, many other individual characteristics exist that might prove to be important predictors of behavior in commons dilemmas. For example, Roch and Samuelson (1997) investigated the relations between environmental uncertainty and social value orientation. Social value orientation influences motives, strategies, and choice behavior in mixed-motive experimental games (Roch & Samuelson, 1997). The three major social value orientations are: 1) cooperative, 2) individualistic, and 3) competitive (Messick & McClintock, 1968). Roch and Samuelson (1997) found evidence suggesting that individual differences may moderate the environmental uncertainty effect. In his text book entitled "Environmental Psychology: Principles and Practice", Gifford (2002) also mentions social values as a particularly important individual difference that has been shown to effect behavior in the commons. Similarly, in their book entitled "Social Dilemmas", Komorita and Parks (1994) identify interpersonal orientation (IO; concept by: Rubin & Brown, 1975; Swap & Rubin, 1983) as a trait that has been related to cooperative and competitive behavior. One with high IO is said to be concerned primarily with the interpersonal relationship and issues such as reciprocity and equity. These people are said to be more collectivistic, whereas, one who is low in IO is said to be more concerned with personal gain, regardless of the other person's situation, and is more individualistic (Komorita & Parks, 1994). Therefore, future research may benefit from including more individual difference variables such as social value orientation or interpersonal orientation in their investigations of commons dilemma situations.

Over-consumption of natural resources is increasing environmental problems and concerns. These pressing issues are the concern of many social scientists who are investigating both individual and group contributions to ecological degradation (Budescu et al., 1995). Individuals make many decisions about resource management everyday and the most crucial aspect of individual-level resource management decisions is that they sum across billions of individuals' actions to societal-level management (Gifford & Wells, 1991; Gifford & Gifford, 2000). Although many studies have been conducted on the effects of various factors on behavior in commons dilemma simulations, we are lacking a unified and complete picture of exactly how these factors interact with or moderate one another to effect individuals' harvesting decisions. Much additional research is needed in order to consistently replicate and unify previous findings in this field so that the application of this information may contribute to the conservation of valuable natural resources and ultimately, our environment as a whole.

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Appendix A: Questionnaire

**Section A: Demographics**

For the following questions, please circle the appropriate answer or fill in the blank with the appropriate information.

1. I am: Male or Female

2. My age is: _______.

3. My probable or intended major at the University of Victoria is (i.e., Business, Economics, Psychology, Sociology etc…).

   ________________________________________________________________

4. Before participating in this study how familiar were you with the concept of commons dilemmas (resource dilemmas / social dilemmas) or related concepts such as "the tragedy of the commons"?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| (not at all familiar) | (heard of it but not familiar) | (slightly familiar) | (familiar) | (very familiar) |

**Section B: Resource Management Self-Efficacy Scale**

Directions: The following statements represent various opinions about resource-management abilities. Your task is to indicate the strength of your agreement with each statement by circling the most appropriate number on a scale from 1 (strongly disagree) to 5 (strongly agree) as illustrated below.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree Nor Disagree | Agree | Strongly Agree |

There are no "right" or "wrong" answers, so select the number that most closely reflects your beliefs about your abilities for each statement. Please take your time and consider each statement carefully.

1) I can influence the state of the resource (i.e., how many fish are in the ocean at any given time). 1 2 3 4 5

2) I cannot influence the final outcome of the resource (i.e., whether the fish become extinct or not).* 1 2 3 4 5

| | | | | | | |
|---|---|---|---|---|---|---|
| 3) | I can influence the behavior of the others who have access to the resource (i.e., those in your ocean). | 1 | 2 | 3 | 4 | 5 |
| 4) | I cannot influence whether the resource is equally distributed among those who have access to it (i.e., the fishers in your ocean).* | 1 | 2 | 3 | 4 | 5 |
| 5) | I cannot ensure that I will make an optimal profit from my resource-management behavior.* | 1 | 2 | 3 | 4 | 5 |
| 6) | I can ensure that the profits of others who are using the resource are maximized (i.e., those in your ocean). | 1 | 2 | 3 | 4 | 5 |
| 7) | I cannot influence the conservation of this resource.* | 1 | 2 | 3 | 4 | 5 |
| 8) | I can coordinate my resource-use behavior with the behavior of others who are using that resource. | 1 | 2 | 3 | 4 | 5 |
| 9) | I can manage my own resource use so that I obtain the results that I desire. | 1 | 2 | 3 | 4 | 5 |
| 10) | I cannot influence the regeneration of the resource (i.e., how many fish are left to spawn at the end of each season).* | 1 | 2 | 3 | 4 | 5 |
| 11) | I can influence how long the resource lasts (i.e., how many seasons that at least some fish live). | 1 | 2 | 3 | 4 | 5 |

Note: Reverse-keyed items are indicated by an asterisk (*).

**Section C: Resource Management Risk Perception Scale**

Directions: The following describe various resource-management goals. Your task is to indicate on a scale from 1 - 100 for each activity:

1) the probability of the activity being beneficial to YOU (Pr. Benefit)
2) the probability of it being harmful to YOU (Pr. Harm)
3) the probability of it being neither beneficial nor harmful to YOU (Pr Neither Benefit Nor Harm)
4) the expected benefit for YOU (Exp. Benefit)
5) the expected harm to YOU (Exp. Harm)
6) how risky the activity is for YOU (How Risky)

There are no "right" or "wrong" answers, so select the number that most closely reflects your opinion about each activity. Please take your time and consider each activity carefully.

1) Take all of the resource that you can as soon as possible.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

2) Save as much as the resource as you can to allow for regeneration.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

3) Try to ensure that the resource is divided evenly among those who are using it.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

4) Try to maximize your personal profit.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

5) Try to maximize the profit of others who are using the resource.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

6) Try to maximize your profit as well as the profit of others using the resource.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

7) Try to conserve the resource as long as possible.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

8) Try to make as much personal profit you can without extinguishing or depleting the resource.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

9) Trust the other individuals who are using the resource to be unselfish.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

10) Coordinate your resource-using behavior with that of other resource users for the benefit of everyone involved.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

11) Coordinate your resource-using behavior with that of other resource users for the benefit of the resource.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

12) Take large amounts of the resource at once (i.e., using the "Cast for Multiple Fish" option).

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

13) Fully deplete the resource as soon as possible.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

14) Try to take more of the resource than other resource users to ensure that you make the most profit.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

15) Take very small amounts of the resource and trust that others will do the same.

| Pr. Benefit | Pr. Harm | Pr. Neither Benefit Nor Harm | Exp. Benefit | Exp. Harm | How Risky |
|---|---|---|---|---|---|
| _______ | _______ | _______ | _______ | _______ | _______ |

**Section D: Fishing Experience Questionnaire**

For this section, please answer the following questions about your fishing experience.

1) Did you find the fishing experience to be frustrating? If so which aspects frustrated you the most?

2) Did you find the fishing experience to be pleasant or enjoyable? If so which aspects did you enjoy the most?

3) Did you find it difficult to coordinate your fishing with that of others in your ocean in order to obtain your desired outcome? If so, what aspects do you think made it so difficult?

4) Did you find it easy to coordinate your fishing with that of others in your ocean in order to obtain your desired outcome? If so, what aspects do you think made it so easy?

5) If your group was not allowed to communicate did you feel this hindered or helped your fishing efforts and in what ways?

6) If your group was allowed to communicate did you feel this hindered or helped your fishing efforts and in what ways?

7) If there were mystery fish in your ocean (fish outlines) did you feel this hindered or helped your fishing efforts and in what ways?

8) If there were not any mystery fish in your ocean (no fish outlines) did you feel this hindered or helped your fishing efforts and in what ways?