Nuclear Proliferation and the Deterrence of Conventional War:
A Proposal

Justin Pollard
April 2009
College of Letters and Science
Department of Economics
University of California at Berkeley
Thesis Adviser: Professor Robert Powell

Thank you to Professor Robert Powell for his supervision, guidance, and support.

Contents

1) Introduction

It seems counterintuitive to think that the spread of nuclear weapons could make the world a safer place, doesn't it? Indeed, it appears painfully logical at first glance to think that a world of ubiquitous nuclear armament is a more dangerous and unstable one. Certainly, a weapon of the nuclear magnitude has the potential to destroy millions of lives. Thus, it seems that each newly born nuclear warhead increases the potential for destruction. Further, the spread of these weapons across countries may increase the chances, however finite, of nuclear war, contributing to an ever more dangerous environment (Waltz, 1981). However, there is another story that lives in parallel to this one.

Imagine a situation in which engaging in a dispute involved risking the possibility of such unbearable destruction that a participant would never enter that dispute in the first place. This explanation may be an equally convincing story when trying to describe the consequences of nuclear proliferation. The spread of these weapons could, in fact, could make the expected cost of conventional war so high (due to the potential for a nuclear strike) that no country would be willing to risk its consequences. If this logic is valid, the spread of nuclear arms could actually contribute to a more peaceful world (Waltz, 1981).

To take another point of view, what if the consequences of a nuclear disaster were relatively minimal for certain countries when compared to others? Traditional circumstances could easily change if one party has very little to lose from nuclear war and is willing to take large risks that others are not. In this case, a rogue state that possesses the capacity for a nuclear strike, despite being militarily weaker (and unable to prevail in conventional warfare), may have the ability to make demands on what would normally be a stronger adversary, thus resulting in a better outcome for this regional power (Powell, 2003).

The inner workings of such complicated interactions are somewhat difficult to see in the observable world. Usually, there are innumerable confounding variables that make it near impossible to isolate the true effects of the variable of interest, in this case the proliferation of nuclear weapons. For that reason, the controlled laboratory environment is a valuable, but until now unused, tool with which to delve into the dynamics of these intricate conditions and test the available theory. With this in mind, the goal of this paper if to propose a well defined laboratory experiment designed to test the above claims.

2) Background: A Case Study

In 1998, nuclear tests executed by both India and Pakistan changed the political climate in the region substantially. After the completion of these trials, and after concluding that Indo-Pakistani relations were improving, the Indian government chose to lower its military presence along both the Indo-Pakistani border as well as the Line of Control in Kashmir[1]. Then, in mid 1999, Pakistani forces crossed the Line of Control and met with Indian troops in a limited war ending in July of the same year. This conflict became known as the Kargil War (Ganguly, 2008).

Over the next two years, relations in south Asia remained tense under continuing Pakistani infiltration of Indian controlled Kashmir. Finally, attacks on Indian soil by Pakistani insurgents in late 2001 prompted the Indian government to begin mobilizing their military along the Indo-Pakistani border. This continued until mid 2002, when the standoff began declining under diplomatic pressure from multiple countries. In mid to late October, the conflict had ended (Ganguly, 2008).

These two conflicts sparked a debate centered on the effects of nuclear proliferation in south Asia between 1999 and 2002. On one side are those who believe that nuclear proliferation has had a militarily stabilizing effect (that is, that the newfound nuclear capacities of both India and Pakistan helped prevent war in South Asia). As an example, proliferation optimist Sumit Ganguly postulates that the availability of nuclear weapons in the area has contributed to regional stability and will continue to do so unless India can obtain and deploy effective antiballistic missile systems (Ganguly, 2008).

On the other side lie the proliferation pessimists (those who think that proliferation in South Asia has had a destabilizing effect). One such pessimist, S. Paul Kapur, maintains that Pakistani possession of nuclear weapons shielded them from all-out Indian retaliation near the turn of the century, thus encouraging aggressive behavior. Further, Kapur asserts that the resulting crises triggered destabilizing changes in India's conventional military strategy (Kapur, 2008).

The fact that this discussion is taking place is itself evidence of the difficulty of pinning down the exact role of nuclear proliferation. Of course, it is never easy to estimate the effect of one variable in such a complex environment. Again, the laboratory can solve that problem.

[1] The Line of Control is the cease fire line separating the Indian and Pakistani controlled parts of the disputed Kashmir region, an area just north of India, north-east of Pakistan, and west of China.

3) Questions to be Examined

There are a few questions that the proposed experiment will try to answer. The first (and most obvious) question follows from the title of the proposal: does nuclear proliferation deter conventional war? In this study, the proliferation of nuclear weapons is modeled by adding a brinkmanship addendum to a modified ultimatum game (described in section 7: The Experimental Model Explained). Though there are certainly instances in which the possession of nuclear weapons is one sided, this experiment is specifically designed to study a situation in which both participating parties have access to a nuclear arsenal (and further that both are able to retaliate if faced with a launch by an aggressor)[2]. The answer to this question could provide some scientific and behavioral evidence into whether nuclear weapons make the world more or less dangerous.

This experiment is also designed to answer another question: does a militarily weaker state become better off when there is a nuclear option? For the sake of this question, “better off” means to have acquired more resources (represented by tokens in this experiment. See section 7: The Experimental Model Explained). From another point of view, the answer to this question may lie in how generous the stronger party is when allocating a scarce resource in the same situation (this resource, again, is represented by tokens). Answering this question will provide some insight into whether or not the proliferation of nuclear weapons provides an effective bargaining chip for weaker countries that otherwise would have no chance of winning a conventional war.

The final question of this study deals with the chance that a nuclear war might occur given that it is a possibility. Namely, how often do two parties engage in brinkmanship (see section 5: Theory: Brinkmanship) when there is the option to deploy nuclear weapons. In other words: is there a large risk of nuclear war when that possibility is available?

[2] Some examples include India and Pakistan or the United States and the Soviet Union.

4) Theory: Conventional War

War in general is inefficient from an economic standpoint. Assuming that war carries with it some cost (a more than reasonable presumption), the same allocation of valuable resources results in a post-war world could have been reached without fighting, and without paying that cost. This argument only breaks down if fighting in and of itself is an activity that provides some utility as a consumer good (for example, it is enjoyable). The question, then, is this: why do countries engage in war knowing that a better outcome can be negotiated (Fearon, 1995)?

To answer this question, Fearon first proves that bargains strictly preferable to war do exist. To this end, he models a war situation as a modified ultimatum game of sorts. He gives the examples of two risk neutral parties splitting $100. If they agree on a division, each walks away with his or her fair share. If they cannot come to an agreement, they can each pay $20 to go to "war" in which each has a certain chance "p" of winning all $100. Thus, the expected payoff of war for a country is

$$EP(war) = p(\$100) + (1-p)(\$0) - \$20$$

In Fearon's example, he uses p = .5 so that the EP(war) for each party is $30. In this example, neither party should accept less than $30 while bargaining, but anything above that should be acceptable and represents a possible bargain that is better than war (Fearon, 1995)[3].

After creating this model and proving that war is an inefficient outcome, Fearon begins to formulate his answer to the above question. In short, there are two main situations in which war could rationally[4] occur: 1) there is private information and incentives to hide this private information or 2) countries cannot commit to a bargain because there are incentives to renege[5].

So what type of private information can lead to war? Fearon again uses his ultimatum model to conclude that private information about the costs or about the value of the prize can lead to conflict. To illustrate, imagine that state A knows state B's cost to fight and how much

---

[3] Fearon assumes that each state knows that some real "p" exists (whether they know the exact value or not), each state is risk neutral or risk averse, and that disputed issues can be bargained over (in other words, they are not indivisible issues) (Fearon, 1995).

[4] His paper is, after all, called "Rationalist Explanations for War".

[5] Fearon also describes a third possibility in which countries cannot bargain upon certain indivisible issues (issues that don't lend themselves to compromise). He gives the example of abortion. This is not included in detail here because Fearon himself is less convinced of this possibility (Fearon, 1995).

state B values the prize. State A can offer a division such that the allocation to state B just entices it to accept the offer and not opt for war. However, if state A is uncertain of state B's cost or valuation (or both), it is possible that state A makes an offer that pushes state B towards war (Fearon, 1995).

Still, since both states know that an efficient bargaining space exists, why can't a state just ask for the information it does not know? The reason is that there may be incentives to hide this information. For example, it is possible that lying about such private information (by playing down the cost or playing up the value of the stakes) makes a state appear more able to fight, thus increasing its chances of gaining a favorable bargaining resolution (Fearon, 1995).

Following from the above two paragraphs, private information and incentives to hide this information can lead to war. In addition, though, the inability to commit to a bargain due to a first-strike advantage (that is, an advantage to striking an opponent before the opponent strikes you) can also lead to conflict. Intuitively, a peaceful resolution can only exist if states do not have the incentive to strike first. This exists only when the benefits derived from a possible bargain outweigh the benefits derived from striking first. Going back to the example above, the benefits from striking first can be denoted

$$EP(\text{striking first}) = p(\$100) – \$20$$

where "p"[6] is the probability of winning the entire prize due to a first-strike advantage (Fearon, 1995).

For a bargain to be possible, a resolution "x" must exist that outweighs the benefit of striking first for both states. Thus,

$$x > p(\$100) – \$20.$$

The lower "p" is, the wider the possible bargain space[7]. However, as "p" grows (that is, as the first-strike advantage grows) the amount of efficient bargains dwindles. If "p" is high enough

[6] Note here that the "p" values for each state can add up to more than 1.
[7] Note that the bargaining space is the set of possible outcomes that gives an $x > p(\$100) - \$20$ for both states.

that the benefit from striking first is greater than any possible "x", then no bargain is possible and war is the only possible outcome (Fearon, 1995)[8].

[8] Fearon stresses that first-strike advantage likely plays a big part in narrowing the set of efficient bargains rather than eliminating it. In that way, first-strike advantage is better described as facilitating other problems (Fearon, 1995).

5) Theory: Brinkmanship

Nuclear deterrence theory, in short, refers to the notion that nuclear weapons can deter the outbreak of conventional war. But how is this possible? The basic idea is that the damage caused by an all out nuclear exchange between two countries (an exchange that may be born out of conventional war) is too great to risk such a conflict.

So can the threat to use unlimited nuclear force deter an opponent from attacking? From a strategic point of view, the answer to this question lies in another: what happens when one country fires nuclear warheads at another? Surely, the other country will do its best to retaliate in a similar fashion, inflicting a similarly high degree of damage. Thus, a state ensures its own destruction by being the first to engage in nuclear war[9]. In other words, the cost of launching a nuclear attack (assured destruction) is greater than the cost of not launching (Powell, 1987).

In this way, engaging in nuclear war is certainly not rational (and the threat of nuclear retaliation, not credible). So how can an irrational threat be any type of deterrent? The key to answering this question is in distinguishing the explicit threat of a nuclear strike from the threat of increasing the autonomous[10] risk of a nuclear strike. Even though the explicit threat of nuclear war may be incredible (that is, the likelihood of suffering massive damage from nuclear retaliation to a first strike is so great that actually launching is not in a state's best interest, thus making the threat of doing so unbelievable), nuclear deterrence can be credible "when there exists the possibility for any conventional conflict to escalate out of control. The threat is not a certainty but rather a probability of mutual destruction" (Nalebuff, 1987).

Where does this possibility of nuclear war come from? Essentially, this possibility stems from threats of nuclear war (or a nuclear strike) that leave something to chance (Schelling, 1960). Since these threats aren't certain to lead to nuclear war, the expected cost of making them is much smaller then actually carrying out an attack. Furthermore, if a state has something very valuable at stake in the crisis, the cost of giving in to its adversary may be greater than the expected cost of enacting a threat that increases the risk of a nuclear exchange. Furthermore, if a

[9] That is, as long as each the state being fired upon has secure second-strike capabilities and can fire back; an essential element of a mutually assured destruction (MAD) crisis according to Powell (Powell, 1987).

[10] Autonomous here is meant to indicate that the actual occurrence of a nuclear exchange is out of either involved party's control. This type of risk may stem from the possibility of something like a technical failure or unauthorized act and can be manipulated through actions such as limited demonstrations of power, imposing blockades, or committing troops (Powell, 1987).

state raises the risk of a nuclear exchange high enough, it may force its opponent to give in because continuing would be too risky (Powell, 1987).

In a situation of this sort, "relative military strength does not matter. Crises are no longer a contest of military strength but of resolve, where resolve is defined as a willingness to run the risk of an unlimited nuclear war" (Powell, 1987)[11]. Thus, the essence of the brinkmanship model of deterrence is that each state tries to coax the other into giving up by increasing the autonomous risk of disaster up to a point that the other state cannot bear (Powell, 1987).

Powell models this situation through an extensive form, sequential move game of imperfect information. In this game, the first player must choose whether to exploit a situation or not or to launch an all out nuclear strike. If the first player chooses to exploit, then the players take turns choosing to escalate the crisis, submit to the opposing player, or launch a nuclear strike. Each successive escalation increases the chances of nuclear war (the worst possible outcome) in which each state suffers massive damage. The imperfect information is modeled through a move by nature at the beginning of the game choosing player 2's type (either a player of high resolve or a player of low resolve). Player 1 does not know what nature chooses, but does know the probability of each type (Powell, 1987).

Powell's analysis of this game draws some interesting conclusions. First, while most analyses of a MAD crisis conclude that the state with the greatest resolve will win, Powell's does not. The presence of imperfect information in his model provokes the result that sometimes the state with the lesser resolve will, in fact, win a battle of brinkmanship by bluffing. Further, the state with the lower resolve is sometimes more likely to escalate a crisis when it faces an opponent of greater resolve (Powell, 1987).

[11] Powell goes on to explicitly define resolve and the concept of critical risk (the maximum risk that a state is willing to bear) in the context of his model of brinkmanship (Powell, 1987).

6) Origins of the Experimental Model

The experimental model developed in this proposal is essentially a combination of Fearon's modified ultimatum model of conventional conflict and Powell's brinkmanship model of imperfect information sprinkled with elements of an Indo-Pakistani type crisis. However, there are a few changes.

To explain, in Fearon's specification the two parties work together to divide the resource and to decide to go to war (Fearon, 1995). On the other hand, the model here incorporates the one sided allocation of a classic ultimatum game (only one player gets to choose how to divide the resource) and makes the decision to go to war sequential by allowing the receiving party to "reject" or "fight" the first player's offer before the first player decides whether to agree to "fight" or to "cede" the entire resource to the second player.

At that point, Fearon's specification is followed by assessing a cost of fighting to both parties[12] and allowing "nature" to choose (with known probability) who gets the resource by winning a conventional war. However, the probabilities, while known, are not equal in some cases. This inequality represents the unequal distribution of power that could be present in a conventional war (perhaps between Iraq and the United States or India and Pakistan).

The main treatment of this experiment is the addition of brinkmanship after the results of a conventional war have been determined. Though the type of brinkmanship used here is different that Powell's brinkmanship game it still remains true to the idea of escalating risk. Instead of players moving sequentially, they move simultaneously and bid a specific level of risk (the risk of a nuclear war)[13]. Powell's incomplete information was kept, however, by allowing nature to choose what type of opponent player 1 is facing. Player 1 only knows that there are two possible types and how likely it is that either type was chosen[14].

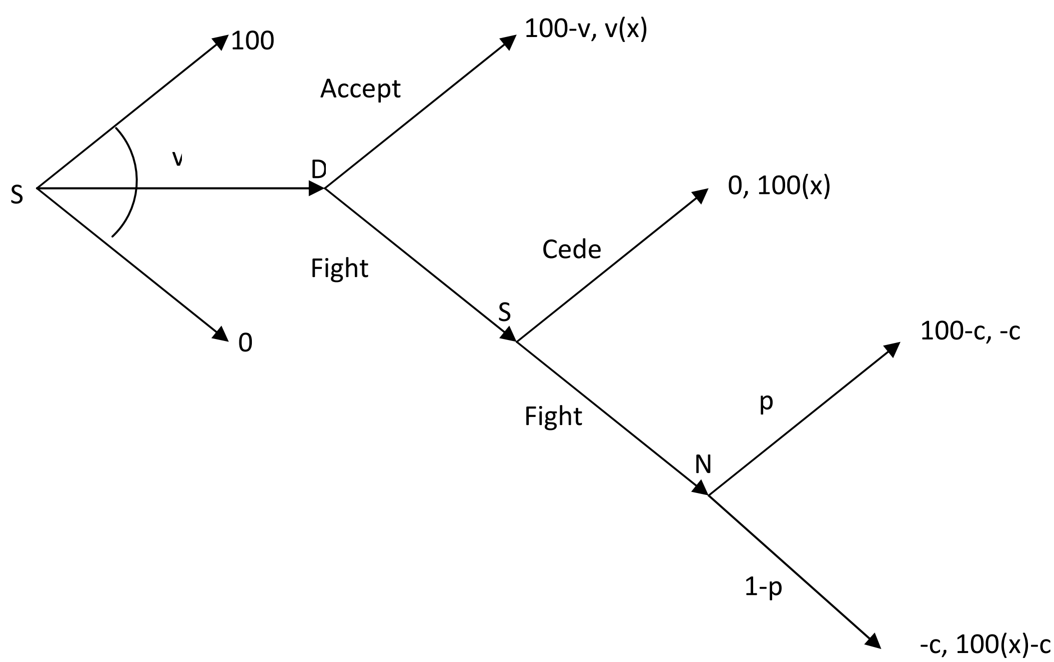
[12] In the model developed here, the cost is assessed from an endowment given to the players beforehand so that no player is forced to pay out of his or her pocket to participate in the experiment.
[13] Powell actually describes a brinkmanship model of this sort in another paper (Powell, 2003).
[14] This fits nicely with Fearon's description of conventional war, which sometimes arises from private information (Fearon, 1995).

7) The Experimental Model Explained

In an ordinary ultimatum game, one player is asked to divide a fixed resource between him or herself and another player. The other player can then accept the division (and both players keep what the first player offered) or reject the division, in which case neither player gets any payout. In this experiment, the simple (or at least seemingly simple) bargaining model is expanded upon.

The basic game here (referred to as the modified ultimatum game and presented in figure 1: Modified Ultimatum Game) differs in a few ways from the ordinary ultimatum game. First, each player is given an endowment of tokens (player 1 has an endowment of 400 tokens and player 2 has one of 100 tokens).

Figure 1: Modified Ultimatum Game[15]



Each token has a set dollar value[16]. These unequal endowments are meant to represent the possible unequal resource allocation that may occur in the real world. This also helps to define each player's role: the satisfied player is player 1 and the dissatisfied player is player 2.

[15] This game is one of incomplete information. The value of "x" varies as specified in section 7: The Experimental Model Explained.
[16] The value of each token should be determined by the experimenter.

The first move of the game is made by player 1 (known as the subject in role 1) who proposes a division of 100 special-tokens representing an existing resource desirable to both parties. These tokens are equal to one regular token for player 1, but take different values for player 2. The value of a special-token for player 2 is "x" and can take the values of .5 or 2 with equal probability. Player 2 knows the valuation of the special-tokens for both him or herself and for player 1. Player 1, however, only knows his or her value and the probability distribution of values of the special-tokens for player 2.

The reason for this uncertainty is alluded to in section 4: Theory: Conventional War and section 5: Theory: Brinkmanship. In short, game theoretic models "have generally viewed crises and escalation as a bargaining process in which uncertainty and the lack of complete information play an essential role" (Powell, 1987). Essentially, if there is no uncertainty, the player in the offering position simply offers the lowest amount that the other player will accept, thus making sure there is no conflict (unless Fearon's bargaining space is nonexistent (Fearon, 1995)). In the interest of making this experiment interesting (and somewhat realistic while preserving the necessary experimental simplicity), the model incorporates one-sided imperfect information[17].

After learning what player 1 has offered, player 2 is then able to "accept" or reject and "fight" that offer. Acceptance by player 2 means that the game is over and both players earn their respective endowments plus the appropriate amount of special-tokens. Rejection means that it is again player 2's turn to make a move.

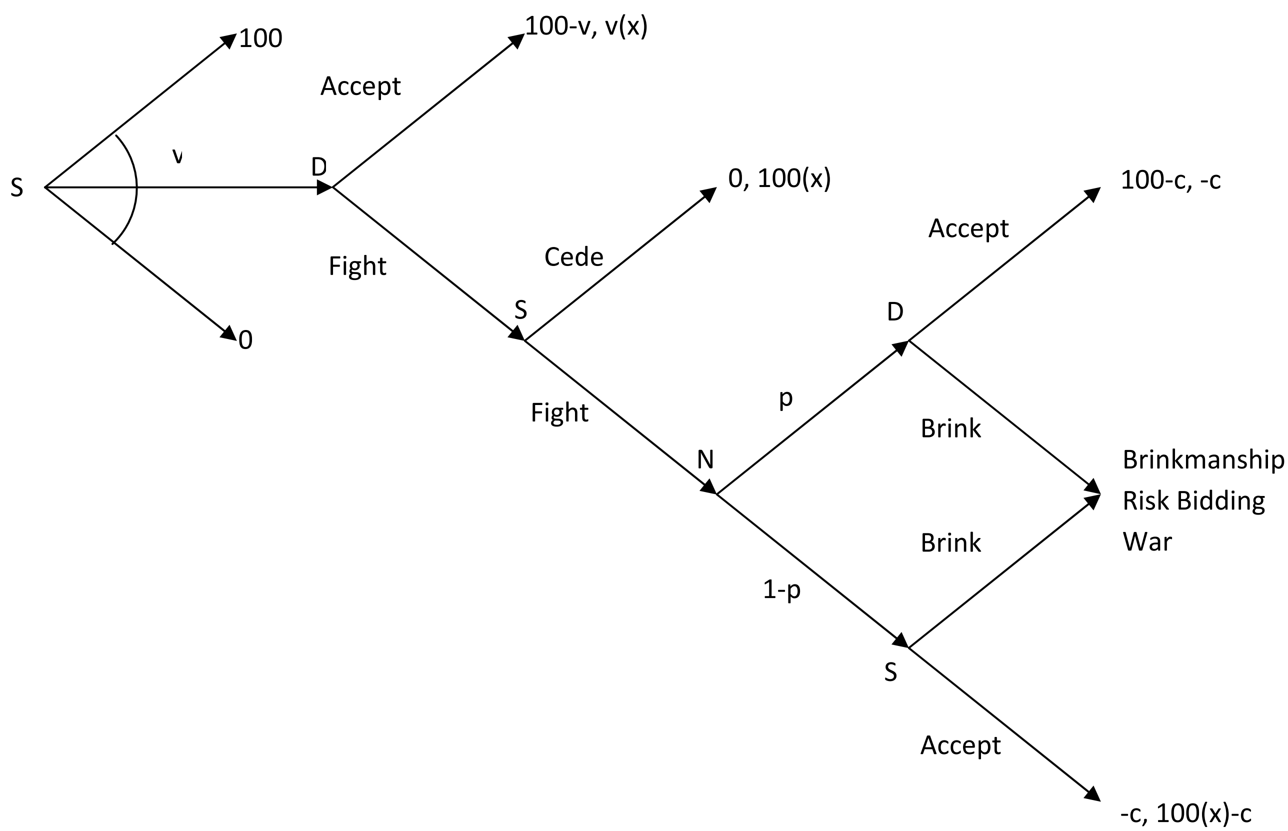
This time, after presumably learning something about player 2's valuation of the special-tokens, player 1 is able to make one of two different moves: "cede" all special-tokens to player 2 or "fight" with player 2 over the entirety of special-tokens. If player 1 "cedes", the game is over and player 1 earns his or her endowment while player 2 earns the endowment plus all 100 special-tokens. This option would potentially allow player 1 to avoid losing part of his or her endowment either through the cost of fighting "c" or through a risk bidding war (the brinkmanship element described below) in which there is a chance for player 1 to lose a significant part of the endowment.

If player 1 decides to fight with player 2 at this stage, nature "N" chooses who wins the 100 special-tokens with certain known probabilities and also assesses a "c" token fee (the cost of fighting is 10 tokens in this study) from each player's endowment. This computer automated

[17] Thus, the equilibria in this model are not so simple.

move represents a conventional war in the two country example. The probabilities denote the balance of power between the two parties (in the example of a battle between two countries, this probability is the chance of winning a conventional war). The probability that player 1 wins is denoted "p" while the probability that player 2 wins is "1-p". "P" can take on the values of .5 or .8 to denote either a balanced power distribution or an unequal power distribution[18].

Modified Ultimatum Game with a Brinkmanship Addendum[19]



In the modified ultimatum game, after the computer chooses the winner of the 100 special-tokens, the game is over. The winner earns his or her endowment (minus the "c" token

[18] A balanced power distribution might represent the USA, USSR rivalry during the Cold War. An unequal distribution could represent the more modern Indo-Pakistani situation described in section 2: Background: A Case Study. The balanced distribution could also serve as a control against which to test whether the balance of power actually matters in determining the outcome.

[19] This game is one of incomplete information. The value of "x" varies as specified in section 7: The Experimental Model Explained.

fee) plus the 100 special-tokens. The other player earns only his or her endowment (minus the "c" token fee).

However, not all interactions will take place under the rules of the modified ultimatum game during this study. Some pairs will play under the rules of the modified ultimatum game with a brinkmanship addendum (see figure 2: Modified Ultimatum Game with a Brinkmanship Addendum). This game will progress exactly like the game described above. However, if the game reaches the point at which the computer decides who receives the 100 special-tokens, it does not end.

Instead, at this point it is up to the loser of the conventional war (that is to say, the player to whom the computer did not give the 100 special-tokens) to make a move. He or she is allowed to either "accept" the outcome or go "brink" by engaging in a risk bidding war (brinkmanship) with the other player. If the losing player chooses to "accept" the outcome, the payoffs are exactly the same as after a "conventional war" in the modified ultimatum game. However, if the losing player chooses the brinkmanship option, both players must make a risk bid "R" for the prize.

Each player's bid represents the chance that the 100 special-tokens will be given to neither player and that 100 tokens from each endowment will be destroyed (in the two country example, this outcome represents a nuclear war in which the resource that was available is destroyed and each country sustains significant damage). Each player's bid can be any integer from 0 up to 100 (meaning 0% chance to 100% chance). The player who bids the highest wins all 100 special-tokens (plus the endowment minus the "c" token fee) with a probability of 100% minus that player's bid. With the same probability, the other player earns only his or her endowment minus "c" tokens. If the computer chooses to destroy the 100 special-tokens (it does so with probability equal to the highest bid) then neither player earns the 100 special-tokens and each player's endowment is reduced by 100 tokens.

For example, if player 1 bids 40 and player 2 bids 47, then the computer destroys the resource with probability equal to 47%. With probability equal to 53%, player 2 wins the 100 special-tokens and earns his or her endowment minus "c" tokens and player 1 earns only his or her endowment minus "c" tokens.

If the players bid the same amount of risk, then that is the chance that all tokens will be repossessed. 100% minus that bid is the chance that each player will get half of the special-tokens and be assessed the 10 token fee.

8) Treatments

The model described in section 7: The Experimental Model Explained results in quite a few different specifications of the game in this study. These different treatments are determined by the exogenous variables that can take on different values (the specific combination of these variables in any given trial is determined by chance). Though this study only[20] has eight possible game specifications, it would be possible for an experimenter to vary other variables as well[21].

The exogenous variables that can take on different values are "p", "x", and "brink" (whether or not there is a brinkmanship addendum). Since each of these variables can take on two values, there are eight specifications as follows:

1) P=.5, x=.5, without addendum
2) P=.5, x=.5, with addendum
3) P=.5, x=2, without addendum
4) P=.5, x=2, with addendum
5) P=.8, x=.5, without addendum
6) P=.8, x=.5, with addendum
7) P=.8, x=2, without addendum
8) P=.8, x=2, with addendum

The results of each different specification will be compared to one another in order to draw conclusions. See section 13: Statistical Presentation for details.

[20] The word "only" makes it seem like eight is a small number of specifications. However, having so many combinations of variables may make the game, as specified here, rather expensive to run due to the need for a lot of data, a lot of trials, and a lot of subjects. It is certainly possible to reduce the number of specifications by keeping one or more of the changing variables constant. For this proposal, though, the price of the experiment was not taken into account.

[21] For example, the size of the endowments.

9) Theoretical Equilibria

The theoretical equilibria in the two specifications of the modified ultimatum game (that is, the modified ultimatum games with one sided imperfect information that take "p" = .8 and "p" =.5) are relatively simple to find and are outlined below[22]. Note that "c" always equals 10 tokens and that "x" varies between .5 and 2 in with equal probability. Further, risk neutrality is assumed (a player is indifferent between a lottery with an expected payoff "EP" equal to "z" and a payoff of "z" for sure). Finally, it is assumed that when a player is indifferent between two options, he or she mixes with probability equal to .5.

The steps used in finding the equilibria are described below in order. The equilibria themselves follow. "EP(-)" denotes the expected payoff to the specified player from taking (-) action.

1) Modified Ultimatum Game in which "p" = .8
    a. Will S ever play "cede"?
        i. No: EP(cede) = 0 < EP(fight) = p(100 – c) + (1-p)(-c) = 70.
    b. What will $D_{x=.5}$ play?
        i. EP(accept) = v(x)
        ii. EP(fight) = p(-c) + (1-p)(100x – c) = 0
        iii. Conclusion: If v(x) > 0 then $D_{x=.5}$ plays "accept"
            1. If v > 0 then $D_{x=.5}$ plays "accept"
        iv. Conclusion: If v(x) = 0 then $D_{x=.5}$ is indifferent between "accept" and "fight"
            1. If v = 0 then $D_{x=.5}$ is indifferent between "accept" and "fight"
    c. What will $D_{x=2}$ play?
        i. EP(accept) = v(x)
        ii. EP(fight) = p(-c) + (1-p)(100x – c) = 30
        iii. Conclusion: If v(x) > 30 then $D_{x=2}$ plays "accept"
            1. If v > 15 then $D_{x=2}$ plays "accept"
        iv. Conclusion: If v(x) = 30 then $D_{x=2}$ is indifferent between "accept" and "fight"

[22] The equilibria of the modified ultimatum games with brinkmanship addenda, on the other hand, are rather complicated to solve. They likely involve mixing over quite a few strategies. However, this experiment's main interest is empirical rather than theoretical, so this is not a big problem.

1. If v = 15 then $D_{x=2}$ is indifferent between "accept" and "fight"

v. Conclusion: If v(x) < 30 then $D_{x=2}$ plays "fight"

1. If v < 15 then $D_{x=2}$ plays "fight"

d. Knowing the above, what will S offer to maximize the EP given that he or she faces each type of D with equal probability?

i. EP(v = 0) = [1/2][(1/2)(100) + (1/2)(70)] + [1/2][70] = 77.5

ii. EP(1 ≤ v ≤ 14) = (1/2)(70) + (1/2)(100 – v)

1. Thus, max EP(v = 1) = 84.5

iii. EP(v = 15) = [1/2][85] + [1/2][(1/2)(85) + (1/2)(70)] = 81.5

iv. EP(v ≥ 16) = 100 – v

1. Thus, max EP(v=16) = 84

v. Conclusion: S offers v = 1 to maximize EP

e. The equilibrium

i. S offers v = 1

ii. $D_{x=.5}$ plays "accept" if v > 0 and is indifferent between "accept" and "fight" if v = 0

iii. $D_{x=2}$ plays "accept" if v > 15, is indifferent between "accept" and "fight" if v = 15, and "fight" if v < 15

iv. S fights

2) Modified Ultimatum Game in which "p" = .5

a. In a similar manner as above, the equilibrium can be shown to be

i. S offers v = 31

ii. $D_{x=.5}$ plays "accept" if v > 30, is indifferent between "accept" and "fight" if v = 30, and "fight" if v < 30

iii. $D_{x=2}$ plays "accept" if v > 45, is indifferent between "accept" and "fight" if v = 45, and "fight" if v < 45

iv. S fights

10) Experimental Design Considerations

The experimental design outlined in this proposal was constructed with some specific issues in mind in order to make the results as robust as possible.

First, the instructions and prompts are written in very neutral language. Each word was chosen in an attempt to render what the subject reads during the experiment null as far as influencing the subject's decision or perception about what the experiment is trying to test. In Friedman and Sunder's opinion, loaded words should be avoided in order to promote dominance (in essence, dominance occurs when the primary change in a subject's realized utility comes from the reward rather than any other influence) (Friedman and Sunder, 1994).

As an example, the word "subject," sometimes accompanied by the role designation, is always used when referring to a participant. It would have been easy to replace this term with the word "player" (or worse "satisfied player" or "dissatisfied player") but this type of terminology could certainly influence the subjects if it conjures up certain previous experiences or incites certain emotions. A neutral term[23] like "subject" helps to avoid this. Similar consideration was taken in using the phrases "him or herself," "his or her," etc.; labeling actions that subjects can make in a neutral manner (like "A" and "B" instead of "accept" and "fight"); not using the word "risk"; and not associating the interaction with any sort of real world scenario (it is simply an "interaction").

Second, no subject ever knows with which other subject he or she is participating. As Camerer puts it, if the subjects know who they are interacting with, "they might like the way the person looks and want to make them happy, or fear retribution or embarrassment if they make a stingy offer and see the person after the experiment" (Camerer, 2003). This type of anonymity helps make sure that the subjects are acting based only on their strategic responses to their partners.

If the experimenter wants to take the first two considerations a step further, the subjects should sit at separate and privately partitioned computer workstations and should be told not to make any type of sound (which is easy enough to accomplish by making a public announcement before beginning the session like the one presented in appendix 3: Pre-Trial and Post-Trial Instructions). Since the sight of certain facial expressions or sounds of joy or sadness could influence a subject's mood, it would be best to avoid them.

---

[23] Though the word "subject" could be a cognitive cue, it is more neutral than the other terms.

Third, the possibility of a subject building some sort of reputation should be "avoided by having subjects play with each other only once in an experimental session" (Camerer, 2003). In order to accomplish this, the study randomly splits the subjects into two groups immediately after they have all signed in at their workstations. No subject will ever interact with a subject in his or her group. Further, subjects in a group will never interact with a subject from the other group more than once. To clarify, for the first interaction of the session, each subject will be paired with a subject from the other group. When the first interaction has been completed by all subject pairs, each subject will be randomly matched with a different subject from the other group (that is, not the subject that he or she just interacted with) and so on with subsequent trials[24].

There is also a design known as the "no-contagion" design which seems to go a step further in making reputation building impossible. In this design two subjects are never rematched and a subject is never matched with a subject that interacts with a subject that the first subject will later be matched with, and so on (Camerer, 2003). This design actually takes a step away from random matching because after the first round of interactions, there are limited paths for a subject to take to satisfy "no-contagion" (thus after a few rounds, the exact path will be determined for the rest of the game). Though again, the subjects never know who they are matched with so this element of certainty probably doesn't matter.

Randomness must also be discussed concerning the different game specifications (there are eight of them specified in section 8: Treatments). All subjects participating in the same experimental session will play under the same rules for each trial during a session[25]. The specification will be randomly selected at the beginning of the session. This will ensure that after a large number of sessions the subject populations playing under each specification are similar. In the interest of money, it may be advisable to run each of the many sessions with a small number of subjects.

Fourth, the subjects in this study are paid and the payment structure was designed in a way that allows for imperfect information and the controlling of wealth effects. But first, why is

[24] Though Camerer suspects that this design does not reduced the possibility of reputation building, it appears to be the most logical design and is the most commonly used protocol (Camerer, 2003).

[25] A problem may occur here because "x" is not being varied during the session. However, since player 1 never knows which type of player 2 he or she is playing against, this shouldn't be a problem. Keeping "x" constant during a session also avoids the possibility of player 2 changing strategies simply because there was a change in "x". If the experimenter does not agree with this reasoning, the solution is simple: perform only one round of trials per experimental session.

it important to pay subjects? According to Camerer, "by inducing value using money payments, the experimenter need rely only on the assumptions that everybody likes having more money and nobody gets tired of having more of it" instead of other assumed motivators like "having their name posted if they did best" (Camerer, 2003). The tokens in this experiment have a specific dollar value, which helps focus the subjects (because they are "competing" for something of real value) as well as reduce the likelihood that a subject will simply try to treat the interaction as a game by trying strategies that he or she would not use in a situation in which something valuable was at stake. Of course, it may be the case with certain subjects that a few dollars per hour is not very valuable. To address that problem, it is probably good to use student subjects for this experiment because as Friedman and Sunder point out, there is a "low opportunity cost of student subjects" (Friedman and Sunder, 1994).

The tokens used as the medium of reward also allow for the imperfect information component of this experiment. Since the special-tokens are worth varying amounts of regular tokens for player 2, and player 1 does not know which valuation has been assigned to player 2[26], the uncertainty that is necessary for a crisis exists (see section 4: Theory: Conventional War and section 5: Theory: Brinkmanship for more discussion). This type of uncertainty would be difficult to create with direct monetary awards (or other direct awards of intrinsic value).

Wealth effects (the difference in behavior caused by the accumulation or loss of wealth) are also avoided by paying subjects from the results of one trial only (Friedman and Sunder, 1994). In this experiment, a subject will play the game multiple times during an experimental session. However, if the subjects were paid for each trial, it would be possible for some subjects to accumulate lots of tokens while others do not. This might cause changes in behavior (perhaps changes in risk preferences, giving up, etc.) that could confound the results. Thus, it is necessary that the subjects only be paid for one trial. Furthermore, the trial for which they are paid must be randomly chosen after all trials have been completed so that no subject knows which trial he or she will be paid for.

The token method could have also been used to control for risk tastes by creating a two stage lottery in this experiment. Instead of specifying dollar values for the tickets, a design meant to induce risk neutrality would essentially map the amount of tokens a subject earns into lottery tickets that would each represent one chance to win a valuable prize at the end of the experiment.

[26] Player 1 does know the distribution of possible values, though.

However, “there is little evidence that the binary lottery procedure works as it should in theory” (Camerer, 2003).

Fifth, this experiment uses the between-subjects design. Because of this, there is no need to consider order effects (each subject participates in only one type of specification and in only one role so there is no order of treatments to vary.) The between-subjects design controls the possibility that a subject is influenced in one round to think differently simply because the specification was different in a previous round (for example, a subject who participated within one of the modified ultimatum games might think that he or she should act differently if now playing under one of the games with a brinkmanship addendum simply because the specification is different). This hypothesis could be tested, as Camerer asserts, by comparing results from a between-subjects design (the design of the experiment outlined here) with a design that allows for subjects to act as their own control (and play under different specifications), called a within-subjects design (Camerer, 2003).

If an experimenter had the desire to test the above reasoning in this experimental setting, all that would be needed is to relax the restriction that a subject can only play in one role. In this way, certain subjects would end up participating in both roles 1 and 2. The experimenter would need to decide what type of procedure to use in order to determine which subjects do participate in both roles, but simple random chance would likely yield at least a few data points of this nature. Allowing subjects to participate in both roles, however, also forces the experimenter to deal with the problem of order effects (in other words, participating in role 1 before role 2 may cause different results from role 2 before role 1 and the experimenter must take that into account) (Camerer, 2003).

Finally, subjects should not be told how many trials they will participate in and should not be told when they are interacting for the last time. If subjects know that they are on the last round, this may be reason to change behavior. If an ending time has been given, it may be necessary to end a bit early to avoid this same problem (Friedman and Sunder, 1994).

11) Experimental Chronology

The exact procedure of the experiment is as follows:

1) The subjects arrive at the lab.
2) When the experiment has been set up in the lab, the subjects are invited in and asked to sit at one of the computers that have been set up for the experiment.
    a. There must be an even number of subjects at each experimental session.
3) Each subject is handed a subject id number and a consent form[27].
    a. Of course, no two subjects should have the same id number.
    b. The subjects should be asked not to start until told to do so by the experimenter or lab assistant running the session.
4) Once all consent forms have been read, signed, and collected, the experimenter or lab assistant running the session should read the short pre-trial instructions contained in appendix 3: Pre-Trial and Post-Trial Instructions.
5) After the instructions are read, the subjects enter their id numbers and begin the experiment (see appendix 1: Instructions and Prompts).
6) When the experimental session has ended, the experimenter or lab assistant should read the post-trial instructions in appendix 3: Pre-Trial and Post-Trial Instructions.
7) The subjects should then be paid for the results of the pre-specified trial for which they are being rewarded.
8) After payment, the subjects can leave and the lab should be prepared for the next experimental session.

[27] Any experiment that uses human subjects must be approved by the CPHS. Requisite for approval is that each subject must sign a consent form before participating in a study.

12) Suggested Data Collection

This experiment will provide a multitude of data for study. Though there are perhaps many ways in which to collect and organize the results, one logical method is to create a chronological description of each interaction. In other words, the data should be able to completely summarize the events of each individual trial.

With this goal in mind, it is easy to create a spreadsheet with which to collect such data[28]. This spreadsheet should describe each trial by placing each subject in a pair in subsequent rows and displaying the following parameters (the following is a key and description of the data called for in Appendix 2: Data Spreadsheet):

1) Trial: This refers to the trial number. It should take the value of the trial number from 1 for the first trial in the first experimental session to n for the last trial of the last experimental session.
2) ID: This refers to the participant ID number used to track that participant's actions.
3) Role: This refers to the role that the particular subject participates in. It can take the values of 1 or 2 depending on the role of the subject.
4) Specs: This refers to the specific game specification. This experiment is specified in the spreadsheet in three different dimensions: "p", "x", and "brink" (in that order). "P" can take the values of .5 or .8 (this corresponds to the distribution of power described in section 7: The Experimental Model Explained). "X" can take the values .5 or 2 corresponding to how many regular tokens a special-token is worth to the subject in role 2 (see section 7: The Experimental Model Explained). "Brink" can take the values of "y" (meaning that the game included the brinkmanship addendum) or "n" (meaning that the game did not include the brinkmanship addendum).Thus, for modified ultimatum game with "p" equal to .5 and "x" equal to .5, "specs" takes the value of (.5, .5, n).
5) Offer: This refers to the division of the special-tokens that the subject in role one offers to the other subject. "Offer" takes the value (100-v, v) ("100-v" corresponds to the portion of the 100 special-tokens allocated to the subject in role 1, while "v" corresponds to the portion allocated to the other subject). For example, if the subject in role 1 offers "v" equal to 30, "offer" takes the value (70, 30).

[28] See Appendix 3: Data Spreadsheet for an example.

6) Response: This refers to the subject in role 2's response to the offer. It can take the values of "a" (when this subject "accepts" the offer) or "f" (when this subject "fights" the offer).
7) 2nd Response: This refers to the subject in role 1's response if the subject in role 2 decides to "fight" the offer. It can take the values of "na" (if the game does not reach this point), "c" (if this subject "cedes" all 100 special-tokens to the other subject), or "f" (if this subject agrees to "fight").
8) Allocation: This refers to whom the 100 special-tokens are given to in the event of both subjects agreeing to fight. It can take the values of "na" (if the game does not reach this point), "1" (if the subject in role 1 is given the special-tokens), or "2" (if the subject in role 2 is given the special-tokens).
9) 3rd Response: This refers to the response of the player who is not given the 100 special-tokens in the modified ultimatum game with a brinkmanship addendum. It can take the values of "na" (if the game does not reach this point), "a" (if the acting subject "accepts" the outcome of the fight), or "b" (if the acting subject chooses to engage in brinkmanship).
10) Bid: This refers to the bid of this player in the event of a brinkmanship risk bidding war. It can take the values of "na" (if the game does not reach this point) or the value of this player's bid from 0 to 100.
11) Outcome: This refers to the outcome of the brinkmanship risk-bidding war. The outcome is specified on two different dimensions: "low or high" and "win, loss, or destroyed". If the game does reach this point, "outcome" takes the value "na". The dimension "low or high" can take the values of "l" (if this subject's bid was lower than the other subject's bid) or "h" (if this subject's bid was higher than the other subject's bid). The dimension "win, loss, or destroyed" can take the values "w" (if this subject has the high bid and receives all special-tokens in addition to his or her endowment from the risk bidding war), "l" (if this subject has the low bid and receives only his or her endowment), or "d" (if all 100 special-tokens are destroyed and each subject suffers a loss to his or her endowment). As an example, if this subject makes a lower bid than the other subject and the other subject wins all the special-tokens, "outcome" takes the value "l, l".
12) Tokens: This refers to the total amount of tokens that this subject earns this round. It should take the value of the number of tokens earned from both the 100 special-tokens

and the subject's endowment. For example, if this subject is playing in role 1 and wins the risk bidding war, "tokens" will take the value 490 (400 tokens from the endowment, minus a 10 token cost of fighting, plus 100 special-tokens that are worth one regular token each).

13) Earn: This refers to the total dollar amount earned by this subject. It should take the value of the amount of tokens earned times the value of each token (the value of each token is up to the experimenter). Thus, if the subject earns 490 tokens and each token is worth $0.05, "earn" takes the value of 24.5 (this value is in dollars).

13) Statistical Presentation

In analyzing any set of data (whether happenstance or experimental), there are two phases. The first is a qualitative phase that describes the data with summary statistics and graphs. The second is more quantitative and is meant to answer specific questions using statistical techniques (Friedman and Sunder, 1994).

This section is meant to give a few ideas as to how the data of this experiment can be presented so as to answer the questions given in section 3: Questions to be Examined. Further, this section also gives examples of possible statistical calculations that can be made to answer the questions[29].

The initial question is quite simple: does the spread of nuclear weapons deter conventional war? In the model presented in this paper (see section 7: The Experimental Model Explained) the state of "conventional war" occurs when both players agree that the computer should decide the outcome (both choose "fight") with probability "p" that player 1 wins the 100 special-tokens and probability "1-p" that player 2 wins. The answer to this question can be represented graphically with a bar chart that displays the percentage of interactions that went to conventional war conditioned on the different specifications (see appendix 4: Qualitative Presentation-Chart 1 for an example). Note that the specifications are written in the same format as specified in section 12: Suggested Data Collection.

Imagine a comparison between the modified ultimatum game and the modified ultimatum game with a brinkmanship addendum for the specifications "p" = .8 and "x" = .5. Namely, say 50% of 100 interactions in the former resulted in "war" and only 40% of 100 interactions in the latter. The null hypothesis is that the difference in the two percentages is equal while the alternative is that the percentage of interactions resulting in "war" without the brinkmanship addendum is larger than the percentage without it.

1) Null: the difference in the percentage of interactions resulting in "war" in the game without brinkmanship is the same as in the game with brinkmanship.
2) Alternative: the difference in the percentage of interactions resulting in "war" in the game without brinkmanship is greater than the percentage in the game with brinkmanship.

[29] The graphs described here (and shown in appendix 4: Qualitative Presentation) are only meant to present some possible ways to present the data. The same goes for the statistical analysis.

First, the z-stat must be constructed. The difference in the sample percentages is 10%. The standard error for the percent of interactions that resulted in "war" from the modified ultimatum game is

$$\text{SE(percent of interactions)} = \{[\sqrt{(100)} \text{ x } \sqrt{(.5 \text{ x } .5)}] / 100\} \text{ x } 100\% = 5\%$$

The parallel standard error for the game with a brinkmanship addendum is

$$\text{SE(percent of interactions)} = \{[\sqrt{(100)} \text{ x } \sqrt{(.4 \text{ x } .6)}] / 100\} \text{ x } 100\% \approx 4.9\%$$

Thus, the standard error for the difference of these two values is

$$\text{SE(difference in percentages)} = \sqrt{(5^2 + 4.9^2)} = 7\%.$$

It follows that the z-stat for the difference in the two percentages is

$$\text{z-stat} = (10\% - 0\%) / 7\% \approx 1.43.$$

The normal table gives a p-value of 7.6% and the null (that the percentages are the same) cannot be rejected at 5% significance. The other three specifications (using other combinations of "p" and "x") can be compared in the same way.

The second question is whether or not a militarily weaker state becomes better off when there is the possibility of nuclear war. As a reminder, the weaker state in this experiment is one whose chance of winning a conventional war is .2. To gain some descriptive insight into the results of this experiment, a bar chart can be used. This time, however, the bar chart can display the average payoff to player 2 conditioned on the specifications. Here a comparison between the different values of "p" (while holding the other two treatment variables constant) can give a visual picture of whether or not the balance of power plays a role in determining the payoff of player 2. See appendix 4: Qualitative Presentation- Chart 2 for an example.

To answer this question more quantitatively, a z-stat very similar to the one used above can be used. This time however, it is the difference in averages that is being examined rather than the difference in percentages.

Imagine that this experiment has yielded an average payoff of 120 tokens (with a standard deviation of 9 tokens) for player 2 in 100 trials of the modified ultimatum game with "p" = .8 (it must or else both players are militarily equal) and "x" = .5. In 100 trials of the brinkmanship addendum game of the same specifications, the average payoff is 130 tokens (with a standard deviation of 16 tokens) for player 2. Is this difference due to chance? The null hypothesis here is that the average payoff is the same for both specifications while the alternative is that the latter specification yields a larger proportion for the weaker player.

1) Null: the difference in the average payoff to player 2 is the same in the games with and without brinkmanship.
2) Alternative: the average payoff to player 2 is larger in the game with brinkmanship than the game without it.

The observed difference in the average is 10 tokens. The standard error for the average in the modified ultimatum game is

$$\text{SE(average payoff)} = [\sqrt{(100)} \times 9] / 100 = .9$$

The standard error for the game with brinkmanship is

$$\text{SE(average payoff)} = [\sqrt{(100)} \times 16] / 100 = 1.6$$

It follows that the standard error for the difference is

$$\text{SE(difference in average payoff)} = \sqrt{(.9^2 + 1.6^2)} \approx 1.84.$$

The z-stat, then, is

$$\text{z-stat} = (10 \text{ tokens} - 0 \text{ tokens}) / 1.84 \text{ tokens} \approx 5.45$$

The normal table gives a p-value of about 0 and the null (that the averages are the same) can be rejected at 5% significance. The other specifications involving "x" = 2 can be compared similarly.

As noted in section 3: Questions to be Examined, another way to determine whether a weaker state is better off is the allocation of the 100 special-tokens by player 1. Here, the same bar chart used to display the data for question 2 works by replacing "Average Payoff to Player 2" with "Average Offer by Player 1". The average offer will be the average "v" (the amount of special-tokens offered to player 2) under each specification. Chart 3 in appendix 4: Qualitative Presentation has an example[30].

The statistical test here is the same as in the second question as well. The only difference is that the average payoff to player 2 is replaced by the average offer to player 2.

The final goal of this study is to evaluate how often two parties will resort to nuclear brinkmanship when there is that option. Again, a bar chart of the type used for the first question easily displays this information. This time, only the data from the games in which there is the possibility of brinkmanship need to be used. This type of display also makes it easy to compare the effects of the different treatments. An example is given in appendix 4: Qualitative Presentation- Chart 4.

The same statistical test can be used to answer this question as can be used to answer the first question. The only difference here is that only the different specifications of the modified ultimatum game with a brinkmanship addendum can be compared (because they are the only specifications that allow the possibility of brinkmanship). The percentage being tested here is the percentage of interactions that result in brinkmanship.

[30] A chart similar to that used to analyze the first and fourth questions might also be helpful here.

14) References

Camerer, Colin F. 2003. Behavioral Game Theory. Princeton, NJ: Princeton University Press.

Fearon, James D. 1995. Rationalist Explanations for War. *International Organization*, 49, 379-414.

Friedman, Daniel and Shyam Sunder. 1994. Experimental Methods: A primer for economists. Cambridge, U.K.: Cambridge University Press.

Ganguly, Sumit. 2008. Nuclear Stability in South Asia. *International Security*, 33, 45-70.

Kapur, S. Paul. 2008. Ten Years of Instability in a Nuclear South Asia. *International Security*, 33, 71-94.

Nalebuff, Barry. 1987. Brinkmanship and Nuclear Deterrence: The Neutrality of Escalation. *Conflict Management and Peace Science*, 9, 19-30.

Powell, Robert. 1987. Crisis Bargaining, Escalation, and MAD. *The American Political Science Review*, 81, 717-735.

---. 2003. Nuclear Deterrence Theory, Nuclear Proliferation, and National Missile Defense. *International Security*, 27, 86-118.

Schelling, Thomas C. 1960. The Strategy of Conflict. Cambridge, MA: Harvard University Press.

Waltz, Kenneth Neal. 1981. The Spread of Nuclear Weapons: More May Be Better. London, UK: International Institute for Strategic Studies.

Appendices

Appendix 1
Instructions and Prompts

After taking a seat at their computers, but before seeing these instructions:

1) Each subject must sign in to their computer workstation by entering their randomly distributed subject id number.
2) Every session will be governed by the same randomly selected specification (there are eight specifications described in section 6: Treatments). The specification can be selected any time before the start of the session.
3) The subjects are divided randomly and unknowingly into two groups of the same number of subjects each.
4) One group is assigned to participate in role 1 and the other in role 2
5) Each subject in each group is randomly paired with a subject in the other group (see section 7: Experimental Design Considerations for the pairing procedure).
6) Each trial is assigned a trial number starting from 1 for the first trial of the first experimental session to "N" for the last trial of the last experimental session.
7) The experimenter must choose for which round subjects will be paid (see section 7: Experimental Design Considerations).
8) The experimenter must choose how many rounds the subjects will play, but should not give the subjects this information (see section 7: Experimental Design Considerations).

Every pair must complete their interaction before the pairs are chosen for the subsequent round. When a new round starts, each subject begins by seeing the first interaction prompt.

When a subject clicks "next" at the end of the last round, the next screen is: The study has concluded. Please stay seated while your payments are being prepared. Thank you for your participation!

Pre-interaction instructions for all subjects participating in a modified ultimatum game specification:

Ultimatum Instructions 1: Please enter your randomly distributed subject id number into the box below and click "next."

Subject id [ ]

[Next]

*After clicking next, the screen should remain blank until all subjects have entered their subject id number and clicked "next."

When all subjects have entered their ids and clicked "next," then UI2: Hello and welcome! Thank you for choosing to participate in this experiment designed to study strategic interaction.

[Next]

UI3: During today's session, you will be paired with multiple other subjects. However, you will only be paired with one other subject at any given time. You will interact with this subject exclusively until you complete the entire interaction. Then you will be randomly paired with another subject.

Next

UI4: Within each pair, one of you will participate in role 1 and the other in role 2. Roles 1 and 2 are different in 2 ways:

1) The order in which the subject in each role gets to choose his or her action and
2) The options that each subject has to choose from when determining how to act with the other subject.

Next

UI5: During the entire experiment today, you have been assigned to participate in role "N0". The subject you are paired with will participate in role "N1"[31].

Next

UI6: Please pay careful attention to the next few screens because they will describe how the interaction between you and the other subject takes place. After you have read the entire description, you will be allowed, if needed, to re-read it before you begin the interaction. Please raise your hand if you do not understand any part of the description.

Next

UI7: Each subject starts each interaction with an endowment of tokens. The subject in role 1 gets 400 tokens as an endowment. The subject in role 2 gets 100 tokens as an endowment. These tokens have a dollar value of "y"[32].

Next

UI8: Next, the subject in role 1 is given an additional 100 special-token gift to divide between him or herself and the subject in role 2. The subject in role 1 can take as many of the tokens as he or she chooses. The other subject will get the rest.

You will be informed of the dollar value of these special-tokens immediately before the start of the interaction.

Next

[31] Note to researcher: N0 and N1 are placeholders in this template. In the actual description, they should be replaced by the number 1 or the number 2 depending on which role the corresponding subject is participating in.

[32] Note to researcher: the dollar value of the tokens must be determined depending on how much the subjects are to be paid. See Friedman and Sunder, 1994 page 50 for one method of how to determine the dollar value of the tokens.

UI9: The subject in role 1 then decides how he or she would like to divide the gift. After he or she has chosen a division, the subject in role 2 is informed of the proposed division of the gift.

Next

UI10: It is then up to the subject in role 2 to:
1) Accept the division of the gift and end the interaction or
2) Reject the division of the gift and propose to the other subject that the computer decide who gets the ENTIRE gift.

If the subject in role 2 accepts the division, each subject ends the interaction and earns his or her endowment plus the amount of special-tokens that each subject receives from the gift.

Next

UI11: If the subject in role 2 proposes that the computer decide who gets the gift, the subject in role 1 must decide whether to:
1) Give the ENTIRE gift to the other subject or
2) Agree that the computer should decide who receives the entire gift.

If the subject in role 1 gives the entire gift to the other subject, then the interaction is over and the subject in role 1 earns his or her endowment and the subject in role 2 earns his or her endowment plus the 100 special-token gift.

Next

UI12: If the subject in role 1 agrees that the computer should decide who gets the entire gift, then the computer will determine who gets the entire gift. If the interaction comes to this point, then the computer will give the gift to the subject in role 1 with probability equal to "p" and to the other subject with probability equal to "1-P" and a fee of 10 tokens will be taken from each subject's endowment no matter what happens next[33].

Next

UI13: The interaction then comes to an end. If the computer gives the gift to the subject in role 1, he or she earns his or her endowment (minus the fee of 10 tokens) plus the ENTIRE gift. The subject in role 2 would then earn his or her endowment minus the same 10 token fee. If the computer gives the gift to the subject in role 2, then the final payoffs are reversed.

[33] Note to researcher: "p" and "1-p" are just placeholders in this template. During the actual experiment, "p" and "1-p" should be replaced by their true, predetermined values.

Next

UI14: Here is a summary of how the interaction will work (you will be able to see this summary while you are participating in the actual interaction)[34]:

1) Roles 1 and 2 each start with their respective endowments.
2) Role 1 receives a 100 special-token gift.
3) Role 1 decides how to divide the gift between both subjects and informs role 2 of the proposed division.
4) Role 2 either accepts the division or proposes that the computer decide which subject receives the ENTIRE gift.
5) If role 2 accepts the division, the interaction is over. If role 2 proposes that the computer decide who gets the ENTIRE gift, role 1 must decide whether to give the entire gift to role 2 or agree to let the computer decide who gets the gift.
6) If role 1 decides to give the entire gift to role 2, the interaction is over. If role 1 agrees to let the computer decide, the computer will give the entire gift to role 1 with probability "p" and to role 2 with probability "1-p" and will assess a fee of 10 tokens from each subject's endowment[35].

Next

UI15: You will be paid for this experiment depending on your earnings from one randomly selected interaction between you and another subject. That is to say, even though you interact multiple times with multiple different subjects, you will only be paid as if you participated in 1 interaction and the interaction for which you will be paid will be randomly selected from all the interactions you participate in during this session.

Next

UI16: Would you like to review the description of the interaction or continue on to the interaction itself[36]?

Review Continue

After clicking through these instructions, each subject will see the interaction prompts corresponding with his or her role.

---

[34] The summary should be present somewhere on each interaction prompt screen.
[35] Note to researcher: "p" and "1-p" are just placeholders in this template. During the actual experiment, "p" and "1-p" should be replaced by their true, predetermined values.
[36] The "review" button should take the subject back to UI2. The "continue" button should take the subject to the appropriate first interaction prompt.

Appendix 1

Instructions and Prompts

Interaction prompts for Role 1 in the modified ultimatum game:

If role 2 is still reading or reviewing the description, then Ultimatum Prompt A1a: Please wait a moment while the interaction is being set up by the computer.

If role 2 is also ready to begin or when role 2 is ready to begin, then Ultimatum Prompt A1b: We are now ready to begin. You have been endowed with 400 tokens that are worth "y[37]" dollars each. Before you decide how to split the 100 special-token gift, you need to know that each special-token that you end up with at the end of the interaction is worth 1 regular token. Unfortunately, you do not know exactly what each special-token is worth to the subject in role 2. Each special-token that the subject in role 2 receives could be worth .5 or 2 regular tokens with equal probability of each valuation.

Next

UPA2: You now must decide how to split the 100 special-token gift. Please type how many of the special-tokens you want and then click submit.

Remember: all of the special-tokens that you don't take will be given to the other subject.

You will take [ ] special-tokens.

Submit

UPA3: Please wait a moment while the subject in role 2 considers your offer.

If the subject in role 2 chooses accept, then UPA4a: The other subject has accepted your offer. You have earned 400 tokens plus "100-v" special-tokens for a total of "400+100-v" total tokens and "(400+100-v)*y" dollars this round. Please click "next" and wait to be paired with another subject[38].

Next

If the subject in role 2 chooses to propose to let the computer decide, then UPA4b: The other subject has rejected your offer and proposed that you both let the computer decide who gets all of the 100 special-tokens. Now you must choose between 2 options:

1) If you would like to give all of the 100 special-tokens to the other subject, click the box labeled "A."

[37] Note to researcher: the dollar value of the tokens must be determined depending on how much the subjects are to be paid. See Friedman and Sunder, 1994 page 50 for one method of how to determine the dollar value of the tokens.
[38] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

2) If you agree with the other subject and would like to allow the computer to decide who gets all of the special-tokens, click the box labeled "B."

Remember: if you click box "B" you will get all of the special-tokens with probability "P" and none of the special tokens with probability "1-p" but both you and the other subject will also lose 10 tokens from your endowments no matter what[39].

[A] [B]

If the subject in role 1 clicks box "A," then UPA5a: You have chosen to give all of the special-tokens to the other subject. You have earned 400 tokens from your endowment for "400*y" dollars this round[40]. Please click "next" and wait to be paired with another subject.

[Next]

If the subject in role 1 clicks box "B," then the computer chooses who receives all the tokens with the specified probabilities.

If the computer gives all of the special-tokens to the subject in role 1, then UPA5bi: The computer has chosen to give all 100 special-tokens to you. You have earned 400 tokens minus 10 tokens from your endowment plus 100 special-tokens for a total of 490 tokens and "490*y" dollars this round[41]. Please click "next" and wait to be paired with another subject.

[Next]

If the computer gives all of the special-tokens to the subject in role 2, then UPA5bii: The computer has chosen to give all 100 special-tokens to the other subject. You have earned 400 tokens minus 10 tokens from your endowment for a total of 390 tokens and "390*y" dollars this round[42]. Please click "next" and wait to be paired with another subject.

[Next]

---

[39] Note to researcher: "p" and "1-p" are just placeholders in this template. During the actual interaction, "p" and "1-p" should be replaced by their true, predetermined values.
[40] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.
[41] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.
[42] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

Interaction screens for role 2 in the modified ultimatum game:

If role 1 is still reading or reviewing the descriptive screen, then Ultimatum Prompt B1a: Please wait a moment while the interaction is being set up by the computer.

If role 1 is also ready to begin or when role 2 is ready to begin, then Ultimatum Prompt B1b: We are now ready to begin. Before the other subject decides how to split the 100 special-token gift, you need to know that each special-token that the other subject ends up with at the end of the interaction is worth 1 regular token. You also need to know that each special-token you end up with at the end of the round is worth "x[43]".

Next

If the subject in role 1 has not yet submitted his division of the gift, then UPB2a: Please wait a moment while the other subject decides how to divide the 100 special-token gift.

If the subject in role 1 has already submitted his division of the gift, then UPB2b: The other subject has offered to give you "v" of the 100 special-tokens and keep "1-v" for him or herself. Now you must choose between 2 options:

1) If you accept this division, please click the box labeled "A."
2) If you want to propose to the other subject that the computer decide who gets the entire gift, please click the box labeled "B."

Remember: if you propose that the computer decide AND the other subject agrees that the computer should decide, then you will receive all of the 100 special-tokens with probability "1-p" and none of the special-tokens with probability "p" but you and the other subject will also both lose 10 tokens from your endowment no matter what[44].

A B

If the subject in role 2 clicks box "A," then UPB3a: You have accepted the other subject's division. You have earned 100 tokens from your endowment plus "v" special-tokens for a total of "v*y" dollars this round[45]. Please click "next" and wait to be paired with another subject.

Next

[43] Note to researcher: "x" is only a placeholder in this template. During the actual interaction, the screen should include the pre-specified value instead of "x."
[44] Note to researcher: all variables in parentheses are only placeholders in this template. They should be replaced with their pre-specified values in the actual interaction.
[45] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

If the subject in role 2 clicks box "B," then UPB3b: You have proposed to the other subject that the computer decide who gets all of the special-tokens. Please wait while the other subject chooses to either give you all 100 special-tokens or accept your proposal and allow the computer to decide the outcome.

If the subject in role 1 chooses to give all 100 special-tokens to the subject in role 2, then UPB4a: The other subject has given you all 100 special-tokens. You have earned 100 tokens from your endowment and 100 special-tokens for a total of "(100+100*x)*y" dollars[46]. Please click "next" and wait to be paired with another subject.

Next

If the subject in role 1 chooses to let the computer decide who gets all 100 special-tokens and the computer gives all of the special-tokens to the subject in role 2, then UPB4bi: The other subject agreed that you should both let the computer decide who gets all 100 special-tokens and the computer chose to give them to you. You have earned 100 tokens minus 10 tokens from your endowment plus 100 special tokens for a total of "(90+100*x)*y" dollars this round[47]. Please click "next" and wait to be paired with another subject.

Next

If the subject in role 1 chooses to let the computer decide who gets all 100 special-tokens and the computer gives all of the special-tokens to the subject in role 1, then UPB4bii: The other subject agreed that you should both let the computer decide who gets all 100 special-tokens and the computer chose to give them to the other subject. You have earned 100 tokens minus 10 tokens from your endowment for a total of "90*y" dollars this round[48]. Please click "next" and wait to be paired with another subject.

Next

[46] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.
[47] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.
[48] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

Appendix 1
Instructions and Prompts

Pre-interaction instructions for all subjects participating in a modified ultimatum game with a brinkmanship addendum specification:

Brinkmanship Instructions 1: Please enter your randomly distributed subject id number into the box below and click "next."

Subject id [ ]

[Next]

*The screen should remain blank until all subjects have entered their subject id number and clicked "next."

When all subjects have entered their ids and clicked "next," then BI2: Hello and welcome! Thank you for choosing to participate in this experiment designed to study a specific type of bargaining process.

[Next]

BI3: During today's session, you will be paired with multiple other subjects. However, you will only be paired with 1 other subject at any given time. You will interact with this subject exclusively until you complete the entire interaction. Then you will be randomly paired with another subject.

[Next]

BI4: Within each pair, one of you will participate in role 1 and the other in role 2. Roles1 and 2 are different in 2 ways:

1) The order in which the subject in each role gets to choose his or her action and
2) The options that each subject has to choose from when determining how to act with the other player.

[Next]

BI5: During the entire experiment today, you have been assigned to participate in role "N0". The subject you are paired with will participate in role "N1"[49].

[Next]

[49] Note to researcher: "N0" and "N1" are placeholders in this template. In the actual description, they should be replaced by the number 1 or the number 2 depending on which role the corresponding subject is participating in.

BI6: Please pay careful attention to the next few screens because they will describe how the interaction between you and the other subject takes place. After you have read the entire description, you will be allowed, if needed, to re-read it before you begin the interaction. Please raise your hand if you do not understand any part of the description.

Next

BI7: Each subject starts each interaction with an endowment of tokens. The subject in role 1 gets 400 tokens as an endowment. The subject in role 2 gets 100 tokens as an endowment. These tokens have a dollar value of "y[50]".

Next

BI8: Next, the subject in role 1 is given an additional 100 special-token gift to divide between him or herself and the subject in role 2. The subject in role 1 can take as many of the tokens as he or she chooses. The other subject will get the rest.

You will be informed of the dollar value of these special-tokens immediately before the start of the interaction.

Next

BI9: The subject in role 1 then decides how he or she would like to divide the gift. After he or she has chosen a division, the subject in role 2 is informed of the proposed division of the gift.

Next

BI10: It is then up to the subject in role 2 to:

1) Accept the division of the gift and end the interaction or
2) Reject the division of the gift and propose to the other subject that the computer decide who gets the ENTIRE gift.

If the subject in role 2 accepts the division, each subject ends the interaction and earns his or her endowment plus the amount of special-tokens that each subject receives from the gift.

Next

BI11: If the subject in role 2 proposes that the computer decide who gets the gift, the subject in role 1 must decide whether to:

1) Give the ENTIRE gift to the other subject or
2) Agree that the computer should decide who receives the entire gift.

[50] Note to researcher: the dollar value of the tokens must be determined depending on how much the subjects are to be paid. See Friedman and Sunder, 1994 page 50 for one method of how to determine the dollar value of the tokens.

If the subject in role 1 gives the entire gift to the other subject, then the interaction is over and the subject in role 1 earns his or her endowment and the subject in role 2 earns his or her endowment plus the 100 special-token gift.

Next

BI12: If the subject in role 1 agrees that the computer should decide who gets the entire gift, then the computer will determine who gets the entire gift. If the interaction comes to this point, then the computer will give the gift to the subject in role 1 with probability equal to "p" and to the other subject with probability equal to "1-P"[51]. If the interaction reaches this point, a fee of 10 tokens will be taken from each subject's endowment no matter what happens next.

Next

BI13: Next, the subject who does not receive the 100 special-token gift must choose between 2 options:

1) Accept the outcome and end the interaction or
2) Engage in a an auction for the 100 special-token gift

If the subject who does not receive the gift accepts the outcome, he or she earns his or her endowment (minus the 10 token fee) and the other subject earns his or her endowment (minus the same 10 token fee) plus all 100 special-tokens.

Next

BI14: If the subject who does not receive the 100 special-token gift chooses to engage in the auction then each subject will be asked to choose a bid from 0 to 100. Each bid must be a whole number. This bid represents the percent chance that the computer repossesses all tokens (both special-tokens and endowment tokens) from both subjects.

After each subject has placed his or her bid, the computer will select the highest bid and choose between 2 options:

1) The computer repossesses ALL tokens (both special-tokens and endowment tokens) with probability equal to the highest bid or
2) The subject with the highest bid gets the ENTIRE 100 special-token gift with probability equal to 100% minus the highest bid.

If the computer chooses the first option, neither subject earns any tokens for this round.

[51] Note to researcher: "p" and "1-p" are just placeholders in this template. During the actual experiment, "p" and "1-p" should be replaced by their true, predetermined values.

If the computer chooses the second option, the subject who bid the highest earns his or her endowment (minus the fee of 10 tokens) plus the ENTIRE gift. The other subject would then earn his or her endowment minus the same 10 token fee.

Next

BI15: For example, if the interaction reaches this point and the subject in role 1 bids 50 (meaning a 50% chance that the computer repossesses all tokens) and the subject in role 2 bids 60 (meaning a 60% chance that the computer repossesses all tokens) then:

1) There is a 60% chance that the computer will choose to repossess ALL tokens from both subjects (both special-tokens and endowment tokens) and
2) A 40% chance that the subject in role 2 will get ALL 100 special-tokens plus his or her endowment (minus the 10 token fee) and the other subject gets only the endowment (minus the 10 token fee).

If the computer selects the first option then neither subject earns any tokens for the round.

Next

BI16: Note that if you and the other subject both choose the same bid, the computer will repossess all of the tokens with a probability equal to your bid and will split the 100 special-token gift in half with a probability equal to 100% minus your bid.

BI17: Here is a summary of how the interaction will work (you will be able to see this summary while you are participating in the actual interaction)[52]:

1) Roles 1 and 2 each start with their respective endowments.
2) Role 1 receives a 100 special-token gift.
3) Role 1 decides how to divide the gift between both subjects and informs role 2 of the proposed division.
4) Role 2 either accepts the division or proposes that the computer decide which subject receives the ENTIRE gift.
5) If role 2 accepts the division, the interaction is over. If role 2 proposes that the computer decide who gets the ENTIRE gift, role 1 must decide whether to give the entire gift to role 2 or agree to let the computer decide who gets the gift.
6) If role 1 decides to give the entire gift to role 2, the interaction is over. If role 1 agrees to let the computer decide, the computer will give the entire gift to role 1 with probability "p" and to role 2 with probability "1-p" and will assess a fee of 10 tokens from each subject's endowment[53].
7) The subject who is not chosen by the computer to receive the gift must chose whether to accept the outcome and end the interaction or engage in an auction for the 100 special-token gift.

---

[52] The summary should be present somewhere on each interaction prompt screen.
[53] Note to researcher: "p" and "1-p" are just placeholders in this template. During the actual experiment, "p" and "1-p" should be replaced by their true, predetermined values.

8) If the subject who does not receive the gift accepts the outcome, the interaction is over. If that subject chooses to engage in an auction, then each subject must choose a bid from 0 to 100 percent chance that both subjects will lose all tokens.

Next

BI18: You will be paid for this experiment depending on your earnings from one randomly selected interaction between you and another subject. That is to say, even though you interact multiple times with multiple different subjects, you will only be paid as if you participated in 1 interaction and the interaction for which you will be paid will be randomly selected from all the interactions you participate in during this session.

BI19: Would you like to review the description of the interaction or continue on to the interaction itself[54]?

Review　　Continue

[54] The "review" button should take the subject back to BI2. The "continue" button should take the subject to the appropriate first interaction prompt.

Appendix 1
Instructions and Prompts

Interaction prompts for Role 1 in the modified ultimatum game with a brinkmanship addendum

If role 2 is still reading or reviewing the description, then Brinkmanship Prompt A1a: Please wait a moment while the interaction is being set up by the computer.

If role 2 is also ready to begin or when role 2 is ready to begin, then Brinkmanship Prompt A1b: We are now ready to begin. You have been endowed with 400 tokens that are worth "y[55]" dollars each. Before you decide how to split the 100 special-token gift, you need to know that each special-token that you end up with at the end of the interaction is worth 1 regular token. Unfortunately, you do not know exactly what each special-token is worth to the subject in role 2. Each special-token that the subject in role 2 receives could be worth .5 or 2 regular tokens with equal probability of each valuation.

[Next]

BPA2: You now must decide how to split the 100 special-token gift. Please type how many of the special-tokens you want and then click submit.

Remember: all of the special-tokens that you don't take will be given to the other subject.

You will take [ ] special-tokens.

[Submit]

BPA3: Please wait a moment while the subject in role 2 considers your offer.

If the subject in role 2 chooses accept, then S4a: The other subject has accepted your offer. You have earned 400 tokens plus "100-v" special-tokens for a total of "400+100-v" total tokens and "(400+100-v)*y" dollars this round[56]. Please click "next" and wait to be paired with another subject.

[Next]

If the subject in role 2 chooses to propose to let the computer decide, then BPA4b: The other subject has rejected your offer and proposed that you both let the computer decide who gets all of the 100 special-tokens. Now you must choose between 2 options:

1) If you would like to give all of the 100 special-tokens to the other subject, click the box labeled "A."

---

[55] Note to researcher: the dollar value of the tokens must be determined depending on how much the subjects are to be paid. See Friedman and Sunder, 1994 page 50 for one method of how to determine the dollar value of the tokens.
[56] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

2) If you agree with the other subject and would like to allow the computer to decide who gets all of the special-tokens, click the box labeled "B."

Remember: if you click box "B" you will get all of the special tokens with probability "P" and none of the special tokens with probability "1-p" but will also lose 10 tokens from your endowment no matter what[57]. Further, whichever subject is not chosen to receive the gift will be able to opt for an auction for the ENTIRE gift if that subject so chooses.

| A | B |

If the subject in role 1 clicks box "A," then BPA5a: You have chosen to give all of the special-tokens to the other subject. You have earned 400 tokens from your endowment for "400*y" dollars this round[58]. Please click "next" and wait to be paired with another subject.

| Next |

If the subject in role 1 clicks box "B," then the computer chooses who receives all the tokens with the specified probabilities.

If the computer gives all of the special-tokens to the subject in role 1, then BPA5bi: The computer has chosen to give all 100 special-tokens to you. Please wait while the other subject decides whether to accept the outcome or engage in an auction for the gift.

*If the interaction reaches this point, follow the prompts below. If not, see BPA5bii and continue from there.

If the other subject chooses to accept the outcome, then BPA6ai: The other subject has accepted the outcome. You have earned 400 minus 10 tokens from your endowment plus 100 special-tokens for "490*y" dollars[59]. Please click "next" and wait to be paired with another subject.

| Next |

If the other subject chooses to engage in an auction, then BPA6aii: The other subject has decided to engage in an auction with you to determine who gets the 100 special-tokens. Please type your bid into the box below and click "submit."

Remember: your bid represents the percent chance that both you and the other subject end this round earning no tokens. Whoever bids the highest will get the 100 special-token gift with a

[57] Note to researcher: "p" and "1-p" are just placeholders in this template. During the actual interaction, "p" and "1-p" should be replaced by their true, predetermined values.
[58] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.
[59] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

chance of 100% minus the bid (e.g. if the highest bid is 60%, then the subject who bid that amount has a 40% chance to get the entire gift) in addition to his or her endowment minus the 10 token fee. The other subject will have the same chance to earn his or her endowment minus the 10 token fee.

Your bid must be a whole number.

I would like to bid [ ]

[Submit]

If the other subject has not yet submitted his or her bid, then BPA7ai: Please wait while the other subject makes a bid.

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 1's bid AND the computer has chosen to repossess all tokens, then BPA7aii1: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

[Next]

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 1's bid AND the computer has chosen to give all the special-tokens to the subject in role 2, then BPA7aii2: The computer chose to give all 100 special-tokens to the other subject. You have earned 390 tokens from your endowment for "390*y" dollars this round[60]. Please click "next" and wait to be paired with another subject.

[Next]

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 1's bid AND the computer has chosen to repossess all tokens, then BPA7aii3: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

[Next]

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 1's bid AND the computer has chosen to give all the special tokens to the subject in role 1, then BPA7aii4: The computer chose to give all 100

[60] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

special-tokens to you. You have earned 390 tokens from your endowment and 100 special-tokens for "490*y" dollars this round[61]. Please click "next" and wait to be paired with another subject.

Next

If the computer gives all of the special-tokens to the subject in role 2, then BPA5bii: The computer has chosen to give all 100 special-tokens to the other subject. You must now choose between 2 options:

1) Accept the outcome and earn "400-c" tokens for . . . dollars this round (click button A to choose this option) or
2) Engage in an auction for the 100 special-token gift (click button B to choose this option.)

A B

If the subject in role 1 clicks button A, then BPA6bi: You have accepted the outcome. You earn 390 tokens for "390*y" dollars this round[62]. Please click "next" and wait to be paired with another subject.

Next

If the subject in role 1 clicks button B, then BPA6bii: You have chosen to engage in an auction to determine who gets the 100 special-tokens. Please type your bid into the box below and click "submit."

Remember: your bid represents the percent chance that both you and the other subject end this round earning no tokens. Whoever bids the highest amount will get the 100 special-token gift with a chance of 100% minus the bid (e.g. if the highest bid is 60%, then the subject who bid that amount has a 40% chance to get the entire gift) in addition to his or her endowment minus the 10 token fee. The other subject will have the same chance to earn his or her endowment minus the 10 token fee.

Your bid must be a whole number.

I would like to bid [ ]

Submit

[61] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.
[62] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

If the other subject has not yet submitted his or her bid, then BPA7bi: Please wait while the other subject makes a bid.

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 1's bid AND the computer has chosen to repossess all tokens, then BPA7bii1: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

Next

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 1's bid AND the computer has chosen to give all the special-tokens to the subject in role 2, then BPA7bii2: The computer chose to give all 100 special-tokens to the other subject. You have earned 390 tokens from your endowment for "390*y" dollars this round[63]. Please click "next" and wait to be paired with another subject.

Next

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 1's bid AND the computer has chosen to repossess all tokens, then BPA7bii3: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

Next

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 1's bid AND the computer has chosen to give all the special tokens to the subject in role 1, then BPA7bii4: The computer chose to give all 100 special-tokens to you. You have earned 390 tokens from your endowment and 100 special-tokens for "490*y" dollars this round[64]. Please click "next" and wait to be paired with another subject.

Next

[63] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.
[64] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the determined values during the actual interaction.

Appendix 1
Instructions and Prompts

Interaction screens for role 2 in the modified ultimatum game with a brinkmanship addendum:

If role 1 is still reading or reviewing the descriptive screens, then Brinkmanship Prompt B1a: Please wait a moment while the interaction is being set up by the computer.

If role 1 is also ready to begin or when role 2 is ready to begin, then Brinkmanship Prompt B1b: We are now ready to begin. Before the other subject decides how to split the 100 special-token gift, you need to know that each special-token that the other subject ends up with at the end of the interaction is worth 1 regular token. You also need to know that each special-token you end up with at the end of the interaction is worth "x"[65].

Next

If the subject in role 1 has not yet submitted his division of the gift, then BPB2a: Please wait a moment while the other subject decides how to divide the 100 special-token gift.

If the subject in role 1 has already submitted his or her division of the gift or when the subject in role 1 submits his or her division, then BPB2b: The other subject has offered to give you "v" of the 100 special-tokens and keep "100-v" for him or herself. Now you must choose between 2 options:

1) If you accept this division, please click the box labeled "A."
2) If you want to propose to the other subject that the computer decide who gets the entire gift, please click the box labeled "B."

Remember: if you propose that the computer decide AND the other subject agrees that the computer should decide, then you will receive all of the 100 special-tokens with probability "1-p" and none of the special-tokens with probability "p" but will also lose 10 tokens from your endowment no matter what[66].

A	B

If the subject in role 2 clicks box "A," then BPB3a: You have accepted the other subject's division. You have earned 100 tokens from your endowment plus "v" special-tokens for a total of "(100+v*x)*y" dollars this round[67]. Please click "next" and wait to be paired with another subject.

---

[65] Note to researcher: "x" is only a placeholder in this template. During the actual interaction, the screen should include the pre-specified value instead of "x".

[66] Note to researcher: all variables in parentheses are only placeholders in this template. They should be replaced with their pre-specified values in the actual interaction.

[67] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

Next

If the subject in role 2 clicks box "B," then BPB3b: You have proposed to the other subject that the computer decide who gets all of the special-tokens. Please wait while the other subject chooses to either give you all 100 special-tokens or accept your proposal and allow the computer to decide the outcome.

If the subject in role 1 chooses to give all 100 special-tokens to the subject in role 2, then BPB4a: The other subject has given you all 100 special-tokens. You have earned 100 tokens from your endowment and 100 special-tokens for a total of "(100+100*x)*y" dollars[68]. Please click "next" and wait to be paired with another subject.

Next

If the subject in role 1 agrees to let the computer decide who gets all 100 special-tokens and the computer gives all of the special-tokens to the subject in role 2, then BPB4bi: The computer has chosen to give all 100 special-tokens to you. Please wait while the other subject decides whether to accept the outcome or engage in an auction for the gift.

Next

*If the interaction reaches this point, follow the prompts below. If not, see BPB4bii and continue from there.

If the other subject chooses to accept the outcome, then BPB5ai: The other subject has accepted the outcome. You have earned 100 minus 10 tokens from your endowment plus 100 special-tokens for "(90+100*x)*y" dollars[69]. Please click "next" and wait to be paired with another subject.

Next

If the other subject chooses to engage in an auction, then BPB5aii: The other subject has decided to engage in an auction with you to determine who gets the 100 special-tokens. Please type your bid into the box below and click "submit."

Remember: your bid represents the percent chance that both you and the other subject end this round earning no tokens. Whoever bids the highest amount will get the 100 special-token gift with a chance of 100% minus the bid (e.g. if the highest bid is 60%, then the subject who bid that

[68] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.
[69] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

amount has a 40% chance to get the entire gift) in addition to his or her endowment minus the 10 token fee. The other subject will have the same chance to earn his or her endowment minus the 10 token fee.

Your bid must be a whole number.

I would like to bid [ ]

[Submit]

If the other subject has not yet submitted his or her bid, then BPB6ai: Please wait while the other subject makes a bid.

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 2's bid AND the computer has chosen to repossess all tokens, then BPB6aii1: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

[Next]

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 2's bid AND the computer has chosen to give all the special-tokens to the subject in role 1, then BPB6aii2: The computer chose to give all 100 special-tokens to the other subject. You have earned 90 tokens from your endowment for "90*y" dollars this round[70]. Please click "next" and wait to be paired with another subject.

[Next]

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 2's bid AND the computer has chosen to repossess all tokens, then BPB6aii3: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

[Next]

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 2's bid AND the computer has chosen to give all the special tokens to the subject in role 2, then BPB6aii4: The computer chose to give all 100 special-tokens to you. You have earned 90 tokens from your endowment and 100 special-tokens

[70] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

for “(90+100*x)*y” dollars this round[71]. Please click “next” and wait to be paired with another subject.

Next

If the computer gives all of the special-tokens to the subject in role 1, then BPB4bii: The computer has chosen to give all 100 special-tokens to the other subject. You must now choose between 2 options:

1) Accept the outcome and earn 90 tokens for “90*y” dollars this round (click button A to choose this option)[72] or
2) Engage in an auction for the 100 special-token gift (click button B to choose this option.)

A B

If the subject in role 2 clicks button A, then BPB5bi: You have accepted the outcome. You earn 90 tokens for “90*y” dollars this round[73]. Please click “next” and wait to be paired with another subject.

Next

If the subject in role 2 clicks button B, then BPB5bii: You have chosen to engage in an auction to determine who gets the 100 special-tokens. Please type your bid into the box below and click “submit.”

Remember: your bid represents the percent chance that both you and the other subject end this round earning no tokens. Whoever bids the highest amount of will get the 100 special-token gift with a chance of 100% minus the bid (e.g. if the highest bid is 60%, then the subject who bid that amount has a 40% chance to get the entire gift) in addition to his or her endowment minus the 10 token fee. The other subject will have the same chance to earn his or her endowment minus the 10 token fee.

Your bid must be a whole number.

I would like to bid [ ]

Submit

[71] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.
[72] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.
[73] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

If the other subject has not yet submitted his or her bid, then BPB6bi: Please wait while the other subject makes a bid.

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 2's bid AND the computer has chosen to repossess all tokens, then BPB6bii1: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

Next

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is higher than the subject in role 2's bid AND the computer has chosen to give all the special-tokens to the subject in role 1, then BPB6bii2: The computer chose to give all 100 special-tokens to the other subject. You have earned 90 tokens from your endowment for "90*y" dollars this round[74]. Please click "next" and wait to be paired with another subject.

Next

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 2's bid AND the computer has chosen to repossess all tokens, then BPB6bii3: The computer chose to repossess all tokens. You have earned no tokens for this round. Please click "next" and wait to be paired with another subject.

Next

If the other subject has already submitted his or her bid or when the other subject submits his or her bid AND it is lower than the subject in role 2's bid AND the computer has chosen to give all the special tokens to the subject in role 2, then BPB6bii4: The computer chose to give all 100 special-tokens to you. You have earned 90 tokens from your endowment and 100 special-tokens for "(90+100*x)*y" dollars this round[75]. Please click "next" and wait to be paired with another subject.

Next

[74] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.
[75] Note to researcher: the values in parentheses are just placeholders in the template prompts. They should be replaced by the definite values during the actual interaction.

Appendix 2

Data Spreadsheet

Trial	ID	Role	Specs	Offer	Response	2nd Response	Allocation	3rd Response	Bid	Outcome	Tokens	Earn
1												
2												
3												
4												
5												
6												
7												
8												

Appendix 3

Pre-Trial and Post-Trial Instructions

Pre-Trial:

Hi,

My name is (experimenter or lab assistant's name) and I am running this experiment in order to study strategic interaction.

OR if the experimenter or lab assistant is working for another principal investigator

My name is (experimenter or lab assistant's name) and I am the administrator running this experiment designed by (principal investigator's name) to study strategic interaction.

Please give me your attention for a moment while I read some important instructions.

First, please do not enter your personal id before I ask you to. After I have finished reading these instructions, I will instruct you to do so.

Second, please refrain from making noises of any kind during the experiment. This includes talking, laughing, sighing, etc. If you do make noise, I will give you a warning. If you make noise a second time, you will be asked to leave the experiment.

Third, please read the instructions and prompts carefully. When the interaction begins, you will be asked to read and click through on-screen instructions. If you have a question at any time while reading the instructions, please raise your hand. Once the interaction has begun, I cannot answer any more questions.

Fourth, though you will participate in many interactions during this session, you will only be paid from the results of one, randomly selected interaction

If there are any questions at this time, you can ask them now.

Thank you for your attention and cooperation. Please enter your id and begin at this time.

Post-Trial:

Thank you for your participation.

Please remain seated while your payments are being prepared. When they are ready, I will ask you to form a single file line so that they can be distributed to you.

Appendix 4
Qualitative Presentation

Chart 1

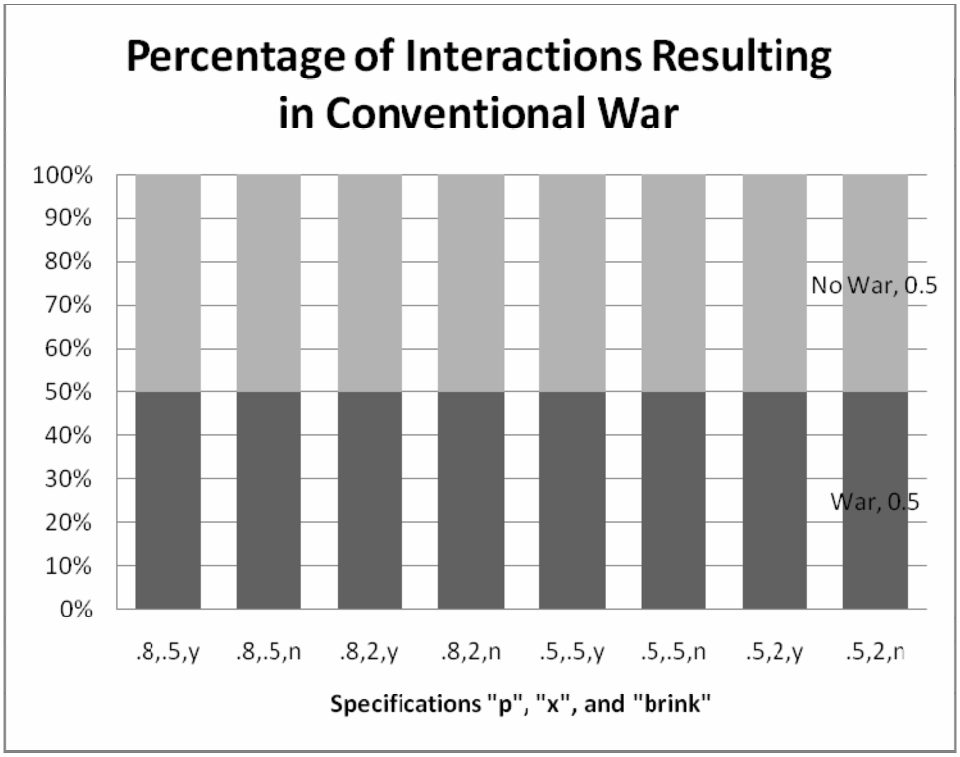
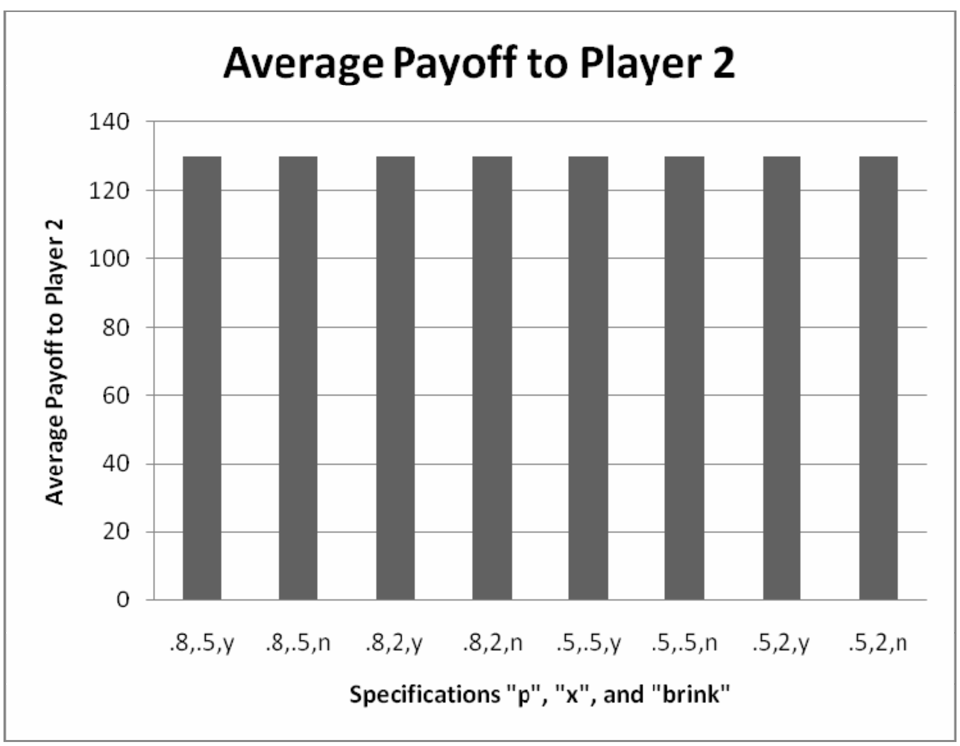


Chart 2



Appendix 4
Qualitative Presentation

Chart 3

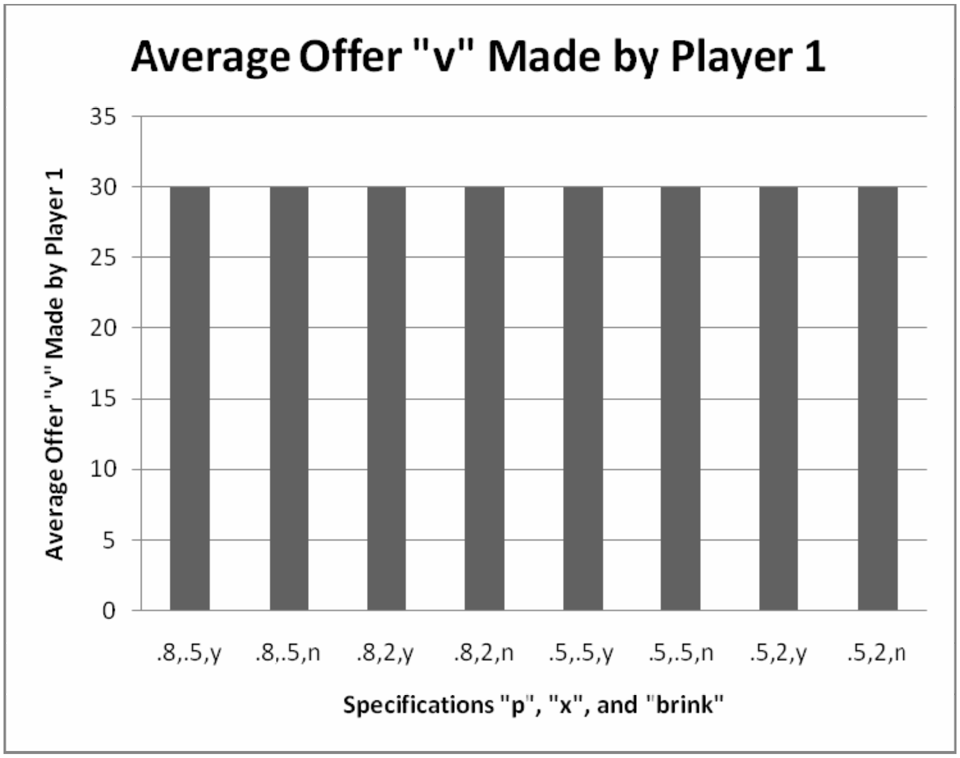


Chart 4