FCC Media Study No. 9:
A Theoretical Analysis of the Impact of Local Market Structure on the Range of Viewpoints Supplied

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June 2011

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1 Executive Summary

In this study we introduce a model of media market competition to examine the impact of ownership structure on the performance of the market in terms of informational efficiency and viewpoint diversity. We adopt the classical mathematical analysis of David Blackwell's 'comparison of experiments,' to measure the quality and diversity of information transmitted in the market and how that quality in turn affects welfare. We argue that Blackwell's method is the appropriate theoretical metric to measure 'the market place for ideas.'

We consider the case of a decision maker (e.g., a voter) who requires information to help her form an opinion or choose an action (e.g., who to vote for). A media outlet is a source of such information. More precisely a media outlet observes information that can inform the decision maker/voter and chooses to transmit a signal, which could vary in its level of accuracy. We define a *media viewpoint*, as the media owner having a preference over the policy outcome that will be influenced by the action chosen by the decision maker. We say there is *diversity of viewpoint* if the media market contains different firms with different viewpoints. In particular, a media firm with a viewpoint may specialize in collecting and disseminating information from a set of sources aligned with that viewpoint. We will say that a media market *exhibits bias*, if in equilibrium a firm suppresses or does not transmit information that is detrimental to its viewpoint. We will say that a media market *exhibits garbling*, when a firm engages in 'signal jamming' or transmits signal that garbles the signal of another media outlet.

We show that with a small number of independent firms the equilibrium will exhibit bias and garbling. This causes a welfare loss to consumers seeking information. In contrast to the classic Steiner result, with multiple outlets owned by one firm (monopoly) there will be no diversity of viewpoint. The amount of bias in equilibrium depends on the cost (or loss of profits) versus the gain from biasing the decision maker. If the cost of biasing or garbling to a media firm increases then the amount of bias diminishes and consumer welfare increases. We model this cost as 'reputation costs.' That is, if two media outlets have similar viewpoints, the one with the greater reputation for being informative will have the greater audience share, and therefore earn more profits. Under the assumption of 'Informational Bertrand Competition' where the more informative firm captures all the market, we obtain informational efficiency with four firms in the market. The key observation is that in order to obtain diversity of viewpoint it is not sufficient to have medias with different viewpoint: competition among firms with the same viewpoint drives informational efficiency. Thus, informational concerns for diversity and localism may require ownership limits more stringent than would be justified by conventional anti-trust analysis alone.

We then test the model with experimental treatments in a controlled laboratory setting. The treatments study the incentives of subjects to bias information, garble information and develop reputations. We find that our theoretical models do quite well at predicting behavior. In general, media firms do behave strategically by biasing and garbling information. Consumers learn that they are doing so and punish firms that withhold information with a smaller market share. We find that the market has better information transmission with four firms than with two, and that there is an additional increase in efficiency when there are six independent firms rather than four. Again this suggest that the number of independent voices is a concern when we consider the FCC's diversity and localism goals.

2 Background

The Federal Communications Commission (FCC or Commission) has authority over the allocation of radio spectrum granted by the 1934 Communications Act. The FCC's charge is to ensures that the ownership of a license to use spectrum is held in the "public interest, convenience and necessity." The FCC's definition of public interest, convenience and necessity includes three elements: competition, diversity, and localism. The FCC reviews transactions conveying the control of a license to ensure that such transactions fit in with its goals. Beyond the mere review of mergers the FCC at the behest of Congress has developed several specific rules that limit the holding of these licenses by entities in the United States. The rules are generally referred to as the "media ownership rules". There are six such rules. These rules broadly fall into three categories; first national rules limiting national ownership of a particular class of broadcast license (TV or radio), second local rules restricting the ownership structure in a local geographic market of a particular class of broadcast license (TV or radio), and third cross-ownership rules limiting ownership across different classes of media.

The Communications Act of 1996 was the first major rewrite of the 1934 Communications Act. The theme of the 1996 Act is that, to the extent possible, regulation should be replaced by competition. In particular as required by the 1996 Act under Section 202, the FCC is required to conduct a (now) Quadrennial Review of media ownership regulations to see "whether any such rules are necessary in the public interest as the result of competition." The courts have interpreted this clause as suggesting that the FCC should review the economic evidence of competition and the impact of New Media to see if the existing ownership rules are still required or if they are made redundant because of the scope of the increasing competition. To assist in deliberations, and meeting the demands placed by the Courts, the 2002 and 2006 reviews included a series of studies. Studies were conducted using both in-house and contracted resources. This study is designed to aid the FCC in its deliberations and to be incorporated as part of the 2010 Quadrennial Review.[1]

This study aims to contribute to this proceeding by investigating how at the local level the ownership structure of media market would affect the level of competition and in particular affect the performance of the media market in terms of serving the interests of the community both in the diversity of viewpoint and the

[1]The Commission recently issued its Notice of Inquiry in MB Docket No. 09-182 as part of the 2010 Quadrennial Review. See http://hraunfoss.fcc.gov/edocs_ public/attachmatch/FCC-10-92A1.pdf. See also, 2006 Quadrennial Regulatory Review: Report and Order and Order on Reconsideration, available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-216A1.pdf.

impact on localism. The FCC rules under review include limits on local TV and radio station ownership, TV-radio cross-ownership, and newspaper-broadcast cross-ownership. These rules are defined with respect to local markets (e.g., the Nielsen Designated Market Area, or DMA, and the Arbitron Radio Metro). Because the local television, local radio, and cross-ownership rules under consideration are defined with respect to local markets, this study is focused on local markets as the primary unit of analysis. This theoretical study is designed to address the Commission's diversity and localism goals, thereby supplementing the empirical analysis in other studies.

The approach assumed in this paper is that the Commission's goal of competition is adequately handled by existing economic anti-trust analysis. Indeed, reviews of any major transaction would be jointly undertaken by both the FCC and either the Department of Justice or the Federal Trade Commission applying existing anti-trust laws. This approach would limit the amount of concentration of ownership in any particular geographic market. Therefore, we do not consider the impact on traditional economic metrics such as pricing and quantity consumed. We feel that there is little new to contribute to this existing standing body of anti-trust economics and law, so we develop a different approach here. The question asked is do the goals of diversity and localism require a more stringent or different standard in particular circumstances? We are interested in the questions of how concentration of ownership in the local geographic level will impact the *quality* of local information transmitted and the *diversity* of viewpoints expressed.

If we examine the scope of national news media, we find that in addition to the existing licensed FCC entities such as television stations and radio broadcast stations, there is a plethora of other information sources. In particular, there is the wide body of newspapers including newspapers that have a national footprint such as, The New York Times, USA Today and the Wall Street Journal. There is also a national news print magazines. There are multiple Cable TV News networks such as CNN and Fox News. In addition, there is of course the burgeoning Internet, the increasing prevalence of conventional media sources on the web, such as NBC.com, NewYorkTimes.com and WashingtonPost.com. In addition, the Internet provides unfiltered access to the AP and Reuters newswire through services such as Google and Yahoo! This leads us to believe that there is indeed sufficient national coverage independent of one's location such that the rules on ownership at the national level are largely irrelevant. When we turn to coverage of the local market, however, there seems to be much more relevant concentration and in particular a lack of diversity of authoritative and reliable news sources at the local level compared with those that exist at the national level. Therefore, our focus in this study is at the local level where there may be just a few broadcast television and radio stations, and a dwindling number of print media.

3 Literature Review

We now turn to a brief review of the existing literature on the economics of the media. In particular, we discuss the extant economic literature and how it relates to the current study. At the outset, it must be said that the body of literature on the economics of the media does not approach the volume and depth of coverage that has been expended on modeling the telecommunications sector. Moreover, the area of media economics is developing rapidly and much of the most important and relevant literature is very recent. We include many recent papers in the references that document or analyze media viewpoint and bias that we do not discuss directly here.

Early work studying the media goes back to the classic paper by Peter Steiner. Steiner (1952) adopted the Hotelling model of spatial competition to the case of media (radio), choosing either what might be thought of as a viewpoint or a programming mix or radio format. In Steiner's radio model one obtains the following result. If we have a mass of consumers located along a line (which we might think of as the diversity of viewpoints from left to right or from lowbrow to highbrow television) and the distribution is single peaked, then the largest mass audience would be located at the median. In a broadcast market driven by advertising revenues, this median preference is where a profit maximizing single firm would locate. If we now introduce competition through a second firm, where would that firm locate? The Hotelling paradox is that the entrant would locate right next to the existing firm. That way, the firm slightly to the left of the median controls all the audience to the left and the firm slightly to the right controls all the audience to the right. The equilibrium is such that firms choose the same spatial location and split the market 50-50. However, entry is detrimental for the first firm as the new firm is now cannibalizing the market of the existing firm. Therefore, if instead we introduce the second license and allocate it to the incumbent, the monopolist owner of two licenses (or duopolist in FCC parlance) would in fact choose to relocate both firms and spread them out so that they do not cannibalize each other's market. Therefore, the Steiner result is that we would have greater diversity with monopoly than we would under competition. In an empirical paper, Berry and Waldfogel (2001) test this result by examining the impact of radio mergers on a station's format choice. They indeed find support for the result. However, although interesting, the model's application is limited to format choice rather than viewpoint. In particular, firms are assumed to have no preference over their choice of location other than market share. That is, the Steiner model assumes away the possibility that media firms might want to shape taste or opinion for either future profit or pure preference reasons. Secondly although the model is sensible as a model of format competition, as we will show it makes less sense once we consider the content 'information.' Moreover, the Steiner result is not robust to the introduction of three or more firms as it becomes very difficult to describe what will be the equilibrium location in the extended model.

Influential work on the regulation of television has been done in the 1970s and 1980s by economists in the so-called "public choice" framework. In particular, Besson et al. (1984) investigated the role of the FCC in terms of limiting entry into the market and also enforcing vertical contracting relations between networks and their affiliate stations. The authors investigated the relationship between the networks and programming suppliers, or the so-called "financial syndication rules". Although this work is important, it is also of limited relevance to the issues here, as we do not focus on the vertical issues.

Another area of research, which is relevant to our current study, is a stream of literature investigating whether or not ownership matters. In particular this is highly relevant to our analysis. Most of this literature is empirical and it begins with the classic paper by Dubin and Spitzer (1993) which investigated if the ownership structure affects the choice of format in radio. In that study, they found that the race of the owner affected the probability that a station would choose to play in a minority favored format. In particular, African-American ownership meant that it was more likely that the station would play an African-American format. Subsequent to the study, the paper by Siegelman and Waldfogel (2001) replicated these results. In particular, that study found that the ownership structure not only affects the format but also the welfare market that minority audiences increase with minority ownership. Obelholzer, Gee and Waldfogel (2006) argue that the result has implications for localism. That is, in markets where there are more Spanish language radio stations there is higher civic participation as measured by voter turnout among Hispanics.

These findings are consistent with the political science literature that studies the importance of information in voting behavior. For a detailed treatise on the topic of how voters use information and how information affects their behavior we refer to Alvarez (1998). In particular, Alvarez examines several presidential elections and finds that if voters have less information about a candidate then (controlling for other factors) they are less likely to vote for that candidate. In addition, he finds that the amount of media exposure and political information voters have also affect their voting behavior. This informational impact is important given the concern of 'localism.' Political scientists have studied the so called "roll-off" phenomenon, that a voter will go through the cost of turning out to vote but not vote on every issue. In particular many voters will vote in the Presidential and Senate elections but not for example the local school board. Considering that their vote is much more likely to be pivotal in a local rather national or statewide election, to an economist this behavior is odd. One rationale that is provided is based on the quality of information. The national media provides extensive coverage of the Presidential candidates positions and competence, but there is a shortage of local information about local elections. Confronted with the lack of quality information people choose to abstain, see Feddersen and Pesendorfer (1996) as well as Katz and Ghirardato (2002). Thus, there is a direct linkage between the quality and diversity of information in a local media market and civic participation, which impacts the FCC's 'localism' concerns. In this study we show that the quality and diversity of information in turn is linked to market structure.

There is also a long literature examining media bias that we will not review here as most of it is beyond our expertise. Recently, there has been a new and sophisticated analysis of measures of media bias or slant using econometric techniques. In particular, the work by Groseclose and Milyo (2005) provides a careful study of the viewpoint or bias of different media. Their work and that of the empirical papers that follow use the Poole-Rosenthal (1997) score a measure of the ideological locations of all of the politicians who served in the U.S. Congress. They find that indeed there is a difference of viewpoint and that different media institutions are well associated with a particular left of center or right of center view. For instance the New York Times is recognized as being a left of center viewpoint, and the Fox News Channel is recognized as being a right of center viewpoint. These findings have also been found in other studies using similar methodologies. Gentzkow and Shapiro (2010) undertake a textural analysis find evidence of bias and that it is demand driven, that is newspapers exhibit a bias to because of the prior belief of the electorate. Puglisi and Snyder (2008) examine the media coverage of political scandals. They find that even controlling for the local Partisan tastes there is bias in that a Democrat-leaning paper will spend relatively more space on Republican scandals than Democrat scandals and Republican-leaning papers do the opposite. They find that the coverage of local scandals rather than national scandals is more driven by local electoral bias.

DellaVigna and Kaplan (2006) studies the introduction of the Fox News Channel on cable television systems. Although Fox News is of course not a broadcast station and therefore subject to FCC, the experiment is interesting because the rollout of

Fox News has the characteristics of a randomized trial. That is, Fox News was shown on some cable systems where they reached the contractual arrangement and not on others, in what appears to be a somewhat random fashion because of the quilt of ownership of cable networks platforms in the United States. Given this randomized "treatment" the authors ask if in the treated markets the voting behavior is different from similar matched markets that were not treated by the introduction of Fox News. What DellaVigna and Kaplan find is that indeed there is an impact of the Fox News introduction resulting in a somewhat higher vote for the Republican candidates than would be expected. The authors then build a structural model to examine behaviorally if and by what mechanism Fox News's introduction changes the opinion of voters. They find that the dominant effect seems to be that the exposure to the information transmitted by Fox News changed opinions. In a related experimental study, Gerber, Karlan and Bergan (2009) randomly assigned households free subscriptions to either the Washington Post or the Washington Times. They find that the households assigned to the Washington Post were eight percentage points more likely to vote for the Democratic candidate for governor than those assigned to the control group. Thus, we conclude from the empirical literature that the ownership of media outlets matters viz-a-viz viewpoint, and that the informational content of a media market can have an effect on how people make decisions such as choosing whether or not to vote and, when they do, who to vote for. Anderson and McLaren (2010) provide several examples of information suppression, and Enikolopov, Petrova and Zhuravskaya (2011) document the influencing of electoral outcomes in Russia. Therefore, from the literature, we conclude the FCC has as a powerful interest in examining the relationship between ownership structure and market performance, in terms of the efficiency of transmission of information and the diversity of viewpoints in the market.

There are several recent theoretical papers examining media competition and information transmission that are related to our study, and bear directly on our results. Many of these papers are 'demand driven,' that is in the model consumer have a 'taste for bias' or behavior characteristic that induces firms in equilibrium to adopt different viewpoints as part of a profit maximizing strategy. The firms themselves have no agenda per se but adopt a viewpoint to capture a segment of the media market. Mullainathan and Shleifer (2005) is perhaps the canonical "demand side" media bias model. It builds on the behavioral economics work of Rabin and Schrag (1999) on what is called "self-confirmatory bias." That is, a decision maker may have a "first impression" bias towards one position or another and in collecting information in the decision-making may receive utility from receiving information that confirms the prior belief or bias. This type of model of consumer behavior is adopted in their study, and they examined the impact of competition when consumers are distributed with certain biases (some people prefer left-wing information while others prefer right-wing information). They find that the market will be characterized by polarization, with firms offering different viewpoints that, in equilibrium, will be biased. Although this model is interesting, it has two limitations from the point of view of the FCC's exercise in examining the role of the media ownership rules. The first problem is that it is very difficult to do any type of economic welfare analysis in these models. Self-confirmatory bias comes from preferences and so it is unclear whether the FCC should consider these biases at all and if it should, whether it is a good thing or a bad thing from the diversity of the viewpoint perspective. Are the perspectives being offered something akin to the diversity of flavors of ice cream or should we think that the diversity of viewpoint being offered here increases polarization in society and leads people to make ineffectual decisions? Baron (2006) demonstrates that this can be the case. The second issue with the Mullainathan and Shleifer model is that, as we shall discuss further, there is a second type of cognitive bias embedded in the model. Indeed, when consumers do not receive the correct signal agents do not make the inference that should be made given the media bias. The model developed below with fully rational agents incorporates exactly these features. Therefore, although Mullainathan and Shleifer (2005) is illustrative, we think that it has little to say on the FCC proceedings. In particular the lack of the ability to make welfare analyses means that although the authors of this study can say how market structure affects the equilibrium, they are unable to make any definitive judgments as to whether or not this is in the public interest. Finally, we are also unconvinced that behavioral biases are the sole (or even the major) factors driving viewpoint diversity. The papers by Gentzkow and Shapiro (2006), Baron (2006), and Bernhardt, Krasa, and Polborn (2008) also analyze media market with demand driven media slant or viewpoint. Baron (2006) is able to provide welfare analysis in his model and finds a role for regulation. In Gentzkow and Shapiro (2006), bias is driven by media outlets trying to gain their reputation by reinforcing a viewer's prior belief rather than a behavioral bias per-se. Like in our study, consumers in that model are rational in that they correctly update their belief upon seeing an uninformative signal.

The closest paper to the current study is the paper by Anderson and McLaren (2010). In particular, they build a "supply side bias" model where the media owners may choose to transmit information or bias the signal by withholding information to the decision maker in equilibrium. The decision maker/consumer is also rational in the sense that she makes the correct inference upon seeing an uninformative signal. The paper characterizes the equilibrium with a single owner of the media outlets and compare that with the introduction of a second owner. They find that competition increases the amount of information transmitted and the diversity of viewpoint. Their model is closely related to our Model 1 below. However, they also include price competition, so our Model 1 can be seen as a special case of their model. Unsurprisingly, our results and conclusions are very similar. Gentzkow and Shapiro (2006) also develop a model where consumers do update correctly and so our models are similar to theirs. Finally, although there is costly communication in our model, there is a link between our work and the models of "cheap talk" with multiple senders, for example Krishna and Morgan (2001).

4 Measuring Welfare in Media Markets

4.1 Blackwell's Theorem

The approach adopted in this study is that the media market functions as an 'information market:' it provides signals to a citizen, or information consumer, who uses the signal to form a belief and choose a plan of action. We then ask when is one market ownership structure better than another? The answer is provided by the simple observation that if a change in ownership structure leads to better information, this increases the utility of the consumer and therefore it is in the public interest.

Our analysis begins with the beautiful theorem of David Blackwell (1951). An elegant proof of Blackwell's theorem is provided in Cremer (1982). In a classic paper on "the comparison of experiments," Blackwell investigated the concept of what it means to have "better information." Blackwell postulated two different measures of the quality information and in a remarkable result he was able to prove that the two different measures turn out to be mathematically equivalent. The first measure is purely statistical, based on information theory and signal transmission whereas the second measure is based on the intuitive economic notion that better information is more valuable to the decision maker when it helps her make better decisions. Blackwell's Theorem is that one information structure is better than another information structure under the first (statistical) criterion if and only if it is better under the second (economic) criterion. This implies that if we can show one media market ownership structure results in a more informative market in the statistical sense, then it leads to higher consumer welfare, *even if we do not know the consumer's utility function*! The approach in our study is to adapt Blackwell's comparison of experiments to the context of media markets, that is, we think of the media market as Blackwell thinks of an experiment. Given the firms and the structure of ownership in the market, firms collect information about the true state of the world. They then process this information and report a signal through the television or radio station to the viewer/listener citizens. A citizen then decides whether to receive this information, that is view the channel or listen to the radio broadcast. Once receiving the signal, she chooses to form a path of action (for example, who to vote for) or chooses to form a set of beliefs about the relevant policy question, (for example, "do the social benefits of a carbon tax outweigh the cost?"). In our paper we will not distinguish between forming beliefs and actually taking an action. The citizens use this information to take the action that maximizes their expected utility. That is, they wish to choose the action that is best for them given their updated beliefs about what the true state of the world conditioned on the information they receive through the media market. In this paper we then ask the following questions: How does the structure of ownership affect the transmission of information and the quality of the signal received by the decision maker? Does the information that is received depend on the market structure or the ownership structure and if so can we characterize the comparative statics of that ownership structure on the quality of the decision being made by the citizen? We continue in this section with an exposition of Blackwell's approach and an example of exactly how we can apply it to different market structures and levels of information transmitted.

The Blackwell framework approaches the world as a statistical problem and assumes that the decision maker is a rational Bayesian expected utility maximizer as axiomatized in the classic work of Savage (1954). That is, the primary concept here is that there is a set of states of the world, S, and a set of actions, A, that can be chosen by a decision maker. Given that the state of the world is s and the decision-maker chooses action a, the decision maker receives a utility of that choice which is denoted $U(a, s)$. The decision maker has a prior probability distribution over the state's $p(s)$ where for all $s \in S$, $p(s) \geq 0$ and $\sum_{s \in S} p(s) = 1$. Given any choice that induces a random utility outcome over the states, the consumer chooses an action to maximize the following expected utility function:

$$\sum_{s \in S} p(s) U(s, a).$$

In this section will assume that the state and signal spaces are finite. However, this is only to aid the exposition. In the following sections we will use convex compact state spaces and continuous probability measures rather than sums, but the concepts are the same.

There is a set of possible signal outcomes denoted T with generic element t. An *experiment* or *signal* or in our context *media information transmission,* is a random variable or a $n \times k$ Markov Matrix $[X]$ where x_{ts} is the probability of observing signal t when the true state of the world is s. That is, for all (t, s) $x_{ts} \geq 0$ and for all states $s \in S$ $\sum_{t \in T} x_{ts} = 1$.

Given a signal matrix $[X]$, a decision maker will upon observing the signal outcome t update her belief about the probabilities of the true state $q(s|t)$, that is, form a posterior distribution via Bayes Law. She will then choose an action to maximize her expected utility:

$$\max_{a \in A} \sum_{s \in S} q(s|t) U(a, s).$$

Let the path of action $a^*(X, t)$ be the solution to the maximization problem, that is the optimal action given information structure $[X]$ after observing signal t. Define the *value of experiment* or information structure $[X]$ as:

$$V(X) = \sum_{t \in T} \sum_{s \in S} x_{ts} U(a^*(X, t), s).$$

under the economic criterion, we will say that X^1 *is more informative than* X^2 or $X^1 \succeq X^2$ if $V(X^1) \geq V(X^2)$, that is if the decision maker has at least as high an expected utility upon acting on the signal X^1 as acting on the signal X^2. Blackwell's statistical definition follows. We will say that X^1 *is a sufficient statistic for* X^2, or $X^1 \supset X^2$, if $[X^1][M] = [X^2]$ for some Markov matrix M. Intuitively this means that X^2 is equal to X^1 plus some noise.

We can now state the theorem:

Proposition 1 *Experiment* $[X^1]$ *is more informative than experiment* $[X^2]$ *if and only if* $[X^1]$ *is a sufficient statistic for* $[X^2]$. *That is,* $X^1 \succeq X^2$ *if and only if* $X^1 \supset X^2$

To illustrate the power of this approach, consider a simple example where the decision maker must choose between two actions "High" and "Low." There are two states of the world. In state s_H, High is the optimal action and in state s_L, Low is the optimal action. Assume that the utility of choosing the optimal action is 1 and the utility of choosing the suboptimal action is 0. Suppose that signals can have three values High, Medium or Low. The prior belief is that each state is equally likely. Consider the two experiments $[X]$ and $[Y]$ below.

TABLE A.4a: Signal [X]

	$\mathbf{x_H}$	$\mathbf{x_M}$	$\mathbf{x_L}$
$\mathbf{s_H}$	1/2	1/2	0
$\mathbf{s_L}$	0	1/2	1/2

TABLE A.4b: Signal [Y]

	$\mathbf{y_H}$	$\mathbf{y_M}$	$\mathbf{y_L}$
$\mathbf{s_H}$	1/3	1/3	1/3
$\mathbf{s_L}$	1/3	1/3	1/3

In this case $[X]$ is preferred to $[Y]$. To see this, consider observing the signal x_H. The agent knows that the true state is s_H and so the agent chooses "High." Similarly if the agent observes s_L she knows the state is s_L and she choose Low. Observing X_2 she knows each outcome is equally likely, so she randomizes. Notice that the subject picks the optimal action 75% of the time. Now consider experiment $[Y]$. As it is equally likely that that signal was generated in either state, the signal provides the subject no basis to revise her prior and so the optimal action is to just pick an action independent of the signal (or randomize). Thus under experiment $[Y]$ the agent makes the correct decision with probability 50%. Therefore, she has a lower level of expected utility.

The most informative signal of course is where we learn every state precisely, called *"Full Information. "* We will refer to a full information signal as $[I]$ because such a signal is equivalent to the Identity matrix where there is a re-labeling of states after we eliminate redundant signals. The matrix of probabilities is the matrix I with 1 on all the diagonal elements and 0 for all the off-diagonal entries. In this case, the signal spans the state space. The opposite extreme is the example $[Y]$ above, that is the matrix where every element is $1/n$. In this case, we learn nothing from the signal and the decision maker continues to hold her prior belief after every signal. That signal will be labeled $[J]$ for *jamming signal* although we could also label it a *Spamming Matrix* as it spans the null space. It will be shown in the next section that the media outlets will either use $[I]$ or degenerate uninformative signal as conditional signals.

TABLE A.4c: Signal [I] "Full Information"

	$\mathbf{I_H}$	$\mathbf{I_M}$	$\mathbf{I_L}$
$\mathbf{s_H}$	1	0	0
$\mathbf{s_L}$	0	0	1

TABLE A.4d: Spamming Matrix [J]

1/3	1/3	1/3
1/3	1/3	1/3
1/3	1/3	1/3

Now notice that $[X] \cdot [J] = [Y]$, that is we obtain experiment $[Y]$ by applying the operator $[J]$ to $[X]$ which dilutes the information transmission.

It is worth reminding the reader at this point what we do not need to know to make welfare comparisons. In particular Blackwell's Theorem does not require us to know the utility function, the decision maker's prior preference, or her beliefs. If we can show that one experiment is a sufficient statistic for another, then it is welfare improving. In the following we demonstrate that we can use this insight to rank equilibria in media markets. Therefore in the models and experiments below we can in a precise manner state arguments like "a market with four independent firms is better than with two" and "in our experiments, the market with six firms performed better than the market with four firms. "

4.2 Strategic Information Disclosure

Blackwell's Theorem provides us with a methodology to evaluate the quality of information transmitted in a market, but it assumes that the signal comes from a neutral source rather than a firm that may have an agenda. The link to an economic model is provided by the seminal works of Milgrom (1981), Grossman (1981) and Jovanovic (1982). In Milgrom's model one agent (a sender, who we can think of as a salesman) has observed the value of a random variable $x \in X$ and chooses to make a report to a second agent (a receiver, who we can think of as a buyer). Given the information, the buyer then must make a decision to purchase a good or not. The higher the value of x the higher the quality of the good and the more valuable it is to the buyer. The salesman can report any signal that contains the truth, but only earns a commission if the buyer buys. Thus the salesman would like to bias the buyer towards a purchase. We assume that he can report any $R \subset X$ with $x \in R$. Thus, the salesman cannot deliberately lie but can be very uninformative by reporting a large R. Notice in particular that if $R \subset R'$ then report R is more informative than report R' in Blackwell's sense. Milgrom's remarkable result is that the salesman should report the simple truth, x. The logic is known as "unraveling." That is, if they buyer sees some set R he knows the true value is in R and so she will form some expectation of the true value in that set. But such an expectation will be below the largest element in R and so the true value cannot be the maximum -otherwise the salesman should have just reported that maximum point and thereby increased the chance of a sale - but then it cannot be the second highest point in R either, and so on... In equilibrium, the only consistent beliefs are that on seeing a set R the truth is the worst point in R. That is, "no news is bad news." This leads to the paradoxical conclusion that the salesman cannot gain by withholding information.

In our context, it means that even with a monopoly information provider who has an incentive to manipulate the decision maker, the equilibrium is full information revelation and therefore by Blackwell's Theorem, fully efficient! The key innovation that Milgrom developed is to have the decision maker correctly condition on what she does not know given the incentives of the sending party. The implication of this analysis for media market is drawn out in a subsequent paper by Milgrom and Roberts (1986) who note that "it has been argued that free and open discussion or competition in the market for ideas will result in the truth being known and appropriate decisions being made and this feature arises naturally in our model."

However, Milgrom's unraveling result depends on some strong key assumptions. In particular the buyer/decision maker knows the bias of the sender, the information structure is common knowledge, and the sender always knows the true value of x. If there is some small probability that the sender does not know the true value then we shall show that complete unraveling fails. Finally there is the "grain of truth" assumption that the sender cannot deliberately mislead the receiver by giving false information- only fuzzy information is allowed. In the following models we will adapt Milgrom's model to the case of media competition, but relax his key assumptions. First we will allow for the possibility that there is "no news" so that when an uninformative signal is observed it could simply be that the sender is uniformed. In our second model we will allow for some specific type of "disinformation" or signal jamming, such that one media firm can confuse the voter -at a cost- by contradicting the signal sent by another media outlet. With these adaptations we find that unraveling still occurs but not to a full extent and that, in equilibrium, the media will either be fully informative or uninformative. Therefore, by Blackwell's theorem all we have to do is measure the size of the set of states of the world where the signal is uninformative. If competition shrinks this set then it automatically increases welfare.

In addition to the seminal literature and works on media bias per se, there is related recent literature on product information disclosure in Industrial Organization and Marketing. Prominent recent papers include Sun (2010), Guo and Zhao (2009), and Board (2009). Sun deals with both horizontal product information (using the classic linear city model, witha monopolist of unknown location) and a quality dimension: first quality is assumed known, and then it isassumed unknown, although in the latter case she assumes that the firm must disclose either all information or none at all –she does not allow the decisions to be split up. Guo and Zhao (2009) address duopolists' incentives to reveal quality information, under the assumption that each is ignorant of the other's quality; Board (2009) does similarly assuming that theyknow each other's quality. The model we develop below is closely related

Board (2009).

5 Model Preliminaries

In the next sections we build three models to analyze the incentives of media outlets to withhold, garble or otherwise bias the information transmitted. All the models have a common basic structure which is developed here.

Consider two media outlets, or editors, that support opposite political policies or parties, A and B (media outlets and candidates will be indexed by i and j with $i \neq j$). With opposite editorial or political views, the media may be competing to influence citizens or decision makers who may be thought of as information consumers or voters. From now on, we will use the canonical case of parties and voters, although one should keep in mind that media outlets are the vehicle to express the information of parties. In particular, we adopt the model used in Political Science known as electoral competition with "ideology" and "valence." That is, there is a one dimensional policy space ranging from "Left" to "Right" and each voter has an ideal point or most preferred policy in that interval. For example we might think of the level of social service expenditure and taxation. Some voters will prefer a higher level of expenditure (and therefore high taxes) while other voters will prefer a lower level of expenditure (and lower taxes). The are two options, one of which must be chosen. We can think of political parties committed to implement these different policies. However, following Stokes (1963) the decision maker also cares about the quality or competence of the elected official. This property is known as "valence" in the political economy literature (see e.g., Groseclose (2001)). Thus voters have preferences over both the policy position of the parties and the quality or valence of each of the candidates. In particular a rational voter would prefer a competent- or high valence- official even if the policy is far from her ideal point, over an incompetent -or low valence- official who would implement a policy closer to her ideal. It is well known that in these spatial models with a majority rule electoral competition, the beliefs and preferences of the median voter determines the electoral outcome. Therefore it is common, even though we have in mind a large number of voters, to focus on the decision of a single citizen, the median voter, as it is the competition for the median voter that determines the final outcome. Formally, we introduce the following elements.

- *Quality* or *valence*. The valence or quality of candidate i is $\theta_i \in [\underline{\theta}, \overline{\theta}]$. We assume that θ_i is drawn from a distribution with c.d.f. $F_i(\theta_i)$.

- *Location* or *ideology*.The policy space is the unit interval $[0, 1]$. It is common knowledge that Media outlet A supports the candidate located at $z = 0$ and Media outlet B supports the candidate located at $z = 1$.

- *Voters' preferences.* For simplicity, we assume there is only one voter who is located at $z \in [0, 1]$. The utility for the voter of supporting candidate i is equal to the candidate i's quality minus the Euclidian distance between the voter's ideal position and the position of the candidate i. Formally, $u_z(A) = \theta_A - z$ if candidate A is elected and $u_z(B) = \theta_B - (1 - z)$ if candidate B is elected. Given such preferences a voter strictly prefers to elect candidate A if he is located at $z < z^*$ and candidate B if he is located at $z > z^*$ where z^* is given by:

$$\theta_A - z^* = \theta_B - (1 - z^*) \quad \Leftrightarrow \quad z^* = \frac{1}{2} + \frac{1}{2}(\theta_A - \theta_B)$$

We assume that the location of the voter is random. More precisely, z is drawn from a uniform distribution $z \sim U[0, 1]$. Naturally and as mentioned earlier, it is formally identical to consider a continuum of voters with z representing the location of the median voter.

- *Media owners' preferences.* Candidates only care about winning the election. Each media owner is interested in the probability that her preferred candidate (or viewpoint) wins. Denote by $\tilde{\theta}_i$ candidate i's expected quality inferred by the voter. As we will develop below, this quality may or may not coincide with the exact quality of candidate i. This inferred quality is what the voter uses for his decision. The utility of media outlet i, Π_i, is simply the probability that candidate i wins the election given the inferred qualities of both candidates:

$$\Pi_A = \Pr[z < z^*] = \frac{1}{2} + \frac{1}{2}(\tilde{\theta}_A - \tilde{\theta}_B) \text{ and } \Pi_B = \Pr[z > z^*] = \frac{1}{2} + \frac{1}{2}(\tilde{\theta}_B - \tilde{\theta}_A)$$

6 Model I: Disclosure under the veil of ignorance

6.1 Information and disclosure

Consider a situation where there are two media outlets, each of which has a "viewpoint." Formally, media outlet i would prefer to see a particular candidate i win the election. However the media outlet may not know the candidate's quality. More precisely, consider the following setting.

- *Information.* Media outlet i observes the exact quality of the candidate it supports with probability $1 - p_i$ (signal $\sigma_i = \theta_i$) and it observes nothing with probability p_i (signal $\sigma_i = \phi_i$).

• *Disclosure*. We take a very simple approach to disclosure. We assume that media outlets can withhold information regarding candidate i but cannot report false or inaccurate information. More precisely, the report $r_i(\sigma_i)$ of media outlet i given his signal is $r_i(\phi_i) = \phi_i$ and $r_i(\theta_i) \in \{\phi_i, \theta_i\}$. This means that whenever θ_i is observed, the media outlet has to choose between full or no disclosure. In particular and only for simplicity, partial disclosure (e.g., reporting an interval R_i such that $\theta_i \in R_i$) is not an option.

• *Timing*. We consider the following timing. First, nature chooses θ_A and θ_B and communicates $\sigma_i \in \{\phi_i, \theta_i\}$ to media outlet i. Second, parties simultaneously choose $r_i(\sigma_i)$. Third, the voter observes (r_A, r_B), updates his beliefs $\tilde{\theta}_A$ and $\tilde{\theta}_B$ and chooses which candidate i to vote for.

6.2 Equilibrium

First, notice that by definition $r_i(\phi_i) = \phi_i$. Therefore, we only need to determine $r_i(\theta_i)$. Second, media outlet i's utility is increasing in $\tilde{\theta}_i$ and decreasing in $\tilde{\theta}_j$, that is, a media outlet benefits when the perceived quality of his preferred candidate is high and the perceived quality of the rival candidate is low. In fact, given Π_i, the objective function of media outlet i is to maximize $\tilde{\theta}_i$. Third, suppose that the equilibrium involves $r_i(\theta_i) = \theta_i$ if $\theta_i \in \Theta_i$ and $r_i(\theta_i) = \phi_i$ if $\theta_i \notin \Theta_i$, where we put a priori no restrictions on the set Θ_i. It is immediate that the expected utility of media outlet i given signal $\sigma_i = \theta_i$, $\Pi_i(\theta_i)$, satisfies the following properties:

$$\Pi_i(\theta_i) = \Pi_i(\theta_i') \;\; \forall\, \theta_i, \theta_i' \notin \Theta_i \quad \text{and} \quad \Pi_i(\theta_i) \geq \Pi_i(\theta_i') \;\; \forall\, \theta_i, \theta_i' \in \Theta_i \;\; \text{with} \;\; \theta_i > \theta_i'$$

Indeed, when media outlet i reports ϕ_i, the voter's belief $\tilde{\theta}_i$ cannot depend on the realized quality. Conversely, when media outlet i reports θ_i, the belief becomes the true quality θ_i. These properties imply that if $\theta_i \notin \Theta_i$ then $\theta_i' \notin \Theta_i$ for all $\theta_i' < \theta_i$ and if $\theta_i \in \Theta_i$ then $\theta_i'' \in \Theta_i$ for all $\theta_i'' > \theta_i$. In other words, the optimal strategy of media outlet i must necessarily be a cutoff strategy, where there exists $x_i \in [0, 1]$ such that:

$$r_i(\theta_i) = \begin{cases} \phi_i & \text{if} \quad \theta_i \in [0, x_i) \\ \theta_i & \text{if} \quad \theta_i \in [x_i, 1] \end{cases}$$

We can now determine the optimal cutoffs (x_A, x_B). The first step consist in determining the posterior belief distribution of consumers when information is not reported. We have:

$$f_i(\theta_i \,|\, r_i = \phi_i) = \frac{\Pr(r_i = \phi_i \,|\, \theta_i) f_i(\theta_i)}{\int_0^1 \Pr(r_i = \phi_i \,|\, \theta_i) f_i(\theta_i) d\theta_i}$$

and therefore:

$$
\begin{aligned}
f_i(\theta_i \,|\, r_i = \phi_i) &= \frac{f_i(\theta_i)}{\int_0^{x_i} f_i(\theta_i)d\theta_i + p_i \int_{x_i}^1 f_i(\theta_i)d\theta_i} \quad \text{if} \quad \theta_i < x_i \\
f_i(\theta_i \,|\, r_i = \phi_i) &= \frac{p_i\, f_i(\theta_i)}{\int_0^{x_i} f_i(\theta_i)d\theta_i + p_i \int_{x_i}^1 f_i(\theta_i)d\theta_i} \quad \text{if} \quad \theta_i > x_i
\end{aligned}
$$

The expected value of θ_i inferred by consumers when information is not reported and given a cutoff x_i is then:

$$
\begin{aligned}
E_i[\theta_i \,|\, \phi_i; x_i] &= \frac{\int_0^{x_i} \theta_i\, f_i(\theta_i)d\theta_i + p_i \int_{x_i}^1 \theta_i\, f_i(\theta_i)d\theta_i}{\int_0^{x_i} f_i(\theta_i)d\theta_i + p_i \int_{x_i}^1 f_i(\theta_i)d\theta_i} = \frac{p_i\, E_i[\theta_i] + (1-p_i) \int_0^{x_i} \theta_i\, f_i(\theta_i)d\theta_i}{p_i + (1-p_i)F_i(x_i)} \\
&= \mu_i\, E_i[\theta_i] + (1-\mu_i)E_i[\theta_i \,|\, \theta_i < x_i] \quad \text{where} \quad \mu_i = \frac{p_i}{p_i + (1-p_i)F_i(x_i)}
\end{aligned}
$$

That is, the expected posterior is a weighted average of the expected prior and the expected posterior conditional on the media outlet having the information and deciding not to disclose it. The weights are given by the likelihood of not receiving the information and the likelihood of receiving the information but deciding not to disclose it.

The equilibrium of the disclosure game is the value x_i such that:[2]

$$
x_i = E_i[\theta_i \,|\, \phi_i; x_i] \tag{1}
$$

Indeed, if the voter anticipates a cutoff x_i, the utility of media outlet i is $\frac{1}{2}(1+\theta_i-\tilde{\theta}_j)$ if $r_i(\theta_i) = \theta_i$ and $\frac{1}{2}(1 + E_i[\theta_i \,|\, \phi_i; x_i] - \tilde{\theta}_j)$ if $r_i(\theta_i) = \phi_i$. Since, by construction, $E_i[\theta_i \,|\, \phi_i; x_i]$ is independent of θ_i, Media outlet i strictly prefers to report $r_i(\theta_i) = \phi_i$ for all $\theta_i < x_i$ and $r_i(\theta_i) = \theta_i$ for all $\theta_i > x_i$. The properties of the equilibrium cutoff as a function of the probability that the media outlet does not get the information, $x_i(p_i)$, are summarized below.

Proposition 2 *The cutoff $x_i(p_i)$ is unique, increasing in p_i and such that $x_i(0) = 0$ and $x_i(1) = E_i[\theta_i]$.*

[2] This result is reminiscent of Dye (1985), although in that paper the conditional expectation is derived heuristically and it turns out that the condition is incorrectly specified. It is also implied by the results of Anderson and McLaren (2010).

Proof. Let $A(x_i) = p_i x_i + (1-p_i) x_i F(x_i) - p_i E_i[\theta_i] - (1-p_i) \int_0^{x_i} \theta_i f(\theta_i) d\theta_i$. Equation (1) can be rewritten as $A(x_i) = 0$. Notice that $A(0) = -p_i E_i[\theta_i] \leq 0$, $A(1) = 1 - E_i[\theta_i] > 0$ and $A'(x_i) = p_i + (1-p_i)F(x_i) > 0$, which together proves the uniqueness. Also, let

$$B(P_i) = \frac{P_i E_i[\theta_i] + \int_0^{x_i} \theta_i f(\theta_i) d\theta_i}{P_i + F_i(x_i)} \quad \text{with} \quad P_i = \frac{p_i}{1-p_i}$$

Equation (1) can be rewritten as $x_i = B(P_i)$. Hence,

$$\frac{dx_i}{dp_i} \propto B'(P_i) = \frac{F_i(x_i)}{[P_i + F_i(x_i)]^2} \Big(E_i[\theta_i] - E_i[\theta_i \,|\, \theta_i < x_i] \Big) > 0$$

Finally, $x_i(0) = 0$ and $x_i(1) = E_i[\theta_i]$ are obtained immediately from (1). □

The intuition behind Equation (1) and Proposition 2 are simple. If parties always know their quality ($p_i = 0$), the standard no-news-is-bad-news unraveling argument of Milgrom (1981) and Milgrom and Roberts (1986) holds: the media outlet always has an interest in revealing the quality of a highest type candidate i, then so does the media outlet with a candidate of second highest quality, and so on. In equilibrium this implies full revelation (this result has been experimentally documented in Forsythe, Isaac and Palfrey (1989)). When $p_i > 0$, media outlets who know that their favorite candidate has low quality may pool with uninformed media outlets and choose not to disclose their information. In that case, no information revelation may occur in equilibrium even in the absence of a disclosure cost.[3] As media outlets become more likely to be (exogenously) uninformed, the incentives of informed media outlets to pool are higher, so the cutoff x_i increases. When media outlets almost never obtain information ($p_i \to 1$) voters infer the expected quality, so any media outlet i would choose not to disclose the quality of any candidate below $E_i[\theta_i]$. Finally, notice that the utility of media outlets, Π_i, is additively separable in the inferred qualities of both candidates, $(\tilde{\theta}_i, \tilde{\theta}_j)$. Therefore, there are no strategic considerations in the disclosure game, that is, the incentives to withhold information of one media outlet i do not depend on the disclosure decision of the other. In the next section, we will test whether informed subjects effectively choose to pool with uninformed ones in a controlled laboratory setting. These results are similar to those in Anderson and McLaren (2010). In that paper they also use a similar welfare measure to ours, although they include pricing for the media, they

[3]However, as shown by Anderson and McLaren (2010), this strategy can backfire when there truly is no news, and the media suffers from the "suspicion effect".

show that welfare increases with two media outlet owners versus a single monopolist owner who will supply only one viewpoint. A similar result obtains in our model. We finally illustrate the result with a simple analytical example.

Example 1 *Suppose that $\theta_i \sim U[0,1]$. Equation (1) becomes:*

$$x_i = \frac{p + (1-p)x_i^2}{2p + 2(1-p)x_i} \;\Leftrightarrow\; x_i = \frac{\sqrt{p} - p}{1-p}$$

7 Model II: Disclosure under the threat of sabotage

7.1 Information and disclosure

Consider the same setting as in section 5 and assume for simplicity that media outlets always observe the quality of candidates ($p_i = 0$).

- *Disclosure.* Just like before, media outlet i can decide whether to disclose ($r_i^i(\theta_i) = \theta_i$) or withhold ($r_i^i(\theta_i) = \phi_i$) the information regarding the quality θ_i of candidate i. The new option is that, in case of disclosure, media outlet j can now choose whether to allow ($r_i^j(\theta_i) = \theta_i$) or garble ($r_i^j(\theta_i) = \gamma_i$) the information regarding candidate i. If media outlet i discloses *and* media outlet j allows information, then the voter learns θ_i. Conversely, if media outlet i withholds *or* media outlet i discloses but media outlet j garbles the information, then the voter obtains no information. Information garbling captures the idea that a media outlet i can confuse the voters by adding noise to the news revealed by the opposing media outlet j. The situation is symmetric for media outlet j. To the best of our knowledge, this option is quite prevalent and yet has never been modeled in the literature before.[4] It is crucial to notice that, in the absence of information, the voter cannot determine whether it is due to withholding by a media outlet i or garbling by the opponent. Also, media outlet j cannot reveal information that has been withheld by media outlet i.

- *Costs.* We assume that media outlet i has a cost $d_i/2$ of withholding his information whereas media outlet j has a cost $c_i/2$ of garbling the information of media outlet i. In our view, it seems natural to assume that a media outlet needs to spend

[4]For example there are many websites with respectively left wing or right wing viewpoints that claim to document instances of misrepresentation by the media outlets.

resources to try and "mislead" the voter by either withholding evidence about himself or suppressing evidence about the opponent. However, our model encompasses other cases. Indeed, a cost to disclose a media outlet i's own information would simply correspond to a negative d_i and a cost to allow the other media outlet's information would correspond to a negative c_i. In particular we can think of these costs as reputation costs. That is, if the consumer learns that the firm has garbled or biased information, then it is an unreliable source and so the consumer is less likely to view or listen to that channel or station in the future, and so the firm's audience share and profits will fall.

- *Timing.* The new timing of the game is the following. First, each media outlet decides whether to disclose or withhold information about its own candidate. Second, if information is disclosed, the other media outlet decides decide whether to allow or garble that information. Third, the voter observes the information if and only if it was both disclosed and allowed. Otherwise she observes nothing and in particular cannot infer whether information was withheld or garbled. In either case, she decides which candidate to support.

7.2 Equilibrium

Consider the case $c_i \geq 0$ and $d_i \geq 0$. As in Model I, qualities are additively separable in the voter's utility function, so the incentives by either media outlet to act on the information of one candidate is independent of the quality of the other candidate. However and as we will see below, the incentives to withhold one's information will depend on the garbling strategy of the rival.

Following an analogous reasoning as in section 6, it is straightforward to notice that both media outlets i and j have cutoff strategies regarding the decision to withhold and suppress information on candidate i's quality. Formally:

$$r_i^i(\theta_i) = \begin{cases} \phi_i & \text{if} \quad \theta_i \in [0, \underline{y}_i) \\ \theta_i & \text{if} \quad \theta_i \in [\underline{y}_i, 1] \end{cases} \quad \text{and} \quad r_i^j(\theta_i) = \begin{cases} \theta_i & \text{if} \quad \theta_i \in [0, \overline{y}_i) \\ \gamma_i & \text{if} \quad \theta_i \in [\overline{y}_i, 1] \end{cases}$$

This means that, in equilibrium, the voter learns θ_i if and only if $\theta_i \in [\underline{y}_i, \overline{y}_i]$. In turn, it implies that the expected quality of media outlet i conditional on the voter not obtaining information is:

$$\begin{aligned} E_i[\theta_i \,|\, \phi_i, \gamma_i; \underline{y}_i, \overline{y}_i] &= E_i\Big[\theta_i \,|\, \theta_i \in [0, \underline{y}_i] \cup [\overline{y}_i, 1]\Big] = \frac{\int_0^{\underline{y}_i} \theta_i \, f_i(\theta_i) d\theta_i + \int_{\overline{y}_i}^1 \theta_i \, f_i(\theta_i) d\theta_i}{F_i(\underline{y}_i) + (1 - F_i(\overline{y}_i))} \\ &= \nu_i \, E_i[\theta_i \,|\, \theta_i < \underline{y}_i] + (1 - \nu_i) E_i[\theta_i \,|\, \theta_i > \overline{y}_i] \text{ where } \nu_i = \frac{F_i(\underline{y}_i)}{F_i(\underline{y}_i) + (1 - F_i(\overline{y}_i))} \end{aligned}$$

The equilibrium of the withholding/garbling information game is given by the pair of cutoffs $(\underline{y}_i, \overline{y}_i)$ that solves the following system of equations:

$$\begin{aligned} E_i[\theta_i \,|\, \phi_i, \gamma_i; \underline{y}_i, \overline{y}_i] - \underline{y}_i &= d_i && (2) \\ \overline{y}_i - E_i[\theta_i \,|\, \phi_i, \gamma_i; \underline{y}_i, \overline{y}_i] &= c_i && (3) \end{aligned}$$

In words, media outlet i prefers to withhold information if the resulting belief about his quality net of the withholding cost, $E_i[\cdot] - d_i$, is greater than his true quality θ_i. The cutoff $\underline{y}_i$ in equation (2) corresponds to the indifference point. Using a similar argument, Media outlet j garbles information when the negative impact in his utility of the belief and the cost, $E_i[\cdot] + c_i$, is smaller than the negative impact of allowing the true quality θ_i to become known. Again, the cutoff $\overline{y}_i$ in equation (3) corresponds to the indifference point. Notice that the choices of media outlets i and j are interrelated: media outlet i's cutoff affects the belief under no information which itself has an effect on j's cutoff, and viceversa. The properties of the cutoffs as a function of the costs of garbling and withholding, $\underline{y}_i(c_i, d_i)$ and $\overline{y}_i(c_i, d_i)$, have some interesting properties that are summarized below.

Proposition 3 *The cutoffs $\underline{y}_i$ and $\overline{y}_i$ are unique. When both the cost of garbling and the cost of withholding are nil, no information ever reaches the voter: $\underline{y}_i(0,0) = \overline{y}_i(0,0) = E_i[\theta_i]$. As either cost increases, there is both less garbling and less withholding: $d\underline{y}_i/dc_i < 0$, $d\overline{y}_i/dc_i > 0$, $d\underline{y}_i/dd_i < 0$, $d\overline{y}_i/dd_i > 0$.*

Proof. Let $(\emptyset)$ denote the situation where no information reaches the decision maker. If B reveals θ_B, A finds it optimal to garble when:

$$\frac{1}{2} + \frac{1}{2}(\theta_A - E_B(\emptyset)) - \frac{c}{2} > \frac{1}{2} + \frac{1}{2}(\theta_A - \theta_B) \quad \Leftrightarrow \quad \theta_B > \overline{y} \equiv E_B(\emptyset) + c$$

Provided A does not garble, it is optimal for B to reveal if

$$\frac{1}{2} + \frac{1}{2}(\theta_B - \theta_A) > \frac{1}{2} + \frac{1}{2}(E_B(\emptyset) - \theta_A) - \frac{d}{2} \quad \Leftrightarrow \quad \theta_B < \underline{y} \equiv E_B(\emptyset) - d.$$

Note that $E_B(\emptyset) = E\left[\theta_B \,|\, \theta_B \in [\underline{\theta}_B, \underline{y}] \cup [\overline{y}, \overline{\theta}_B]\right]$ and we have the following equality:

$$\underline{y} + d = E\left[\theta_B \,|\, \theta_B \in [\underline{\theta}_B, \underline{y}] \cup [\underline{y} + d + c, \overline{\theta}_B]\right]$$

or, equivalently:

$$H(\underline{y}, d, c) = (\underline{y} + d)[F(\underline{y}) + 1 - F(\underline{y} + d + c)] - \int_{\underline{\theta}_B}^{\underline{y}} s f(s) ds - \int_{\underline{y}+d+c}^{\overline{\theta}_B} s f(s) ds = 0.$$

We consider two cases.

Case 1: $c > 0$ and $d > 0$. We have $H(\overline{\theta}_B, d, c) > 0$ and therefore $\underline{y} < \overline{\theta}_B$. Moreover $H(\underline{\theta}_B, d, c) = d(1 - F(d+c)) - \int_{d+c}^{\overline{\theta}_B} sf(s)ds$ is increasing in d. Let $\hat{d}$ the point such that $H(\underline{\theta}_B, \hat{d}, c) = 0$. For all $d < \hat{d}$ we have $\underline{y} > \underline{\theta}_B$, and for all $d > \hat{d}$, we have $\underline{y} = \underline{\theta}_B$. Note also that $\frac{\partial H}{\partial \underline{y}} = F(\underline{y}) + 1 - F(\underline{y} + d + c) + df(\underline{y}) + cf(\underline{y} + d + c) > 0$, $\frac{\partial H}{\partial d} = F(\underline{y}) + 1 - F(\underline{y} + d + c) + cf(\underline{y} + d + c) > 0$ and $\frac{\partial H}{\partial c} = cf(\underline{y} + d + c) > 0$. Whenever the solution is interior (i.e. when $d < \hat{d}$), we have $H(\underline{y}, d, c) = 0$. Differentiating this equation with respect to d (respectively c), it comes immediately that the equilibrium lower cutoff $\underline{y}(d, c)$ is increasing in both c and d. Last, the equilibrium higher cutoff is $\overline{y}(d, c) = \underline{y}(d, c) + d + c$ and it is increasing in both d and c.
Case 2: $c > 0$ and $d < 0$. Note first that the problem is well defined if $d + c > 0$ (to guarantee that $\underline{y} < \overline{y}$). In that case $H(\underline{\theta}_B, d, c) < 0$ and therefore $\underline{y} > \underline{\theta}_B$. We have $H(\overline{\theta}_B, d, c) = 1 + d - \int_{\underline{\theta}_B}^{\overline{\theta}_B} sf(s)ds$ which is increasing in d. Let $\tilde{d}$ the point such that $H(\overline{\theta}_B, \tilde{d}, c) = 0$. For all $d < \tilde{d}$ we have $\underline{y} = \overline{\theta}_B$, and for all $d > \tilde{d}$, we have $\underline{y} < \overline{\theta}_B$.

We still have $\frac{\partial H}{\partial d} > 0$ and $\frac{\partial H}{\partial c} > 0$ but $\frac{\partial H}{\partial \underline{y}} \gtrless 0$. As long as d is small enough, the equilibrium lower cutoff $\underline{y}(d, c)$ is still increasing in both c and d. The equilibrium higher cutoff is now decreasing in d and its variations with c are ambiguous. □

As stated in Proposition 3, the solution to the system of equations (2) and (3) has a unique solution for any distribution $F_i(\cdot)$. Also, when both parties can withhold and garble quality at no cost, then no information gets ever transmitted to the voter, again independently of the distribution from which the quality is drawn. Indeed, media outlet i has always incentives to withhold the worst possible information of candidate i and media outlet j to garble the best possible information of candidate i (and viceversa for information regarding candidate j). An unraveling argument applies simultaneously to both sides, which results in a complete suppression of information by one of the media outlets. Not surprisingly, as the cost of information withdrawal increases, media outlet i has less incentives to withhold average information, which formally results in a decrease in the cutoff $\underline{y}_i$. More interestingly, this decrease in $\underline{y}_i$ implies less incentives for media outlet j to garble information. Indeed, when no information reaches the voter, it may mean either very low quality (withheld by media outlet i) or very high quality (garbled by media outlet j). If media outlet i withholds less information then no information is more likely to reflect high quality. In other words, the expected quality of media outlet i conditional on no information reaching the voter increases. This in turn means that garbling information is relatively less profitable for media outlet j, who therefore has less incentives to do so. Formally, $\overline{y}_i$ increases. We illustrate the result with a simple example.

Example 2 *Suppose that $\theta_i \sim U[0,1]$. Equations (2) and (3) become:*

$$\frac{\underline{y}_i^2 + (1-\overline{y}_i^2)}{2\underline{y}_i + 2(1-\overline{y}_i)} = \underline{y}_i + d_i \quad \text{and} \quad \frac{\underline{y}_i^2 + (1-\overline{y}_i^2)}{2\underline{y}_i + 2(1-\overline{y}_i)} = \overline{y}_i - c_i$$

$$\Leftrightarrow \quad \underline{y}_i = \frac{(1-d_i)^2 - c_i^2}{2} \quad \text{and} \quad \overline{y}_i = \frac{1 + d_i^2 - c_i^2 + 2c_i}{2}$$

8 Model III: Disclosure, Competition and Reputation Costs

Now we consider that the costs introduced in the last section are indeed *reputation costs*. That is, there is some loss in audience share for any media outlet that engages in biasing or garbling of information. However, our key point is that the consumer must be able to learn who is the "garbling" media outlet and which media outlet is being informative.

Suppose that the market structure has just two firms, one representing each viewpoint. If media i provides an uninformative signal regarding candidate i (i.e., it withholds information) the consumer cannot turn to media j to get that information (and similarly with candidate j). Suppose now that there are four firms, with two firms of each viewpoint. Suppose also that media outlets 1 and 2 favor candidate A and firms 3 and 4 favor candidate B. In addition suppose that the consumer faces a (perhaps very small) cost of getting multiple sources of information from the same viewpoint. Assume that if the consumer is indifferent between two information sources then she randomizes and views either with a 50/50 probability. We will call this the assumption of "Informational Bertrand Competition." We augment the model with a value of the audience M for each viewpoint. If a single firm captures all the audience for that viewpoint then it earns M in addition to the payoff above. If both firms capture an audience then the payoff is $M/2$. Suppose now that firms 1 and 2 choose different cutoff strategies, in particular $\underline{y}_1 < \underline{y}_2$. That is, firm 1 is more informative than firm 2 even though they both have the same viewpoint. In equilibrium, the consumer is aware of the strategies being played by the firms (although not the value of the private information), and given the cost of multiple sources will choose firm 1. Note that there is no benefit from a second sourcing with firm 2 because whenever firm's 1 signal is uninformative, so is firm 2's. Therefore we conclude that (i) the strategy of firm 2 cannot influence the decision maker, and (ii) firm 2 receives no audience share. Thus, there is no benefit from biasing the decision maker and firm 2 incurs the cost of lost market share. But now consider any interior point where the firms are splitting the audience 50/50. If firm 1 was to change its strategy so that it becomes informative on a slightly larger set then it would now capture 100% of the market, and the set of signals on which the consumers action changes can be made arbitrarily small. Thus we cannot have an equilibrium with incomplete information transmission. We have established the following result.

Proposition 4 *Suppose that there are multiple firms with the same viewpoint and in the equilibrium some information is transmitted. Then the cutoffs* $\underline{y}_i$ *and* $\overline{y}_i$ *are unique and identical for firms with the same viewpoint. Moreover under Informational Bertrand Competition the equilibrium becomes fully revealing, that is, all firms transmit their information for every signal.*

Proof. Consider firms 1 and 2 and fix the strategies of firms 3 and 4. If both firms have an audience then the consumer must be indifferent between firm and 1 and 2. Now fix $\overline{y}_1$ and $\overline{y}_2$ and assume that $\underline{y}_1 < \underline{y}_2$. Then notice that if the consumer was indifferent between firms 1 and 2 if firm 2 lowers $\underline{y}_2$ then the consumer will receive more information and so receive a higher expected utility from firm 2. Therefore, the consumer will choose to get information from firm 2 exclusively which increases firm 2's utility by $M/2$. However firm 2 also saves the incremental cost of withholding on a smaller set and at the first order conditions for $\underline{y}_2$ at an interior equilibrium the marginal benefit of withholding - influencing the consumers decision- is equal to the marginal cost. Therefore, firm 2 strictly benefits from changing its strategy. A similar argument applies to establish $\overline{y}_1 = \overline{y}_2$. A symmetric argument applies to firms 3 and 4. Now suppose that we have a symmetric interior equilibrium where less than full information is being disclosed. In particular suppose that $\overline{y}_1 = \overline{y}_2 < 1$. Then the consumer is indifferent between firms 1 and 2 and will source her information from only one of them. Again at an interior equilibrium the marginal cost of garbling on larger set equals the marginal gain from the incremental probability of changing the consumers decision. However by marginally increasing $\overline{y}_1$ firm 1 captures all the market and so increases its profits discretely by $M/2$. Thus again there will be an unraveling as firms 1 and 2 compete for market share. The symmetric argument applies to both $\underline{y}_i$ and firms 3 and 4. Therefore the equilibrium involves full information revelation. □

Informational Bertrand Competition is obviously an extreme assumption, but it obtains a strong result: full information efficiency with two firms of each viewpoint.

Like the standard Bertrand model, we think of this as being a benchmark that provides useful insights. In particular it may be that there is still an increase in informational efficiency and social welfare as we move above 4 independent owners or firms. That is, if consumers do not perfectly know each firm's strategy, but rather learn from their history of behavior it may be that there is an incremental benefit from more competition. Similarly if firms viewpoints are drawn at random and the existing firms in the market all have the same viewpoint then introducing a fifth firm could add viewpoint diversity and a sixth firm with that under-represented viewpoint will induce competition. This would result in a probabilistic increase in welfare. To address these concerns we adopt experimental techniques, as reported in the next sections.

9 Experimental design and procedures

We tested in the laboratory Models II and III, from now on labeled experiments 1 and 2. Although Model I provides the basic framework for our analysis we did not test it for two reasons. First, it is closest to the existing theoretical and experimental literature (Forsythe, Isaac and Palfrey, 1989), so the gains of a new test are smallest. Second, it provides a reason for non-disclosure (veil of ignorance) which, in our view, is interesting but less relevant for the application to competition and the structure of media ownership than the other two models. Since, we are primary concerned with the effect of media *competition* on information provision, we decided to concentrate on the other two models.

We conducted 2 sessions of experiment 1 with a total of 24 subjects and 2 sessions of experiment 2 with a total of 29 subjects. Sessions were conducted at the Computer Laboratory of the Economics Department at the University of Southern California. Subjects were a mixed of registered undergraduate and graduate students at the University of Southern California who were recruited with in-class announcements and by email solicitation. All interaction between subjects was anonymous and computerized, using an extension of the open source software package 'Multistage Games.'[5] No subject participated in more than one session. For each session in experiment 1, twelve subjects were randomly assigned in groups of three for each match, with random rematching after each match. In experiment 2, subjects were randomly assigned in either groups of five (session 3) or seven (session 4) at the beginning of the session and remained in the same group until the end of

[5] Documentation and instructions for downloading the software can be found at http://multistage.ssel.caltech.edu.

the experiment. Table 1 displays the pertinent details of the four sessions.

Session	date	experiment	# subjects	group size	matching
1	01/19/2011	1	12	3	random
2	01/19/2011	1	12	3	random
3	01/19/2011	2	15	5	fixed
4	01/19/2011	2	14	7	fixed

Table 1: Session details

At the beginning of each session, instructions were read by the experimenter, which fully explained the rules, information structure, and computer interface.[6] After the instructions were finished, one practice match was conducted, for which subjects received no payment. After the practice match, there was an interactive computerized comprehension quiz that all subjects had to answer correctly before proceeding to the paid matches.

9.1 Experiment 1

The experimental game closely followed the Model II setting described in section 7 above. At the beginning of each match, each subject in a group was randomly assigned a role as either A, B or C. A number was then drawn randomly from a uniform distribution between 0 and 100. This number, called state, was disclosed to the players with roles A and B.[7] They had to decide independently and simultaneously whether to disclose the state to agent C. If A (respectively B) decided not to transmit the information, he incurred a cost c_A (respectively c_B) that was deducted from his final payoff. These costs were known from all participants in the group but they varied as will be detailed below. The state was disclosed to C only when *both* A and B decided to transmit the information. If at least one agent decided not to transmit, then C would observe "state is unknown" but not the identity of the player responsible for the no-transmission. The act of no-transmission thus captures both "withholding" and "garbling" in the terminology of section 7. The crucial factor is that information remains unknown it *at least one* agent does not transmit it. The

[6] Sample copies of the instructions are attached in the Appendix.

[7] As we will see below, payoffs are constructed in a way that the state can be understood as $\theta_A - \theta_B$, the difference between the qualities of candidates A and B. Since θ_A and θ_B enter additively in the media outlets' utility function, considering a uni-dimensional state parameter ($\theta \equiv \theta_A - \theta_B$) simplifies the exposition without affecting the main conclusions.

subject with Role C had then to choose a number between 0 and 100. The payoffs of subjects in roles A, B and C, denominated in points, were respectively:

$$\pi_A = z, \quad \pi_B = 100 - z, \quad \pi_C = 100 - \frac{(z-\theta)^2}{40}$$

where z is the action taken by C and θ is the state (revealed to C or not). Notice that these payoffs constitute a reduced-form representation of the payoffs in Model II. In particular, they imply that the participant with Role A wants to maximize the action chosen by C, the participant with Role B wants to minimize it while the best strategy of the participant with Role C is to choose an action equal to the expected value of the state given the information he observes. Trivially, when the state is disclosed, the optimal action is to choose a number equal to the true state. We chose to endow role C with a quadratic scoring rule because we thought it was easier to explain this reduced-form payoff rather than the more elaborate median voter preferences. Notice that the objective was *not* to test whether subjects realize that the quadratic scoring rule is "proper", in the sense that it is optimal to report your expected belief. Instead, we did explain in detail during the instructions that the quadratic rule has this property and asked one question in the quiz to make sure they understood it. The goal was to encourage subjects in role C to report their expected belief about the state, and to encourage subjects in roles A and B to try and bias that expected belief with their decision to transmit or not the information.

Given this design, the equilibrium strategy of all players follows the basic principles described previously. The participant with Role A should withhold low values while the participant with Role B should withhold high values. A non-informed participant with Role C should infer that either A or B had incentives to withhold the state and choose the expected value taking this piece of information into account.

Subjects participated in 45 paid matches, with opponents and roles randomly reassigned and states randomly drawn at the beginning of each match. The design included three blocks of fifteen matches, where the cost pairs (c_A, c_B) were identical within blocks and different across blocks. The three cost pairs were the same in both sessions. Namely, we considered the pairs $(0,0)$, $(40,0)$ and $(40,40)$. However, to control for order effects, the sequence in the second session was modified to $(40,40)$, $(0,0)$ and $(40,0)$. Subjects were paid a \$5 show-up fee and the sum of their earnings over all 45 paid matches, in cash, in private, immediately following the session at the exchange rate of 160 points = \$1.00. Sessions averaged one hour and a half in length, and subject earnings averaged \$21.

9.2 Experiment 2

The experimental game 2 closely followed the Model III setting described in section 8. We also ran two sessions of this experiment in which subjects formed 3 groups of 5 and 2 groups of 7 respectively. At the beginning of the session, groups were formed and each subject in a group was randomly assigned a role as either A, B or C. In groups of 5, two players were assigned Role A and two players were assigned Role B. In groups of 7, three players were assigned Role A and three players were assigned Role B. In either case, one player was always assigned Role C. The groups and roles remained fixed for the entire session. In each match, two numbers were then drawn randomly from a uniform distribution between 0 and 100. One of these numbers, called state A, was disclosed to all the players with role A. The second number, called state B, was disclosed to all the players with role B. All players in Roles A and B had then to decide independently and simultaneously whether to disclose the corresponding state to agent C or not. There were no costs associated with withholding information in this experiment. The remaining player C could then view the decision of players in roles A and B. More precisely, by clicking on a button hiding the information relative to a player with role A, state A was revealed to C if that player decided to transmit, and the computer reported that the state was "unknown" if that player decided to withhold. That is, whenever the state was reported unknown, C could infer that the player decided to withhold the information. The same applied to state B and players with Role B. Revealing the decisions of a player in role A or B was costly to C but yielded a benefit to that player. The costs varied as we will detail below. Player C had to take two actions consisting in choosing two numbers between 0 and 100. The payoffs, denominated in points of subjects in roles A, B and C were respectively:

$$\pi_A = 50 + z_A - z_B + b_A, \quad \pi_B = 50 + z_B - z_A + b_B, \quad \pi_C = 120 - \frac{(z_A - \theta_A)^2}{40} - \frac{(z_B - \theta_B)^2}{40} - k$$

where θ_i is state i, z_i is the action taken by C regarding state i, b_i is a variable that takes value 0 if C did not view that player's decision and 20 if he did, and k is the total cost paid by C for viewing the decisions of the A and B players. According to these payoffs, subjects with role A want C to take a high action z_A and a low action z_B whereas subjects in role B want the opposite, although with their transmission / withholding decision they can only influence the action regarding their own state. Moreover, each subject with role A or B wants C to view his own decision in order to obtain the extra payoff. This captures reputation effects. Finally and as in experiment 1, the quadratic scoring rule implied that subjects in role C should take the action closest to their expected belief of the state. Again, this was clearly explained in the instructions. Unfortunately and as we will develop below, some subjects in sessions 3 and 4 did not seem to comprehend that aspect of the game.

In both sessions, subjects participated in 40 paid matches, with states randomly drawn at the beginning of each match. The design included two blocks of twenty matches, where the cost for C of viewing the decisions of A and B were identical within blocks and different across blocks. In the session with groups of five participants, in the first block, viewing the decision of one A player had cost 5 and viewing the decision of a second A player had cost 30. Viewing the decision of one B player had cost 10, and viewing the decision of a second B player had cost 50. The costs for viewing decisions by A and B players were reversed in the second block. In the session with groups of seven participants, Role C could reveal the decision of at most two players with Role A and at most two players with Role B. The costs were the same as in the session with groups of five participants. Sessions averaged one hour and a half in length. Subjects were paid a \$5 show-up fee and the sum of their earnings over all 40 paid matches, and their earnings averaged \$20.

10 Results of experiment 1

10.1 Aggregate analysis

We first conducted an aggregate analysis of the experimental data. Our objective was to determine whether actual decisions were close to our theoretical predictions for each of the roles and for each pair of costs. From now on, the cost pairs (c_A, c_B) we used in the experiments, namely $(0, 0)$, $(40, 0)$ and $(40, 40)$, will be denoted LL, HL and HH where L stands for 'low' and H for 'high'. Table 2 summarizes the theoretical predictions using the analytical expression derived in Example 2. In each case, subjects in Role A should withhold low values of the state θ while subjects in Role B should withhold high values of θ. The optimal decision of C is to choose an action equal to the true state when it has been transmitted by both A and B. When the state is not transmitted, C should report the expected value of θ conditional on observing no transmission.

Not surprisingly, subjects are supposed to withhold less frequently when their cost increases. In our case, A's cutoff decreases as we move from LL to HL and B's cutoff increases as we move from HL to HH. Perhaps more subtly and as already discussed in the theory section, costs are strategic complements: an individual is less likely to withhold information as the cost of the other individual increases. In our case, A's cutoff decreases as we move from HL to HH and B's cutoff increases as we move from LL to HL.

	LL	HL	HH
A withholds	$\theta < 50$	$\theta < 18$	$\theta < 10$
B withholds	$\theta > 50$	$\theta > 58$	$\theta > 90$
C's action if uninformed	50	58	50

Table 2: Theoretical Predictions

Figures 1, 2 and 3 represent the distributions of the behavior of players in Roles A and B for each pair of costs. Due to the relatively small number of observations, we grouped the states in bins of 10, that is, [0-10], [11,20], [21,30], etc. For each bin, we computed the proportion of times players in each role withheld the information. The figures also report the total number of observations in each bin. We can see that the decisions are qualitatively consistent with the theoretical predictions. For instance in the LL configuration, Nash equilibrium theory predicts that subjects in Role A would withhold information with probability 1 if the state was below 50 and with probability 0 if the state was above 50. Predictions in Role B were reversed. Naturally, the empirical behavior does not exhibit such extreme behavior of either always or never withholding. However, we still notice a sharp decline near the equilibrium threshold 50. A similar decline is observed in the other two cost configurations. To formally test for differences between theoretical predictions and empirical behavior, we ran McNemar's χ^2 tests to compare the actual decision to "Withhold" or "Transmit" with the Nash equilibrium in each trial for each Role and under each cost configuration. Differences were not statistically significant for LL under either role. For HL, differences were statistically significant at $p < 0.01$ for Role A and at $p < 0.05$ for Role B. Finally, for HH the differences were again statistically significant at $p < 0.01$ for Role A and significant at $p < 0.1$ for Role B.

Table 3 presents a different look at the same data. It summarizes the number of instances where only A, only B, both A and B and neither A nor B transmitted information. It also compares these observations with the theoretical predictions.

	LL		HL		HH	
	theory	emp.	theory	emp.	theory	emp.
Only A withholds	61	44	15	20	15	26
Only B withholds	59	46	50	53	13	18
Both A and B withhold	0	18	0	6	0	1
Both A and B transmit	0	12	55	41	92	75

Table 3: Withholding strategies

Again, the table suggests that empirical behavior matches reasonably well the theoretical predictions. Perhaps the most noticeable difference is that, contrary to the theoretical predictions, both agents sometimes choose simultaneously to withhold information. However, this occurs in less than 7% of the observations.

We then studied the effect of a change in the costs of withholding on the decision to withhold. To analyze the effect of the cost faced by a player on his own behavior, we compared the decision of players with Role A under LL with their decisions under HL and the decision of players with Role B under HL with their decisions under HH. We used a two-sample Wilcoxon test to test for the equality of the distributions of behavior and found that in both cases the distributions were significantly different at $p < 0.1$. To analyze the more subtle effect of the cost of the rival, we compared the decision of players with Role A under HL with their decisions under HH and the decision of players with Role B under LL with their decisions under HL. Contrary to the theoretical predictions, we found no statistical difference between the two distributions in either case.

To complete the analysis, we ran a Probit regression of the decision of players in Roles A and B as a function of the state and the cost parameters. The results are reported in Table 4. For each role, the player's own cost of withholding had a negative and significant effect. Also, subjects in Role A withheld significantly less often the higher the state whereas subjects in Role B withheld significantly more often the higher the state. This is consistent with the results we already reported. The indirect effect of the rival's cost on a player's probability of withholding had the correct (negative) sign but was not statistically significant, again in line with the results of the Wilcoxon test.[8]

Result 1 *The decision of subjects in Roles A and B to withhold information is remarkably close to the theory predictions, with the state being rarely revealed in the absence of a cost of withholding. Subjects' reaction to an increase in their own cost is also remarkably close to the theoretical predictions. However and contrary to equilibrium theory, subjects do not react to an increase in the rival's cost.*

We started the study of the behavior of agents in role C by checking whether they choose a decision equal to the state whenever it was transmitted. They overwhelmingly do, as we found only one mistake by one player in the first round of a session. Naturally, the more interesting analysis consists in studying the behavior

[8] Instead of a "reduced-form" Probit estimation, it could be also interesting to build a stochastic choice model that could then be structurally estimated (as for example in Quantal Response Equilibrium (McKelvey and Palfrey, 1995)).

	A witholds	B withholds
State	-0.0401***	0.0415***
	(0.00636)	(0.00619)
Cost of A	-0.0291***	-0.00613
	(0.00778)	(0.00541)
Cost of B	-0.00335	-0.0387***
	(0.00415)	(0.00723)
Constant	2.073***	-1.925***
	(0.356)	(0.371)
N	360	360
Pseudo R^2	0.411	0.437

Clustered standard errors in parentheses
*** $p < 0.01$

Table 4: Probit analysis

when C is not informed about the state. Table 5 reports some basic statistics in this case.

	LL	HL	HH
# obs.	108	79	45
Mean	54.37	55.83	55.44
Std. Dev.	16.85	19.05	20.77

Table 5: Action by Role C

Remember from Table 2 that C should choose actions 50, 58 and 50 under LL, HL and HH respectively. The empirical decisions are, on average, relatively 'close' to each other and to the theoretical prediction. To analyze differences more rigorously, we used a Wilcoxon test to test for the equality of the actual decisions and the theoretical prediction. For LL and HH the hypothesis was rejected at $p < 0.05$ and $p < 0.10$ respectively, suggestion that actions by C are higher than predicted. The same test showed that under HL differences between actual choices and Nash theory are not statistically significant. It is also interesting to determine whether empirical choices are different for the different cost pairs. Again, we performed a series of Wilcoxon tests and found that differences in the distribution of behavior between LL and HH and between HL and HH are not statistically significant but that differences between LL and HL are significant at $p < 0.10$.

Figure 4 depicts the cumulative distribution function of the decision made by subjects with Role C for each pair of costs. Notice that for LL there is a substantial fraction of players choosing exactly 50. This is also the case for HH, although the proportion of observations in [51-80] is larger in that case (around 25%). Finally, it is interesting to notice that in HL, the two modal choices are 50 and 60, although the dispersion of choices is substantially larger. The result can be summarized as follows.

Result 2 *Subjects in Role C play on average according to theory when they do not know the state. However, there is substantial dispersion in their behavior.*

Overall, the aggregate analysis suggests that behavior is reasonably in line with our predictions, which implies that when two medias with opposite objectives can garble information which is contrary to their interests, they will do it. This results in very little information transmission in equilibrium. For the case of Roles A and B, subjects understood the simpler strategic aspects of the game (the effect of their cost on the decision to transmit information). Nevertheless, their choice does not reflect variations in the cost of the rival, which is a more subtle consideration. Subjects in Role C make decisions that are also close to Nash theory. A fraction of players also seem to realize that in the asymmetric case (high cost for A and low cost for B) withholding is more likely to come from B and react by choosing higher actions. However, the aggregate differences are small. Also, the behavior is more erratic which translates into a larger dispersion of choices. In general, we notice an attempt by C to base the decision on the information that is observed. If players C were neglecting the fact that A and B act strategically, their action would be to choose 50 in all scenarii.

10.2 Individual analysis

Our next step of the analysis consists in looking at the data at the individual level. First, we determine whether subjects employ stable cutpoints strategies. Indeed, for each state subjects in roles A and B need to choose whether to withhold or transmit the state. It seems natural that if a subject in role A transmits state x, she should transmit all states that are more favorable than x (that is, all $x' > x$) and if she withholds state y, she should also withhold all states that are less favorable than y

(that is, all $y' < y$). The symmetric reasoning should apply to subjects in role B. We look at the behavior of each individual in each role and for each pair of costs separately and determine whether there is a stable cutpoint (optimal or not) that could rationalize their choices. The results are presented in Table 6.

session	1			2		
costs	LL	HL	HH	LL	HL	HH
Role A	8	11	12	11	11	11
Role B	7	11	12	11	10	11

number of subjects per role and cost pair is 12

Table 6: Individuals using cutpoint strategies

In the vast majority of the cases (126 out of 144) subjects use stable cutoff strategies. In 9 out of the 12 treatments, either 11 or all 12 out of 12 subjects use a cutpoint strategy. This is not all that surprising since the aggregate analysis already showed that behavior in roles A and B is quite close to the theoretical predictions. Some mistakes occur simply because subjects play many matches (45) and they may sometimes misread whether they are currently playing under role A or B.[9] The exception is session 1 under cost LL, where 4 out of 12 subjects in role A and 5 out of 12 subjects in role B do not play according to a cutpoint strategy. A possible explanation is that LL corresponds to the first treatment played by subjects in that session, and that individuals are still learning how to play the game.

A more stringent test consists in determining whether subjects who do use a cutpoint strategy apply the optimal one. Table 7 presents the number of individuals per treatment whose behavior can be rationalized by the use of a cutpoint strategy which is within 5 units of the optimal one.[10] By definition, only those individuals using cutpoints strategies as defined in Table 6 are candidates for optimal cutpoints.

Overall in three-quarters of the cases where subjects use cutpoint strategies, the cutpoints are "approximately optimal" (95 out of 126). This also corresponds to two-thirds of all cases (95 out of 144), which reinforces our previous conclusion that subjects play this game rather well.

[9] For example, we have one case of an individual in Role B who always plays according to the theory except for one observations where he/she transmits when the state is 81. It is likely that the subject believed he/she was in Role A.

[10] So, for example, a subject with role A in HH whose choices are consistent with a strategy of withholding when $\theta \leq 45$ and transmitting when $\theta \geq 46$ will be considered as using an optimal cutpoint strategy. We include some degree of freedom (± 5 units) to allow for minor deviations.

session	1			2		
costs	LL	HL	HH	LL	HL	HH
Role A	7	8	10	8	7	6
Role B	7	9	10	9	6	8

number of subjects per role and cost pair is 12

Table 7: Individuals using "approximately optimal" cutpoint strategies

In Figure 5 we look at each individual (ordered by their ID number) and determine the number of mistakes under roles A or B during the entire experiment, that is, for all three costs pairs. Subjects play on average 30 times in those roles (10 times under each cost pair). According to this figure, half the subjects make 3 mistakes or less (about 10% of the time or less) during the entire session, with two subjects not making any mistake at all and no subject making more than 10 mistakes overall. The result of the individual analysis is summarized as follows.

Result 3 *Most players withhold information using a rational and consistent cutpoint strategy. Half the subjects play extremely close to the theory and less than 20% exhibit significant departures. Most departures occur in the first matches of the experiment.*

Finally, there is an interesting relation between this experiment and some previous literature. Brocas, Carrillo and Palfrey (2010) show that agents with opposing interests strategically collect information to influence the behavior of decision makers. In particular, if the current belief is against the interests of one agent, she will actively search for information in the hope that it will contradict current evidence. The present paper shows that conditional on having the information, agents with opposing interests will also strategically choose whether to convey it or not to an unbiased third party in order to influence her choice. Both dimensions (strategic collection and strategic revelation) affect final decisions. Subjects in the laboratory experiments realize to a large extent the strategic aspects of this process.

11 Results of experiment 2

Experiment 2 consisted of two sessions (sessions 3 and 4). In session 3 we collected data on 3 groups of 5 players (groups 1, 2 and 3) whereas in session 4 we collected data on two groups of 7 players (groups 4 and 5). A first pass at the data reveals that the players in Role C in groups 1 and 5 made a large number of trivial mistakes.

In particular, these two players typically incurred the cost of viewing the decision of players in roles A and B. Then, they chose an action different from the state in 40% and 98% of the observations respectively. Given that viewing is costly, the C player in group 5 for example ended up obtaining a negative payoff.[11] In our view, these two subjects did not understand the rules of the experiment and may have completed the quiz by selecting answers randomly until they were correct. In any case, there was very little information to extract from their behavior. It is also difficult to infer anything from the behavior of other players in those groups, since they could clearly see the erratic nature of their partner's behavior. We therefore decided to remove the observations obtained for these two groups. This leaves us with less data than ideal: two groups of five players (groups 2 and 3) and one group of seven players (group 4). In those groups, we counted only 2 mistakes by C in the 189 observations where the state was revealed.[12]

Remember there are two possible cost configurations vis-à-vis the A and B players. In the first one, viewing the decision of one agent costs 5 points to the C player and viewing the decision of a second agent costs 30 points to the C player. We call this configuration "low cost". In the second one, the costs are 10 and 50 rather than 5 and 30.[13] We call this configuration "high cost". In the first 20 rounds of the experiment, C faced a "low cost" configuration with respect to state A and the A agents and a "high cost" configuration with respect to state B and the B agents. In the last 20 rounds, the cost configurations were reversed.

Note that when C does not attempt to view the decision of A or B players, he should choose action $a = E[\theta] = 50$. Given the payoff function considered in the experiment, the expected loss of choosing that strategy is:[14]

$$-\int_0^{100} \frac{(s-50)^2}{40} \frac{1}{100} ds = -20.83$$

This loss should be compared to the cost of viewing an agent's decision (5 in the low cost configuration and 10 in the high cost). This means that C should

[11] We did not subtract this payoff and paid him the full show-up fee of \$5. Notice that by using a suboptimal and very conservative strategy of never viewing any decision and choosing 50 all the time, that subject would have earned approximately \$18 (plus show-up fee). For comparison, the other C player in the session (group 4) earned \$25.50 (plus show up fee).

[12] This extremely low proportion of mistakes is consistent with the behavior in sessions 1 and 2 of experiment 1.

[13] Recall that the groups of 5 and 7 were identical in that respect: the decision of the third agent in the group of seven could never be observed.

[14] Recall that C players get a fixed 120 points in each match to which the costs of actions and viewing decisions are subtracted.

view the decision of one A or B player if he anticipates that they will transmit the information with probability greater than $5/20.83 \simeq 0.24$ and $10/20.83 \simeq 0.48$ in the low cost and high cost configurations respectively. Since A and B should compete à la Bertrand in the information transmission game and always reveal the state, it is optimal for C to view the decision of one agent under either configuration. Moreover if, out of equilibrium, C learns that the agent has withheld the information, then he should never look at a second agent. Indeed, the maximum possible gain (if that agent reveals with probability 1) is 20.83 and the cost is either 30 or 50.

11.1 Aggregate analysis

Despite the relatively small number of subjects, we can draw interesting conclusions regarding the three important decisions in the experiment: (i) the decision to transmit or withhold by A and B; (ii) the decision of C to view the information transmitted (if any); and (iii) the action of C when the state remains unknown.

Figures 6-9 represent the distribution of the probability of withholding by players pooling roles A and B but separating by group size (5 or 7) and cost configuration (low or high). Contrary to the theoretical predictions, players withhold information a substantial fraction of the time for all values of the state (40.6% in groups of 5 and 17.9% in the group of 7). We also observe a declining probability of withholding as the state increases, although not as sharply as one would expect.[15] We ran a series of McNemar's χ^2 test by groups, role and cost configurations and they revealed that the decision was statistically different from the theoretical prediction of never withholding. We also ran a Wilcoxon test to test for the equality in the probability of withholding between cost structures and we found no statistical difference.

Most of the time player C viewed at least one of the agent's decision about each state. Table 8 shows how many times player C viewed 0, 1 and 2 decisions for each group. In the overwhelming majority of cases (231 out of 240) player C viewed exactly one decision. Also, whenever player C viewed two decisions, the information was either not revealed or revealed by at most one player.[16] This is in strong accordance to the theoretical predictions where viewing one (but not two) decisions is optimal if player C thinks there is a reasonable chance that the player has transmitted it.

[15] For example, for the groups of 5 with high cost, in 5 out of 26 observations subjects withhold information when the state is above 80. Given such favorable state and no cost of transmitting, one would think that subjects should be eager to let player C know about these "good news".

[16] Our software did not record the order of decisions viewed and it is not possible to see directly whether C opened a second box after a transmission or a no transmission, but in line with a rational choice, we strongly suspect that it is the latter.

	Decisions viewed		
	0	1	2
Group 2 (5 players)	1	78	1
Group 3 (5 players)	0	79	1
Group 4 (7 players)	2	74	4

Table 8: Distribution of clicks

Player C obtained information frequently. There were only 5 out of 80 observations in the group of 7 (6.3%) and 46 out of 160 observations in the groups of 5 (28.8%) where C did not learn the state. These include 3 observations where player C chose not to view any decision and 48 observations where he did view at least one. When the state remained unknown, the reported actions averaged 10 in the group of 7 (although the number of observations is very small). We summarize the reports for the groups of 5 players in Table 9. Players tended to report higher values for state A independently of the cost.

First 20 rounds	State A	State B	Last 20 rounds	State A	State B
Mean	42.55	34.26	Mean	48.5	38.13
Std. Dev.	14.62	25.58	Std. Dev.	18.28	27.11

Table 9: Actions by C when uninformed (groups of 5)

Interestingly, C consistently chose actions below the average state. Notice that 50 is the optimal choice if C decides not to view any decision. However, after viewing a decision and learning that player A or B has (out of equilibrium) chosen to withhold the state, he realizes that this is most likely to have occurred because the state is low. It is therefore natural to reduce the ex-post belief of the state. Notice also that subjects are less likely to withhold in groups of 7 than in groups of 5. Therefore, no information in the former case is a stronger indication of a low state than in the latter case. This would explain the substantially lower choice of action under no information in the group of 7 (around 10) than in the groups of 5 (around 40). However, we do not want to stress this result excessively given that it is based on a very small sample. The results of the aggregate analysis can be summarized as follows.

Result 4 *A and B players withhold information more often than predicted by theory*

(40.6% in groups of 5 and 17.9% in the group of 7). C players view almost invariably one decision as predicted by theory and often become informed (71% in groups of 5 and 94% in the group of 7). They realize that when information is withheld, the state is likely to be low and choose low actions (around 40 in groups of 5 and 10 in the group of 7).

11.2 Dynamic effects and reputation

An important aspect of our design is *reputation*. Players remain in the same groups and can learn from previous interactions. Our next step is to study the dynamics of the behavior. The first indication that reputation plays an important role is the fact that the proportion of instances where C viewed one decision and remained uninformed (28.8% and 6.3% in groups of 5 and 7 respectively) is significantly smaller than the overall probability of withholding by players A and B (40.6% and 17.9% in groups of 5 and 7 respectively). In other words, C players seem to learn which players are most likely to transmit their information and exploit that circumstance.

Interestingly, C generally does not view twice in a row the decision of the same player if the state is not transmitted the first time. To see this, we counted the number of times C viewed a player who withheld information in match t and compared it to the number of times C view the decision of the same player in match $t+1$. In groups of 5, C continued to view the same player in 35% of the cases, and in the group of 7 only in 14% of the cases. Table 10 shows the results.

	# Decisions withheld at t	# view same player at $t+1$
Groups of 5	45	16
Group of 7	7	1

Table 10: View same player when state is withheld.

Along the same lines, C does not switch to view the decision of a different player when the state is transmitted to him. We counted the number of times player C viewed a player who transmitted information in match t and compared it to the number of times C switched to a different player in match $t+1$. C switched in 18% and 6% of the cases in the groups of 5 and 7 respectively. The behavior of C in the group of 7 shows a stronger level of rationality since he has more options for deviations and yet decides to switch less frequently. The results are summarized in Table 11.

	# decisions transmitted at t	# switch player at $t+1$
Groups of 5	112	20
Group of 7	73	5

Table 11: Switch players when state is transmitted.

A more detailed description of the dynamics can be found in Figures 10-15. For each state (A or B) and each group (2, 3 or 4) it plots which player the subject in role C chose to view (labeled 1 or 2 in the groups of 5 and 1, 2 or 3 in the group of 7). It also shows whether the decision of that player was to transmit (blue diamond) or withhold (red square) the information. The main conclusions can be summarized as follows. First, except for a few observations, the strategy of C is to view one player for each state and keep viewing that same player as long as the state is transmitted (the diamonds). When it is not (a square), C switches to another potential provider of information. Rarely C switches without motive or stays with a player who withholds. Second, players in Roles A and B realize C is playing the strategy we just described. A player who knows C obtains information from him tends to continue transmitting information. As a result, there are remarkably long streaks of mutual understanding between C and one of the A or B players, where the former keeps viewing the same player and the latter retains attention by revealing his information (for example, in the group of 7, the streak lasts for 32 and 30 matches for state A and B respectively). Third, in the majority of the cases, the behavior of players is consistent with the theoretical prediction. Player C almost invariably views the decision of exactly one player per state. If that player withholds information, he moves to the next match without viewing the decision of a second one. Also, the player who anticipates to be viewed transmits his information. However, we know from the analysis of the probability of withholding that players tend to withhold relatively often. In fact, many players who know that C is not observing their decision choose to withhold. For example, player B_2 in group 2 withheld 15 times after round 24, when C obtained information from B_1. Player A_2 in group 3 withheld 19 times after round 15, when C obtained information from A_1. This behavior, however, is not shared by all players. For example, in group 4, C obtained information from A_1 after round 9. In that group, A_3 withheld 15 times after that round whereas A_2 withheld 0 times. The withholding pattern of the "ignored" subject may be the result of frustration, whereas the transmission pattern may occur in the hope of a future switch. The result regarding reputation effects can be summarized as follows.

Result 5 *Subjects develop strong reputations: C players stick to agents who transmit information and A and B players transmit information to keep their partnership with C.*

11.3 Group size as a disciplining mechanism

Last, a major motive to run sessions with groups of 5 and 7 players was to determine the impact of *group size* on behavior. From Figures 6-9, we see that the probability of withholding is generally smaller in the larger group (40.6% in groups of 5 and 17.9% in the group of 7 pooling high and low cost together). A two-sample Wilcoxon test revealed statistically significant differences at $p < 0.1$ in the low cost configuration and at $p < 0.01$ in the high cost configuration. It suggests that players in Roles A and B understood that it is relatively more difficult to coordinate their decisions on "withhold" the stronger the competition within viewpoints, that is, the higher the number of players with identical preferences and information. Also, if a C player stops "trusting" a partner, he has more alternatives to choose from, so it is less likely that he will come back. Not surprisingly, we also get that, in equilibrium, player C in groups of 5 remains uninformed about the state substantially more often than in the group of 7 (28.8% v. 6.3%). This is due to the differences in the withholding behavior mentioned above, but also to the fact that player C in the group of 7 is more systematic about switching partners who withhold information and keeping partners who transmit it than player C in the groups of 5.

From Figures 10-15, we can also see that the behavior converges to the theoretical prediction more rapidly in the group of 7 than in the groups of 5. Furthermore, the streaks during which the predicted outcome is obtained (C views one player who transmits information) are much longer in the larger group. Table 12 reports the round after which player C always views exactly one player per state and obtains always the information. This is the outcome predicted by the theory. We can see that there is no or a very late convergence in groups of 5, whereas convergence is fast in the group of 7. Perhaps more importantly, Table 13 reports the longest streak of matches where C views exactly one player per state and obtains always the information. Again, the streaks are much shorter in the groups of 5. After a few periods of playing at equilibrium, the player in Role A or B who has been the source of information starts deviating. This is generally followed by a switch to another potential provider of information. A possible explanation for these differences between groups of 5 and group of 7 is the fact that with 3 players in the same role, C has two alternatives in order to discipline the behavior of the player whose information he is currently viewing. Therefore, even if one of them is playing out of equilibrium (withholding) there is still another option. This is indeed what seems to be happening in group 4. For the last 30 matches of the game, Player C stays with A_1 and B_3 (who always transmit). In the meantime, A_3 and B_1 withhold information 15 and 7 times. However, A_2 and B_2 withhold 0 and 1 time respectively. In other words, if A_1 or B_3 were to deviate, C could still find at least one other player willing to transmit.

	State A	State B
Group 2 (5 players)	40	40
Group 3 (5 players)	30	40
Group 4 (7 players)	9	11

Table 12: Match at which behavior converges to the theoretical predictions

	State A	State B
Group 2 (5 players)	4	13
Group 3 (5 players)	14	13
Group 4 (7 players)	32	30

Table 13: Length of the longer streak consistent with the theoretical predictions

Taken together, these results suggest that, even tough players deviate sometimes from the theoretical predictions, there is more discipline in larger groups. Given the small number of observations, it is not possible to draw finer conclusions. Nevertheless, these results are promising: increasing competition within viewpoints (even if it is just from two to three) should promote transmission of information.

Result 6 *The level of competition within viewpoints matters: A and B transmit more information, C learns the state more often and longer partnerships are formed in the group of 7 than in the groups of 5.*

Overall, players do understand the reputation effect: player C exploits reputation to extract information, and players A and B transmit information to generate a high reputation. However, in the presence of costs of acquiring information, a player who transmits does not benefit from reputation if player C never check his decisions. In other words, costs induce inertia and it is extremely important to "capture" C as early as possible. It is therefore necessary to have several players in each Role to increase the probability of transmission, even though only one of them benefits from the reputation effect in equilibrium.

Notice also that we have focused on one representative voter or media consumer (player C). If we considered many consumers, it could be the case that some would develop strong reputations with one A player and others with a different A player. In equilibrium, every media would reveal information to keep their base and try to "steal" consumers from other medias. It could be interesting to study this variant in the laboratory.

12 Concluding remarks and future research

This paper has analyzed the incentives of media outlets with preferences over policy outcomes to withhold information that goes against their interests. Building on Blackwell's theorem on the comparison of information structures Blackwell, (1953), we have argued that consumer's welfare increases if the media outlets provide more information in a mathematically precise sense.

We have then provided three theoretical benchmarks. In the first one, we study a media with *monopoly power* over information (or, equivalently, two medias each one with information about a different aspect of policies). We show that if the media does not receive information with positive probability, then it can claim ignorance in order to avoid reporting unfavorable evidence. In equilibrium and conditional on receiving information, a media is more likely to claim ignorance the higher the probability of not being informed. This result, which is reminiscent of Dye (1985), suggests that information which is more difficult to obtain is more subject to manipulation or, more precisely, to suppression. Although interesting, the setting ignores strategic considerations in the incentives of different media sourcess to report news. Our second benchmark explicitly incorporates competition *between viewpoints* for information provision. We consider two medias with opposite preferences who always obtain the information and can decide to withhold it, possibly at a cost. We assume that information reaches consumers only if *both* transmit it. The idea is that even if one media wants to inform the consumer, the other can provide arguments that introduce noise and garbles the signal. In that setting, we show that each media has strong incentives not to transmit information which goes against its interests. Therefore, in equilibrium, only "neutral" information (that is, information which is not strongly in favor of the interests of one media and strongly against the interests of the other) will be eventually transmitted. In the extreme case where garbling information is costless, no news will ever reach consumers. We find that as the cost of information garbling increases, more information is transmitted, and for sufficiently high costs all information is revealed. We can interpret these costs as "reputation costs" that is if a media outlet gains a reputation for being uninformative then consumers will punish it with a loss of audience and so revenues. Our third and last benchmark deals with competition *within viewpoints*. We assume that several medias with identical viewpoints can withhold or transmit information. Contrary to the previous setting, withholding information is costless. Moreover, medias benefit not only from transmitting biased information but also from consumers' observing their choice (for example, buying the newspaper or watching the TV channel). In that situation there is a "Bertrand" type of competition: each media wants to be observed by consumers so they all choose to reveal their information in equilibrium. In other words, competition within viewpoints dramatically enhances information revelation.

We have then tested the theory in controlled laboratory experiments. In Experiment 1, we test the model of competition between viewpoints. Our subjects play remarkably close to Nash equilibrium predictions. In particular, when the cost of withholding information is nil, the subject with unfavorable information always withholds it so that news rarely reach consumers. As the costs increase, information withholding decreases. Finally, consumers realize that withholding is more likely by medias with lower costs and choose their action accordingly. The only significant departure of the empirical behavior relative to the theory is that subjects underreact to changes in the cost of the rival. In Experiment 2, we test the model of competition within viewpoints. In that case, deviations from theoretical predictions are more significant. Nevertheless, the empirical behavior converges to the theoretical predictions quicker when there is more competition. This benefits consumers as the information is transmitted more often. This suggests that an increased number of medias generates discipline among outlets and promotes the dissemination of information.

Future research should focus on three under-explored aspects of the analysis. First, the relation of this paper with the existing literature is not fully explored. It would be helpful to analyze more systematically the connections between each of the three models and the existing theoretical and experimental papers on the subject. Second, the connection between the three rationales for information withholding should be strengthened. We have emphasized the possibility of not having any information as a possible "excuse" that a monopolist can use for not revealing unfavorable information (model 1). Similarly, we have argued that competition between viewpoints generates diversity only if the cost of withholding is sufficiently high (model 2). Finally, under competition within viewpoints, reputation can induce unraveling of information if there are enough firms with similar preferences and enough concern for attracting viewers (model 3). In practice, the three motives are interrelated and the analysis would benefit from a closer look at the possible interactions. Third, and most importantly, the results of the experiments are highly informative but, nevertheless, in order to test their robustness, we would want to have more observations. These considerations will be the object of future work.

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APPENDIX A - FIGURES

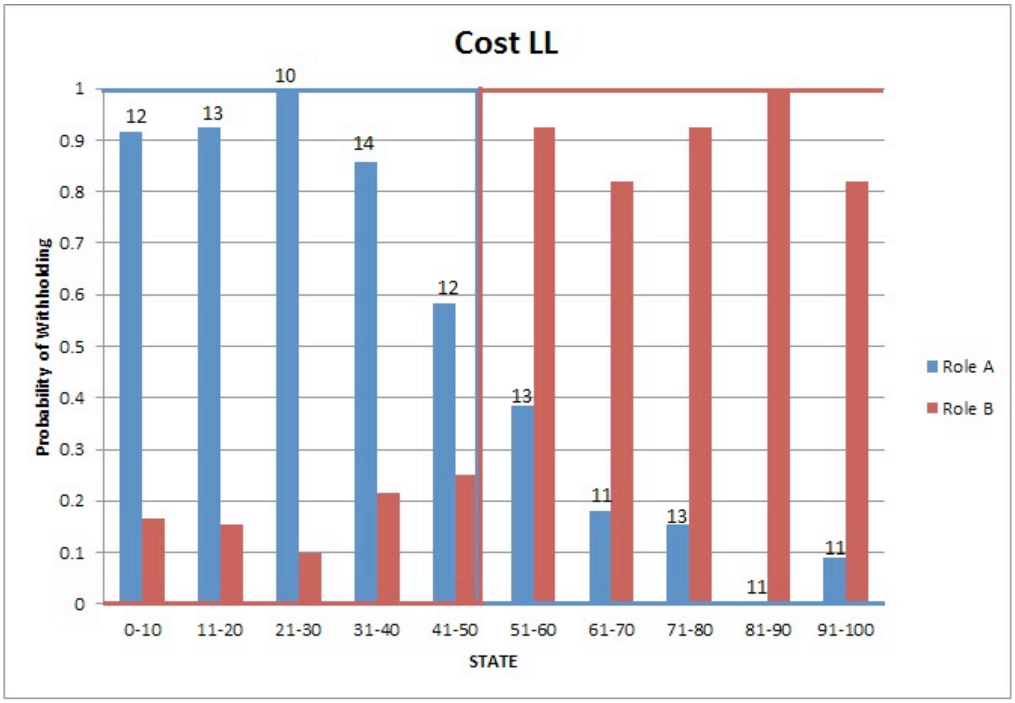

Figure 1 - Distribution of behavior of Roles A and B in LL.

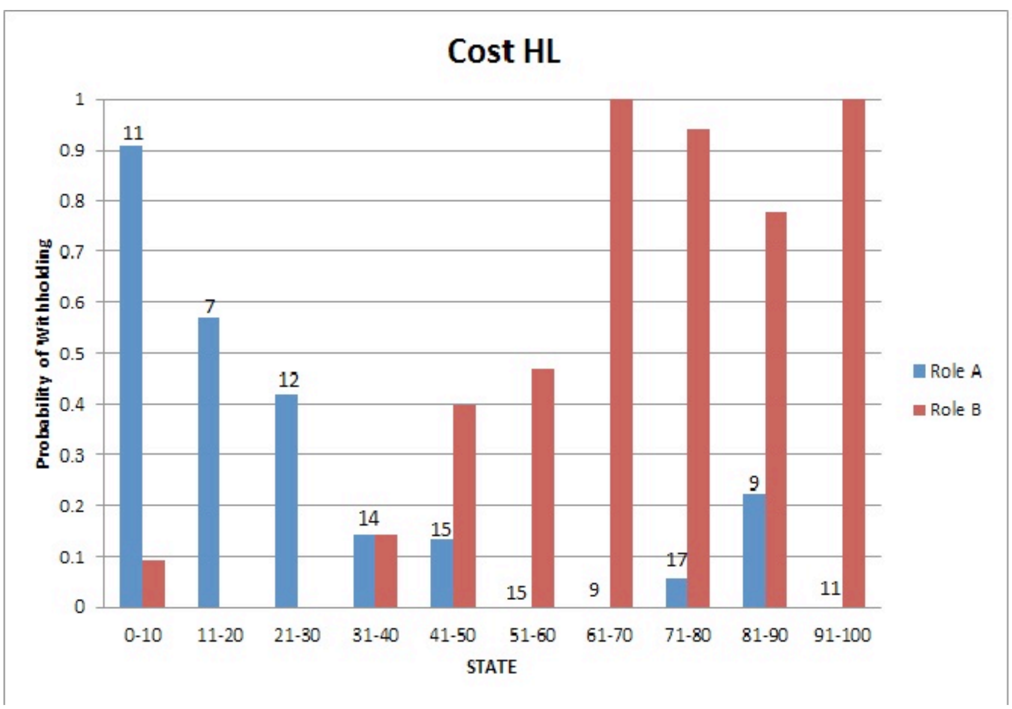

Figure 2 - Distribution of behavior of Roles A and B in HL.

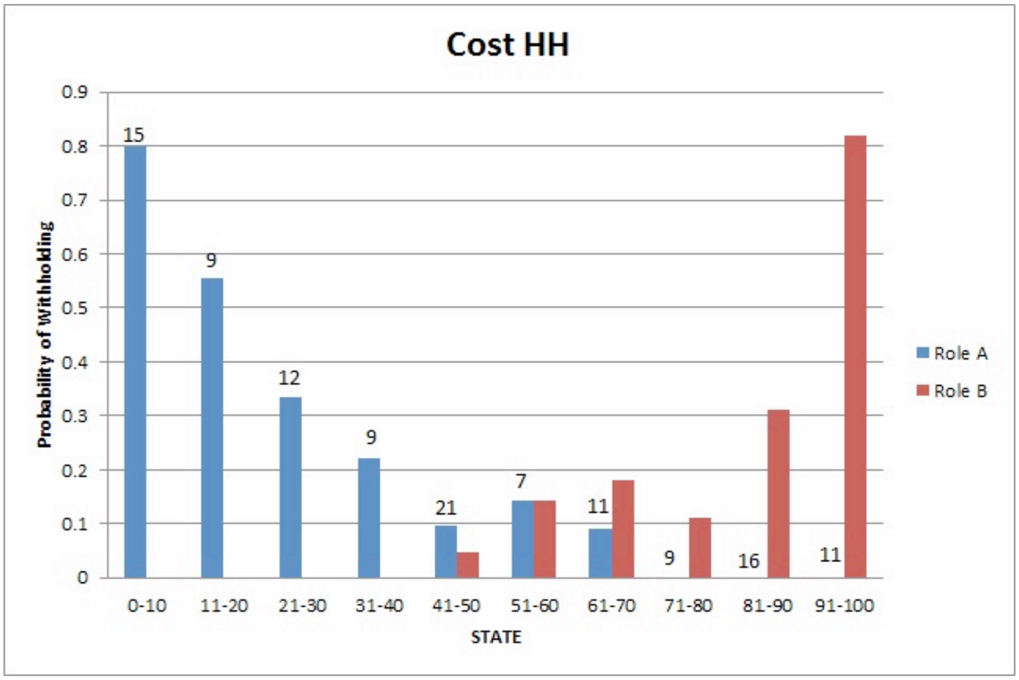

Figure 3 - Distribution of behavior of Roles A and B in HH.

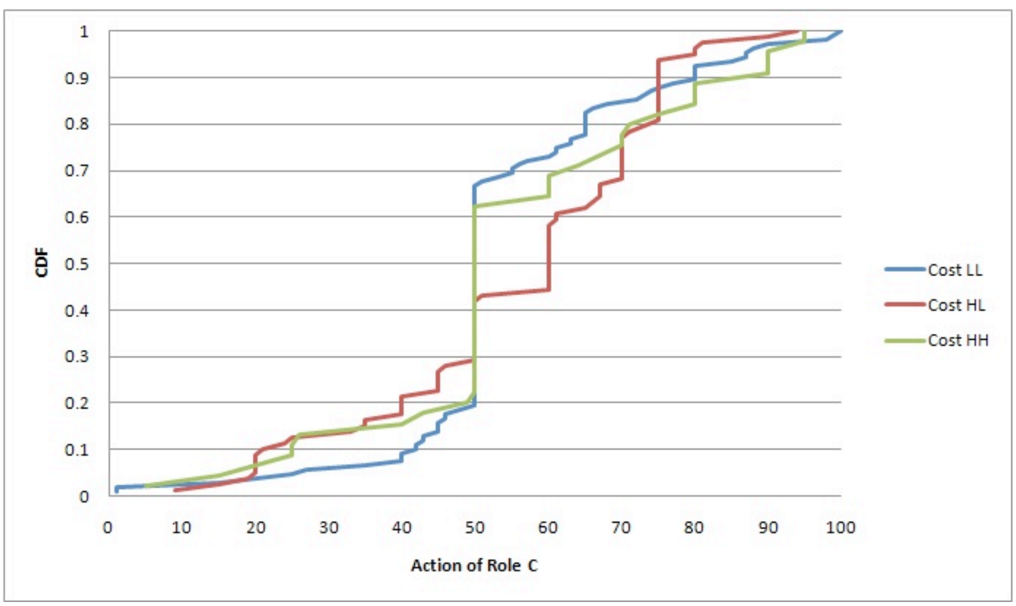

Figure 4 - Cumulative distribution functions of C's action.

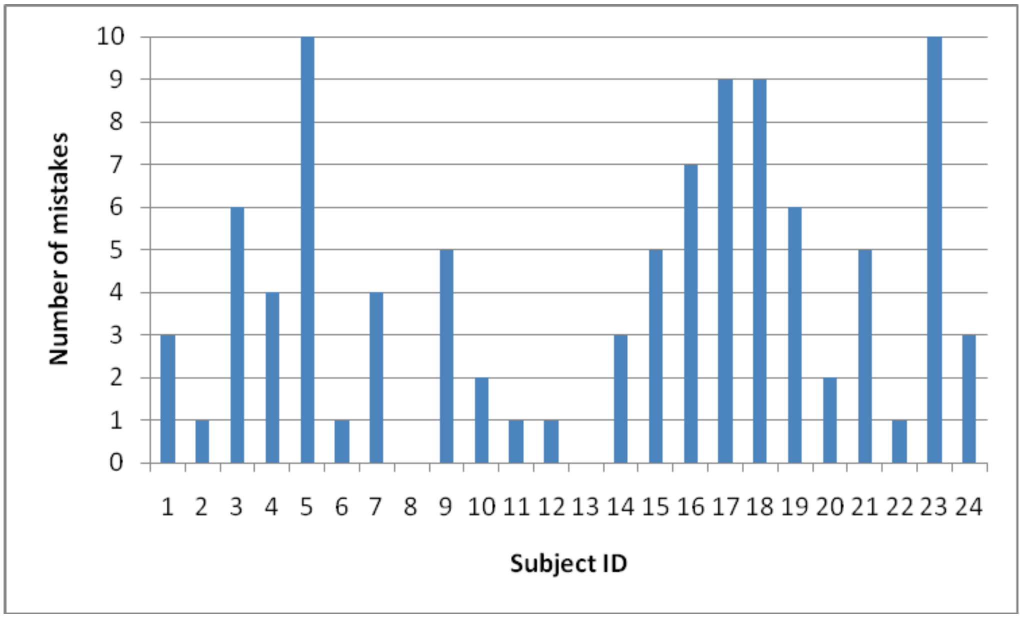

Figure 5 – Number of mistakes by individual under Roles A and B

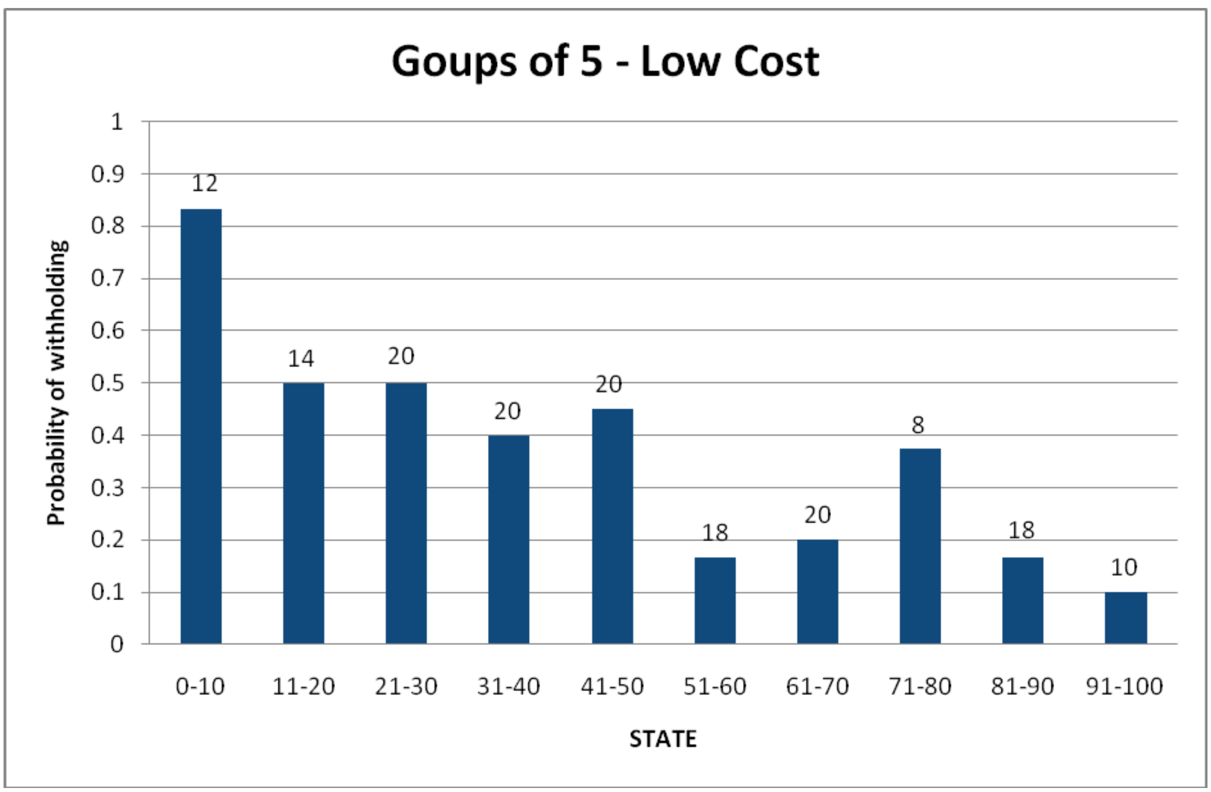

Figure 6 – Distribution of behavior of Roles A and B in groups of 5 with low costs.

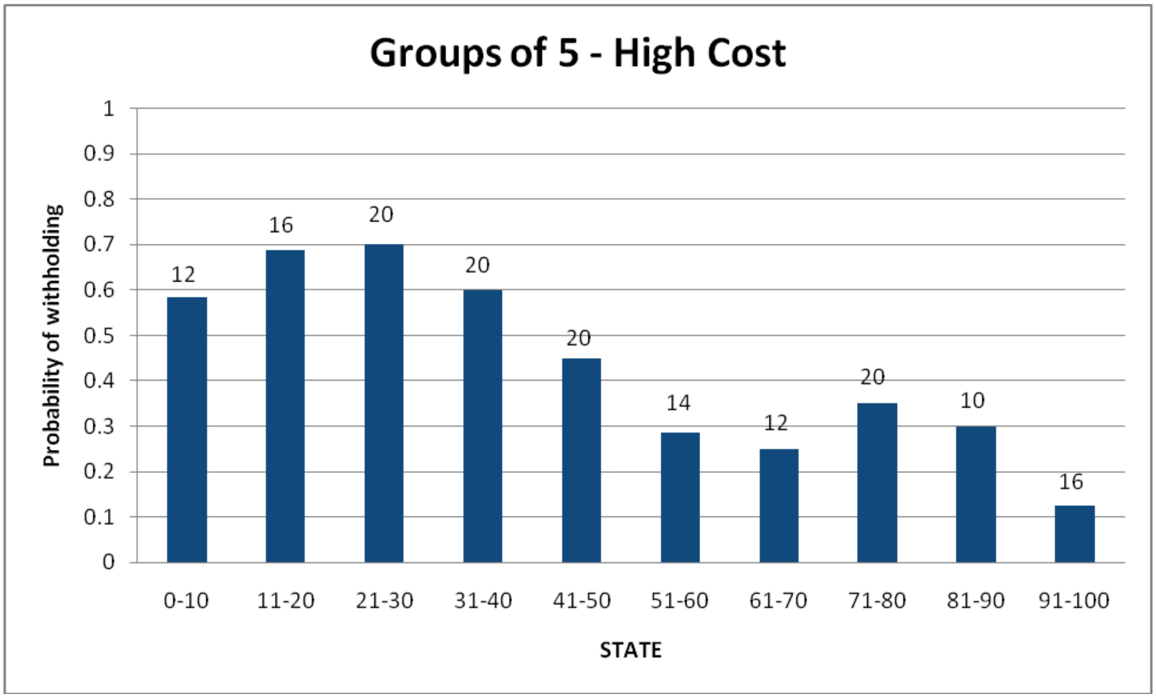

Figure 7 – Distribution of behavior of Roles A and B in groups of 5 with high costs.

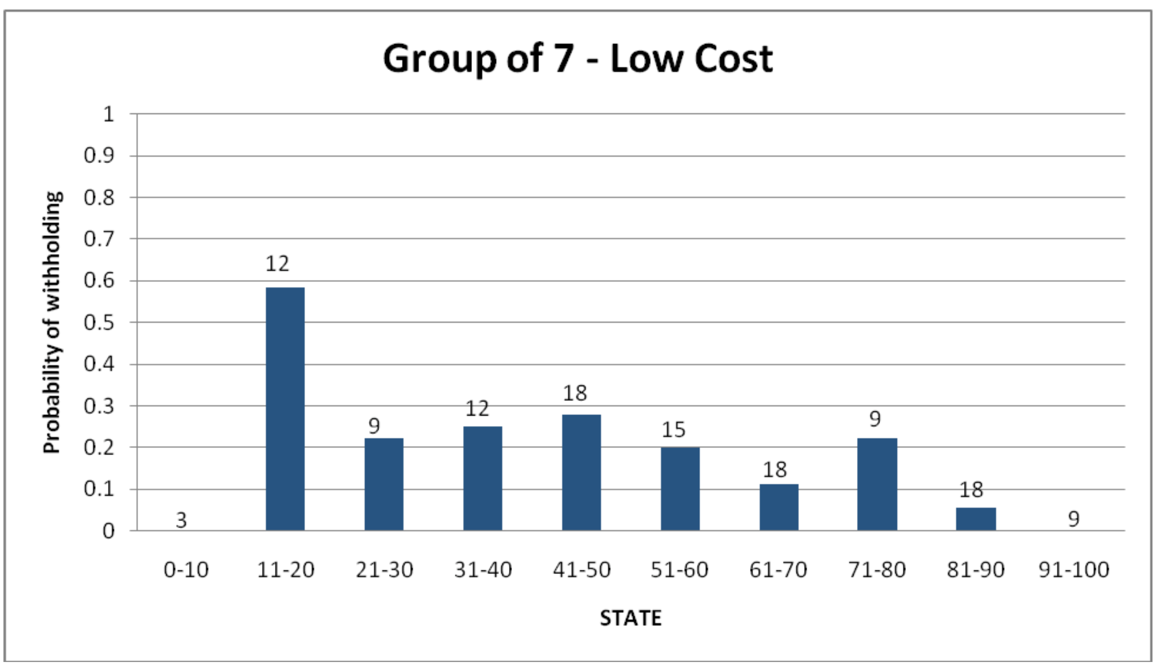

Figure 8 – Distribution of behavior of Roles A and B in group of 7 with low costs.

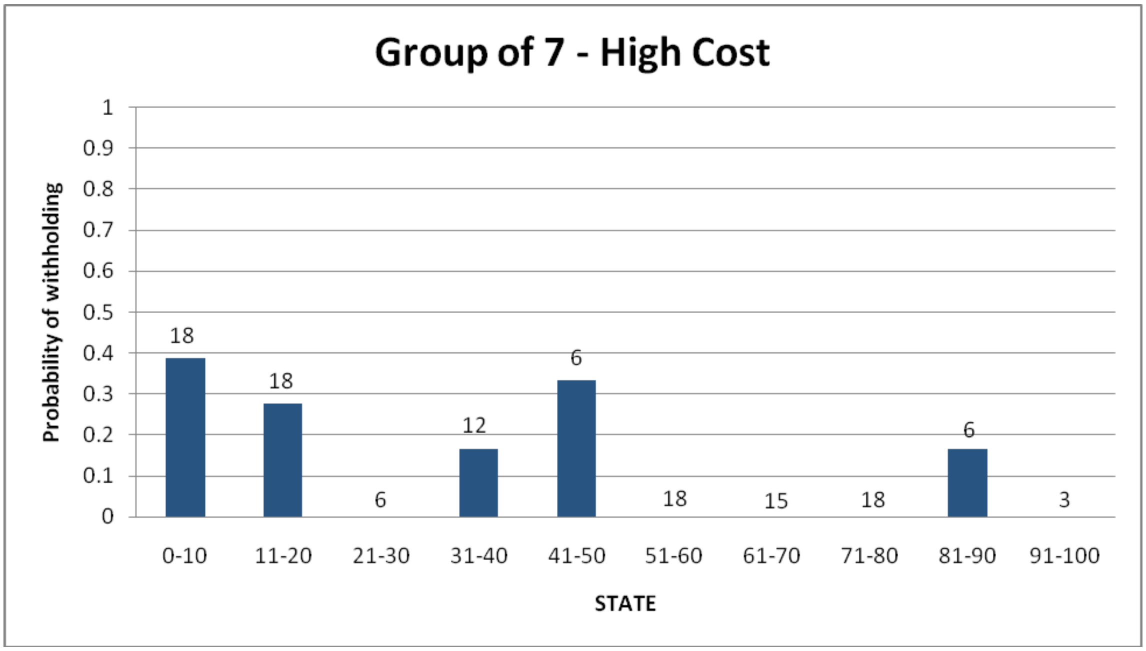

Figure 9 – Distribution of behavior of Roles A and B in group of 7 with high costs.

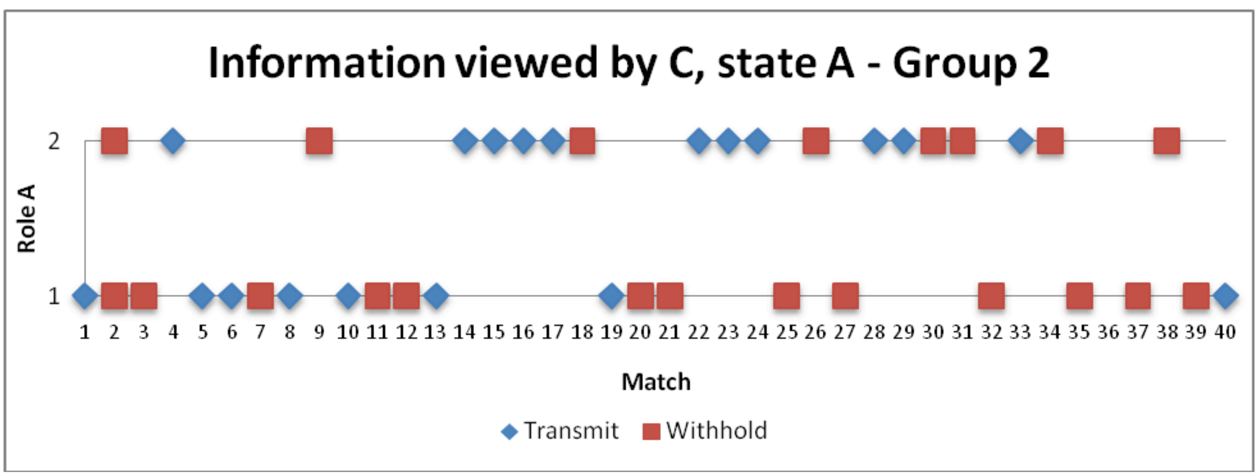

Figure 10 – Decisions viewed and information transmitted in Group 2, state A.

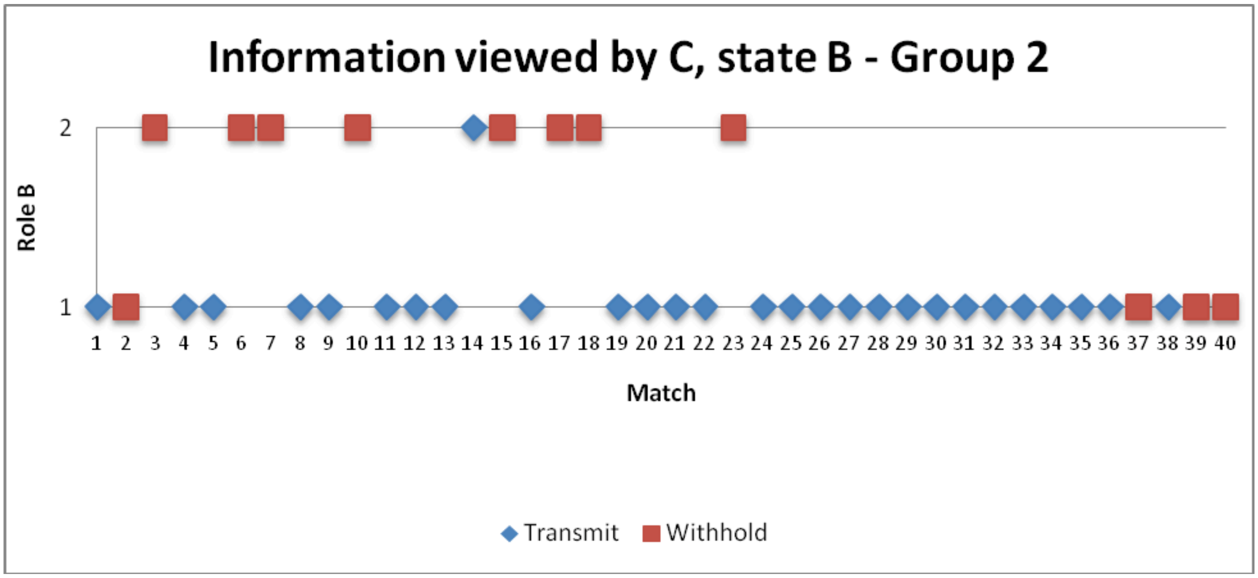

Figure 11 – Decisions viewed and information transmitted in Group 2, state B.

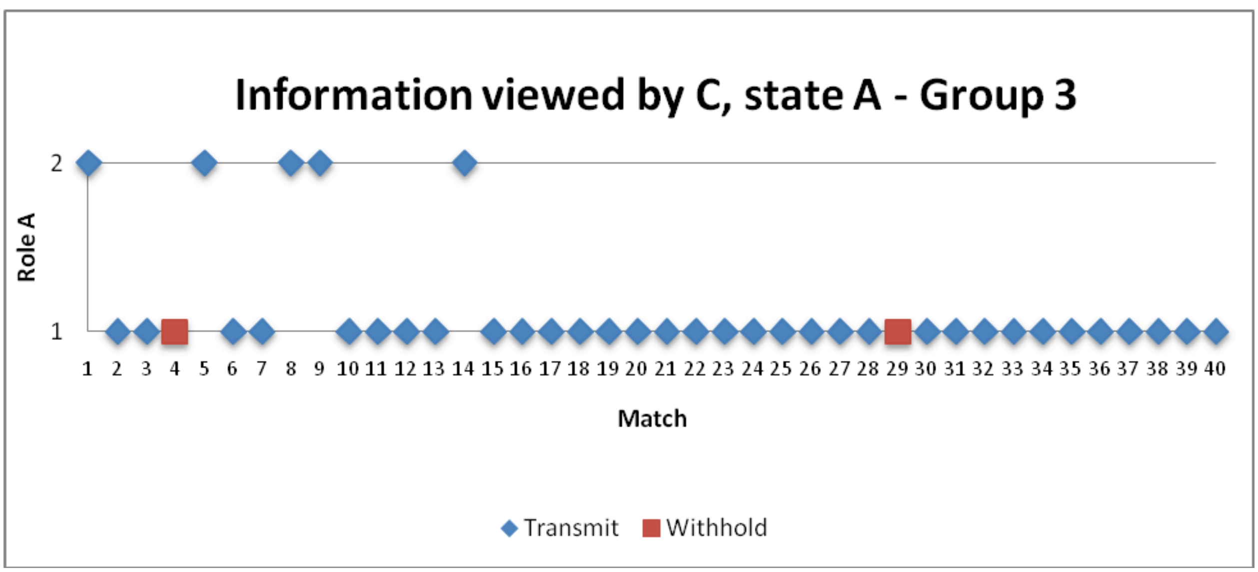

Figure 12 – Decisions viewed and information transmitted in Group 3, state A.

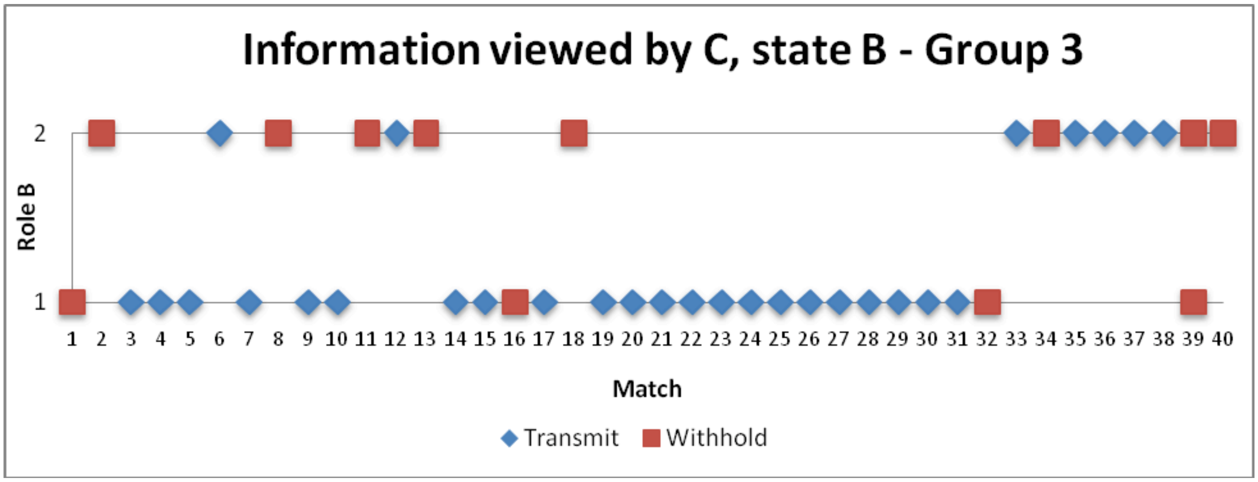

Figure 13 – Decisions viewed and information transmitted in Group 3, state B.

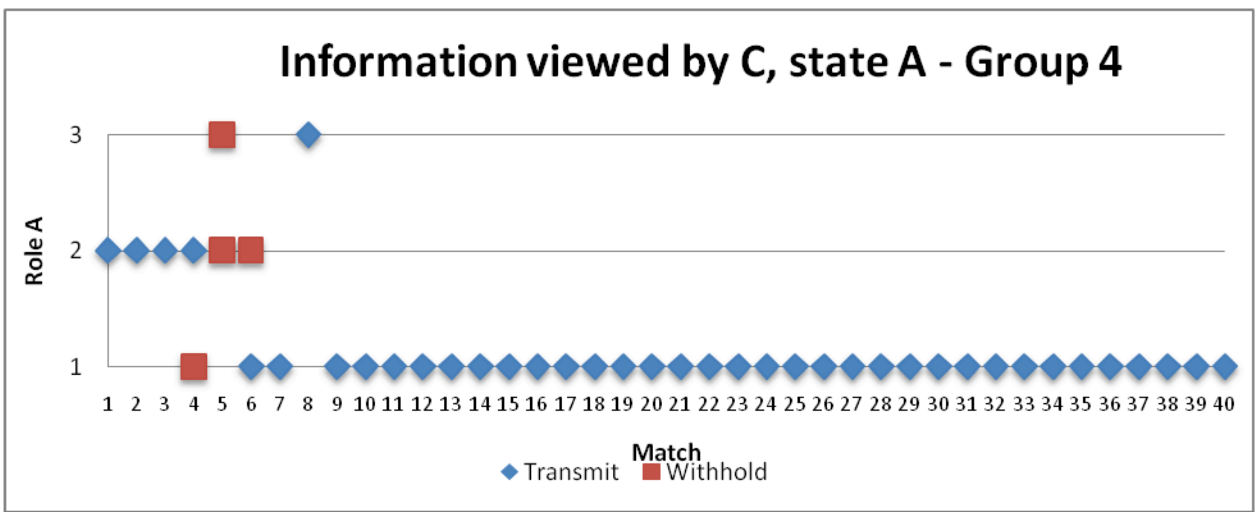

Figure 14 – Decisions viewed and information transmitted in Group 4, state A.

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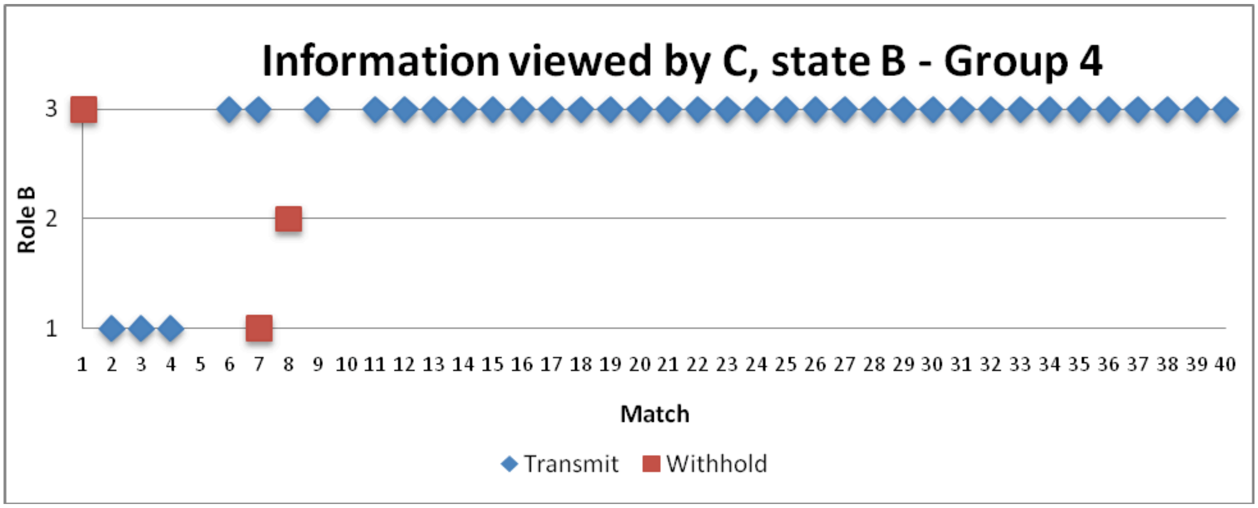


Figure 15 – Decisions viewed and information transmitted in Group 4, state B.

APPENDIX B – INSTRUCTIONS

FCC -- EXPERIMENT 1 – INSTRUCTIONS – 01.16.2011

Thank you for agreeing to participate in this research experiment on group decision making. During the experiment we would like to have your undistracted attention. Do not open other applications on your computer, chat with other students, use your phone or headphones, etc.

For your participation, you will be paid in cash from a research grant, at the end of the experiment. Different participants may earn different amounts. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance. It is very important that you listen carefully, and fully understand the instructions. You will be asked some review questions after the instructions, which you will have to answer correctly before we can begin the experiment.

If you have questions, don't be shy about asking them. If you have a question, but you don't ask it, you might make a mistake which could cost you money.

The entire experiment will take place through computer terminals. All interaction between you and other participants will take place through the computer interface. It is important that you not try to communicate with other participants during the experiment, except according to the rules described in the instructions.

We will start with a brief instruction period. During this instruction period, you will be given a complete description of the experiment and will be shown how to use the computer. At the end of the session, you will be paid the sum of what you have earned in all matches. Everyone will be paid in private and you are under no obligation to tell others how much you earned. Your earnings during the experiment are denominated in **points**. At the end of the experiment you will be paid $1.00 for every **_160_ points** you have earned.

The experiment will consist of several matches. In each match, you will be grouped with two other participants in the experiment. Since there are ____ participants in today's session, there will be ____ groups of 3 in each match. You are not told the identity of the participants you are grouped with. Your payoff depends only on your decision and the decisions of the two participants you are grouped with. What happens in the other groups has no effect on your payoff and vice versa. Your decisions are not revealed to participants in the other groups.

In each match, you will have either *Role A, Role B* or *Role C*. Which Role (A, B, or C) you have is random in each match and is clearly displayed on the screen. The computer will also draw one number between 0 and 100 and all numbers are equally likely. This number is called the **state**.

What to do

If you have Role A, the computer will disclose the state to you. You will then have to "Transmit" the state or "Withhold" the state. If you choose to "Withhold" the state, you will pay a cost. If you choose to "Transmit" the state you will not pay any cost.

If you have Role B, the same options are offered to you except that the cost if you choose to "Withhold" the state may be different. Both costs will be clearly displayed on your screen. Last, you will not be able to see the decision of the participant in the other role when you make your decision. After choosing "Transmit" or "Withhold", you will be instructed to wait.

If you have Role C, you will be instructed to wait until the two other participants have each chosen to “Transmit” or “Withhold” the state. Then, the computer will display the cost of withholding for the participants with roles A and B. The computer will also display the state if **both** roles A and B choose to “Transmit” the state. If **at least one** of them chooses to “Withhold” the state, the computer will report that the state is “unknown”. In either case, you will be prompted to select your action which consists of a number between 0 and 100.

When the participant with role C has chosen the action, the computer displays the state and the action of role C. Each participant can also see the payoff of all the participants in the group.

When all groups have finished the match and have seen the results, we proceed to the next match. For the next match, the computer randomly reassigns all participants to new groups. In each group, the computer assigns new roles, and randomly selects a new state between 0 and 100. The new assignments do not depend in any way on the past decisions of any participant including you and are done completely randomly by the computer. The assignments are independent across groups, across participants, and across matches. This next match then follows the same rules as the previous match.

How much you get

If your role is A, your payoff is the action selected by C minus the cost if you withheld the state. Therefore, A wants C to choose an action as high as possible.

If your role is B, your payoff is 100 minus the action selected by C minus the cost if you withheld the state. Therefore, B wants C to choose an action as low as possible.

If you have Role C, your payoff depends on both the state and the action. It is equal to:

$$100 - (\text{state} - \text{action})^2 / 40$$

Note that you maximize your earnings if you choose an action that equals your expectation regarding the state. To see this, suppose you think there is 50% chance the state is 20 and 50% chance the state is 40. The amount you earn in expectation is:

$$100 - 0.5(20 - \text{action})^2 / 40 - 0.50\ (40 - \text{action})^2 / 40.$$

Therefore if you choose action 20 or 40, your payoff is 95
Instead, if you choose 30 (that is, 20*0.5 + 40*0.5), your payoff is 97.5.

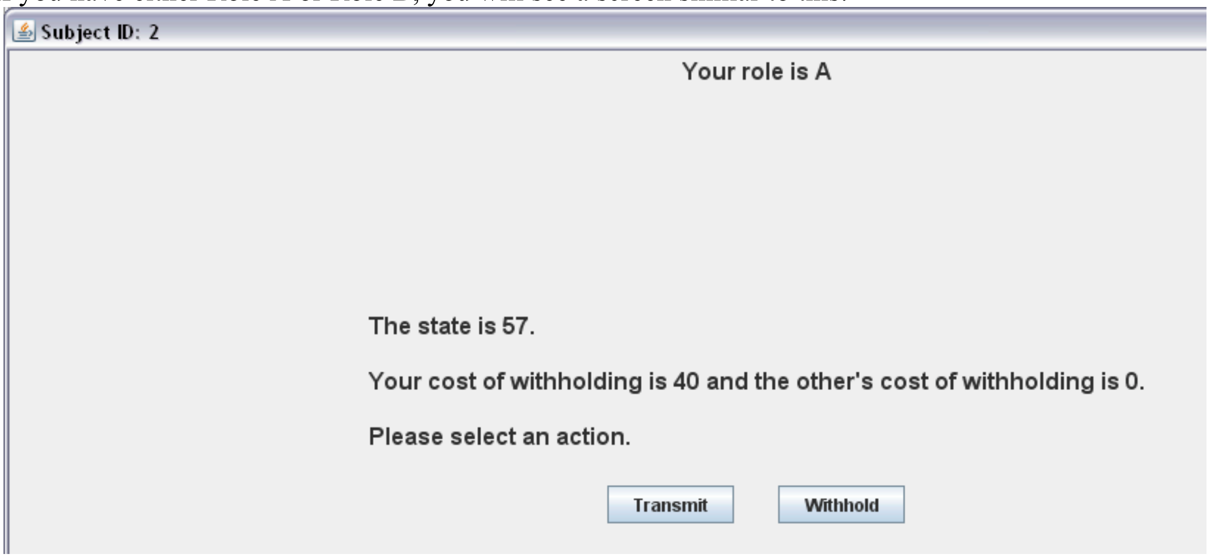
Finally, if you know the state for sure, then you should choose your action equal to the state and obtain a payoff of 100 for sure.

There will be one practice match. The points accumulated in this match do not count towards your final dollar earnings. The practice match is similar to the matches in the experiment.

Before the practice match, we will present the game using screenshots. It is important that you understand this information. If you have a question during this presentation, raise your hand and we will answer you.

Display 1. Sample screenshot for roles A and B

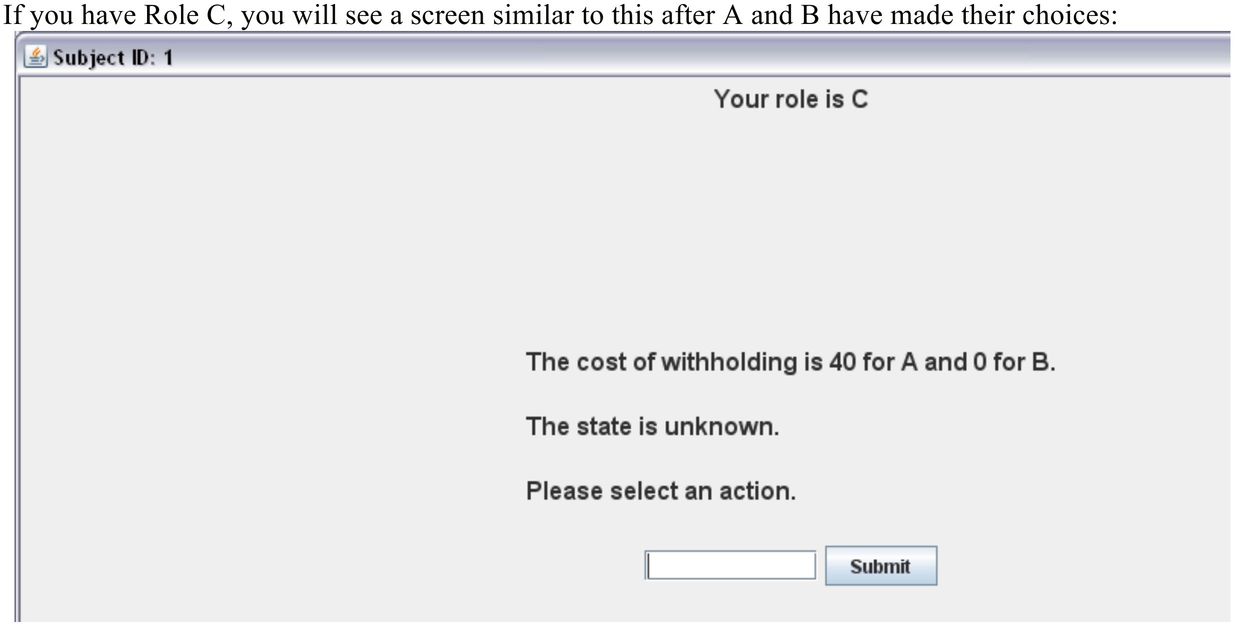
If you have either Role A or Role B, you will see a screen similar to this:



Your Role is displayed at the top of the screen. In that example, you have Role A. In that match, the state is 57. Your cost of withholding the state is 40 and the cost of withholding of the participant with role B is 0. If you want to Transmit, you have to click the "Transmit" button. If you want to "Withhold", you have to click the "Withhold" button.

Display 2. Sample screenshot for role C

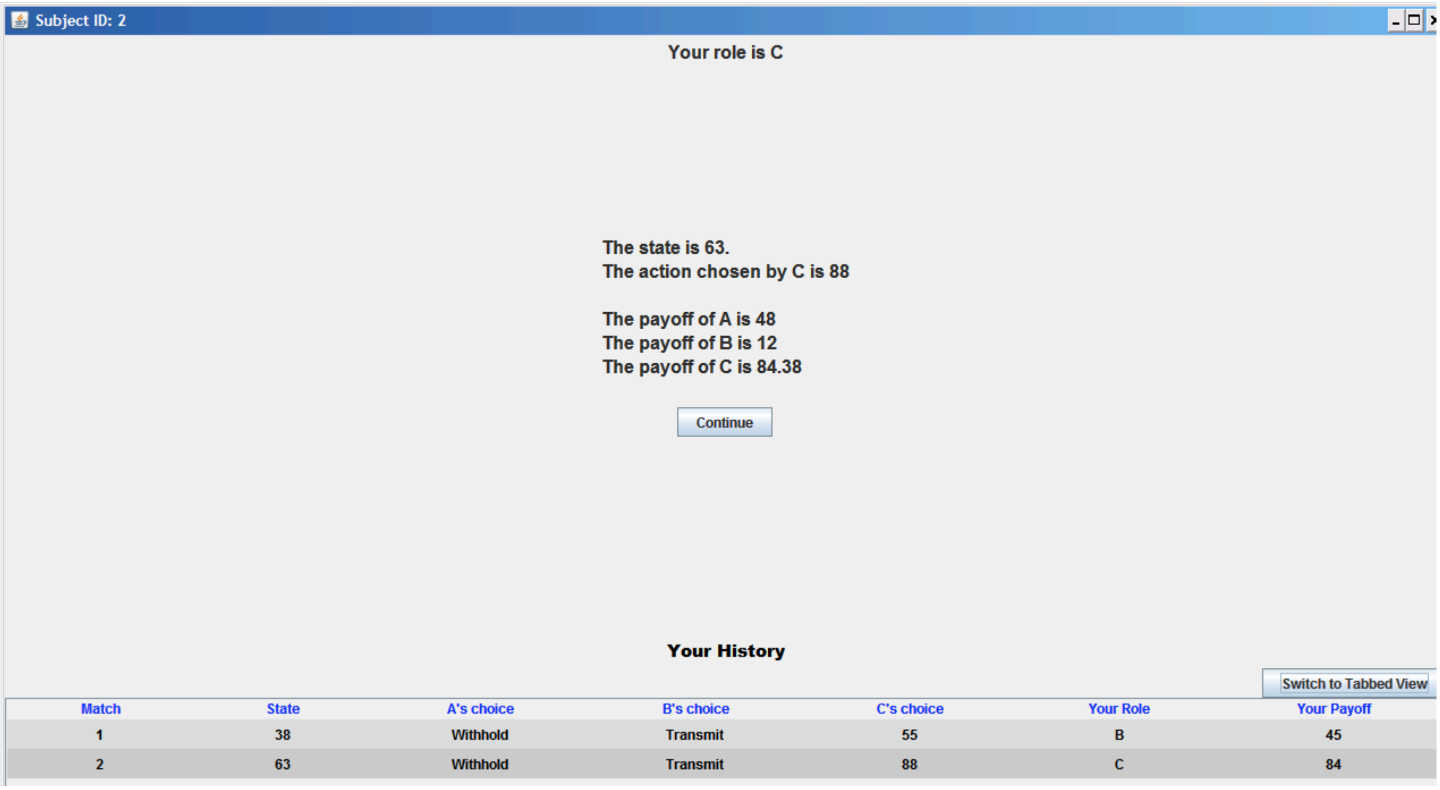
If you have Role C, you will see a screen similar to this after A and B have made their choices:



The costs of withholding for both roles A and B are clearly displayed. In that example, they are 40 and 0 respectively. The state is unknown in that example, which means that either role A or role B or both A and B have chosen to "withhold" the state. You must choose your action by entering a number between 0 and 100 in the box and click "Submit".

Display 3. Sample screenshot of the last screen

This is the last screen you see in the match.



Participants in all three roles A, B and C see the exact same screen, except for the top line that displays your role and the bottom history lines. In that example, the state was 63 and C selected action 88. The participant with Role A obtained 48 points, the participant with Role B obtained 12 points and the participant with Role C obtained 84.38 points. These payoffs correspond to a different match than the one in displays 1 and 2 and it is presented only for illustration.

At the bottom of the screen, the history of previous matches is displayed. For each match, the screen shows the state, the decision of roles A and B (transmit or withhold) and the action of role C (number between 0 and 100). It also shows your own role and the payoff you obtained. To reach the next match, you need to click “Continue”.

Recap

Here is a brief recap of the important things you will see, and how they affect your payoffs:

(1) Roles A and B know the state. Each chooses whether to “Transmit” or to “Withhold” the state. The decisions to “Withhold” have costs for A and for B which are displayed.
(2) Role C observes the state only if BOTH Roles A and B decided to “Transmit”. Role C observes “state is unknown” if at least one of them chooses to “Withhold” the state.
(3) The payoff for A is the action of C minus the cost if A withheld the state. The payoff for B is 100 minus the action of C minus the cost if B withheld the state.
(4) The payoff of C depends on the state and his own action. It is maximized by reporting the expected value of the state based on the information observed.

Are there any questions?

[PAUSE to answer questions]

We will now begin the Practice session and go through 1 practice match to familiarize you with the computer interface and the procedures. During the practice match, **please do not hit any keys until you are asked to**, and when you enter information, please do exactly as asked. Remember, you are **not paid** for the practice match. At the end of the practice match you will have to answer some review questions. Everyone must answer all the questions correctly before the experiment can begin.

[AUTHENTICATE clients]

Please double click on the icon on your desktop that says ________. When the computer prompts you for your name, type your First and Last name. Then click SUBMIT and wait for further instructions.

[START game]

You now see the first screen of the experiment on your computer. Raise your hand high if you do. Please do not hit any key.

[PAUSE TO BE SURE EVERYONE HAS THE CORRECT SCREEN]

At the top left of the screen you see your **subject ID**. Please record that on your record sheet now. Some of you have Role A, some have Role B and some have Role C. If you have Role A or Role B, the screen looks similar to the screenshot in display 1. If you have Role C, you are instructed to wait. In both cases, at the bottom of the screen you can see a history panel with all the information relevant for each match.

If you have Role A or Role B and your subject ID is even, click on the "Transmit" button. Otherwise, click on the "Withhold" button. Note that it does not matter which one you choose since you will not be paid for this match.

If you have Role C, you should now see a screen similar to the screenshot in display 2. It displays the state if both roles A and B chose to "Transmit". Otherwise it displays "the state is unknown". If you have Role A or Role B, you are instructed to wait.

If you have Role C, type the last two digits of your social security number. It does not matter which number you type since you will not be paid for this match.

You should now all see a screen similar to the one in display 3. It displays the state, the action of C and the payoffs of all participants in your group.

Now click "Continue". The practice match is over. Please complete the review questions before we begin the paid session. Once you answer all the questions correctly, click submit. After all participants in your group have answered all questions correctly, the quiz will disappear from your screen. Raise your hand if you have any question.

[WAIT FOR EVERYONE TO FINISH THE QUIZ]

Are there any questions before we begin with the paid session?

We will now begin with the paid matches. If there are any problems or questions from this point on, raise your hand and an experimenter will come and assist you.

For the next matches the cost of withholding for Role A is ___ and for Role B is ___.

[at the end of GAME ____]

For the next ___ matches the cost of withholding for Role A is ___ and for Role B is ___. The rules of the match are the same as before.

[at the end of GAME ____]

For the next ___ matches the cost of withholding for Role A is ___ and for Role B is ___. The rules of the match are the same as before.

[at the end of GAME ____]

This was the last match of the experiment. You will be paid the payoff you have accumulated in the ____ paid matches. The payoff appears on your screen. Please write this payoff in your record sheet and remember to CLICK OK after you are done.

[CLICK ON WRITE OUTPUT]

We will now pay each of you in private in the next room in the order of your Subject ID number. Remember you are under no obligation to reveal your earnings to the other participants.

Please put the mouse behind the computer and do not use either the mouse or the keyboard. Please remain seated until we call you to be paid. Do not converse with the other participants or use your cell phone. Thank you for your cooperation.

[CALL all the participants in sequence by their ID #]

[Note to experimenter: use the “pay” file to call and pay subjects]

Could the person with ID number 1 go to the next room to be paid?

RECORD SHEET

Subject ID: ___________

TOTAL EARNINGS: $______

Name:__________________________

Date:__________________________

Amount received:_______________

School ID #:____________________

Signature:______________________

FCC – EXPERIMENT 2 (groups of 5) – INSTRUCTIONS – 01.17.2011

Thank you for agreeing to participate in this research experiment on group decision making. During the experiment we would like to have your undistracted attention. Do not open other applications on your computer, chat with other students, use your phone or headphones, read, etc.

For your participation, you will be paid in cash from a research grant, at the end of the experiment. Different participants may earn different amounts. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance. It is very important that you listen carefully, and fully understand the instructions. You will be asked some review questions after the instructions, which you will have to answer correctly before we can begin the experiment.

If you have questions, don't be shy about asking them. If you have a question, but you don't ask it, you might make a mistake which could cost you money.

The entire experiment will take place through computer terminals. All interaction between you and other participants will take place through the computer interface. It is important that you not try to communicate with other participants during the experiment, except according to the rules described in the instructions.

We will start with a brief instruction period. During this instruction period, you will be given a complete description of the experiment and will be shown how to use the computers. At the end of the session, you will be paid the sum of what you have earned in all matches. Everyone will be paid in private and you are under no obligation to tell others how much you earned. Your earnings during the experiment are denominated in **points**. At the end of the experiment you will be paid $1.00 for every **_160_ points** you have earned.

At the beginning of the experiment, you will be grouped with **four** other participants. Since there are ____ subjects in today's session, there will be ____ groups of **five**. You are not told the identity of the participants you are grouped with. Your payoff depends only on your decision and the decisions of the participants you are grouped with. What happens in the other groups has no effect on your payoff and vice versa. Your decisions are not revealed to participants in the other groups.

In each group, there will be three types of roles, Role A, Role B and Role C. There will be **two** participants in Role A, called **A1, A2** participants, **two** participants in Role B, called **B1, B2** participants and one participant in Role C, called C participant. You will have either role A, role B or role C. Which role you have is randomly selected at the beginning of the experiment and is clearly displayed on the screen. You will keep the same role and will be in the same group with the same participants for the entire duration of the experiment.

The experiment will consist of several matches. In each match, the computer will draw two numbers. Each of these numbers can be any number between 0 and 100 and all numbers are equally likely. These numbers are called **state A** and **state B**.

What to do

If your role is **A1 or A2** (you are an A participant) the computer will disclose state A to you but not state B. Similarly, if your role is **B1 or B2** (you are a B participant) the computer will disclose state B to you but not state A. All A participants see the same state A, and all B participants see the same state B. You will then have to choose whether to "Transmit" or "Withhold" the state. You will not see the decision selected by any of the other A or B participants when you make your decision. You will then be instructed to wait.

If you are a C participant, you will be instructed to wait until all A and B participants have each chosen an action ("Transmit" or "Withhold"). Then, you will see **four** buttons that hide the decision of each A and B participant.

You will first have the possibility to view the decision of each A participant. If you click on one of the A buttons (**A1 or A2**), the computer will reveal state A if that A participant chose "Transmit" and state "unknown" if that A participant chose "Withhold". You can then view the decision of another A participant, and so on. Notice that if the two A participants decided to "Transmit" and you view their decisions, the same number is revealed to you, namely state A. It is entirely your decision to view none, one or **two** decisions of the A participants. If you choose to view the decision of one A participant, it is also your choice whether to view the decision of **A1 or A2**. Finally, there are costs of viewing these decisions. When you decide to not view any more decisions of A participants, you must take **action A**, which consists in typing a number between 0 and 100. You then need to click "Submit".

You will then repeat the same steps regarding B participants. The only difference is that the costs of viewing the decisions of the B participants are different, as explained after. When you decide to not view any more decisions of B participants, you must take **action B**, which consists in typing a number between 0 and 100. You then need to click "Submit".

When the C participant has made his decisions, the computer reveals the states A and B and displays the actions A and B selected by the C participant. Each participant can also see the payoffs of all the participants in the group.

When all groups have finished the match and have seen the results, we proceed to the next match. For the next match, the computer randomly selects two new numbers between 0 and 100 which correspond to the new states A and B. In the new match, you will be in the same group with the same participants and you will keep the same Role. Also, at the bottom of the screen you will see a History summarizing what has happened in the past matches of your group: which A and B participants chose to transmit and which ones chose to withhold, which decisions of As and Bs the C participant chose to view, what were the states A and B and what were the actions A and B taken by the C participant.

How much you get

If you are an A participant, your payoff is **50** plus the difference between action A and action B. Furthermore, if C viewed your decision, then you also get an extra **20** points. Therefore, you want C (i) to view your decision (for 20 points), (ii) to choose an action A as high as possible, and (iii) to choose an action B as low as possible.

If you are a B participant, your payoff is **50** plus the difference between action B and action A. Furthermore, if C viewed your decision, then you also get an extra **20** points. Therefore, you want C (i) to view your decision (for 20 points), (ii) to choose an action B as high as possible, and (iii) to choose an action A as low as possible.

If you are a C participant, your payoff depends on both states and on both actions, and it is decreased by the total cost of viewing decisions of A and B participants. It is equal to:

120 – (state A – action A)^2 / **40** – (state B – action B)^2 / **40** – cost of viewing As and Bs decisions.

Note that you maximize your earnings if you choose each action equal to the expected value of the corresponding state. To see this, suppose for simplicity there is only state A, and suppose there is 50% chance that state A is 20 and 50 % chance it is 40, the amount you earn in expectation is:

120 – 0.5(20- action A)^2 / 40 – 0.5(40- action A)^2 / 40 –cost of viewing As and Bs decisions

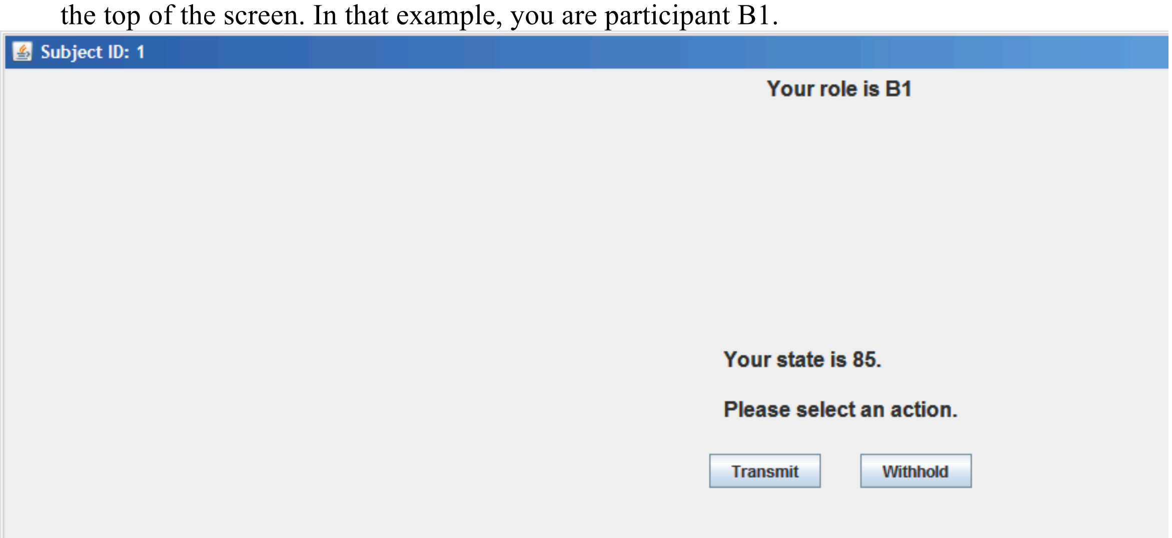
Therefore if you choose action 20 or 40, your payoff is 115 – cost of viewing As and Bs decisions. Instead, if you choose 30 (that is, 20*0.5 + 40*0.5), your payoff is 117.5 – cost of viewing As and Bs decisions. Naturally, if you know one of the states for sure, then you should choose the action for that state equal to the state.

The cost of viewing the decisions of A and B participants are as follows. In the first part of the experiment, the first decision of an A participant you view costs _**5**_ points (it is the same cost for viewing the decisions of **A1 and A2**). The second decision of an A participant you view costs _**30**_ points. Similarly, the first decision of a B participant you view costs _**10**_ points, and the second decision of a B participant you view costs _**50**_ points. The costs in the second part of the experiment will be reversed, and will be clearly explained when we reach that stage.

There will be one practice match. The points accumulated in this match do not count towards your final dollar earnings. The practice match is similar to the matches in the experiment.

Before the practice match, we will present the game using screenshots. It is important that you understand this information. If you have a question during this presentation, raise your hand and we will answer you.

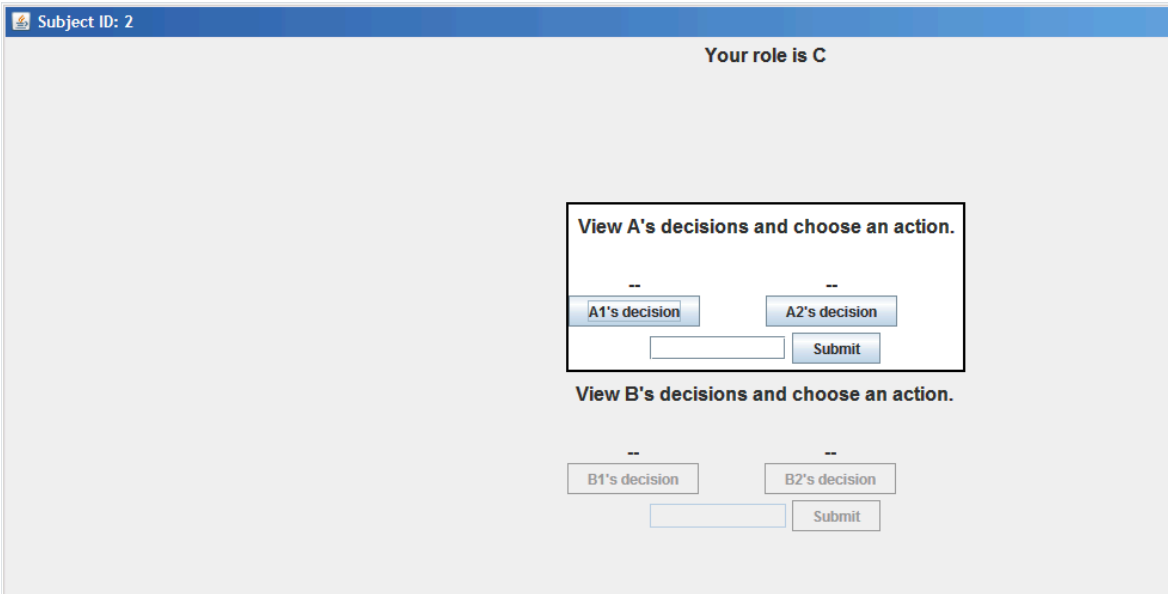
Display 1. Sample screenshot for A and B participants
This screen is displayed to you if you are either an A or a B participant. The exact Role is displayed at the top of the screen. In that example, you are participant B1.



In that match, state B is 85. You have to choose between "Transmit" or "Withhold" the state. You simply need to click the corresponding button.

Display 2. First sample screenshot for C participant

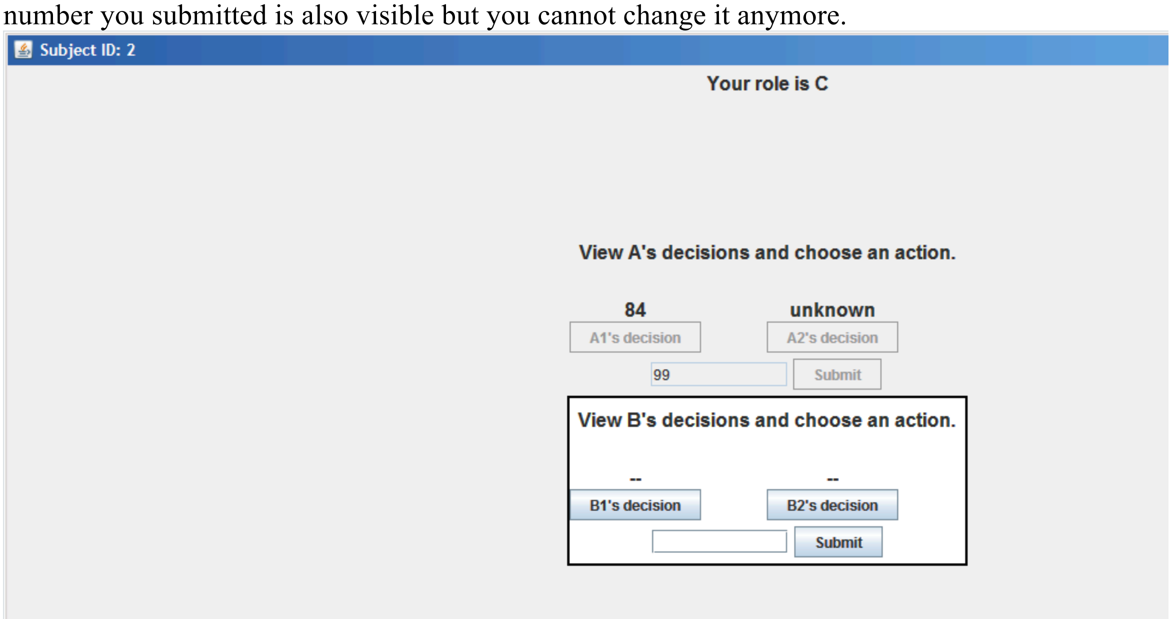
This screen is displayed to you if you have Role C and after all A and B participants have made their decisions.



You have the possibility to view the decisions of **A1 and A2**. You must then enter a number in the box and click "Submit". Notice that below those boxes are buttons to view the decisions of B participants, but they are disabled at this point.

Display 3. Second sample screenshot for C participant

This screen is the second screen you see when you have Role C. Once you have submitted your decision regarding state A, the buttons to view the decisions of A participants are disabled. The number you submitted is also visible but you cannot change it anymore.

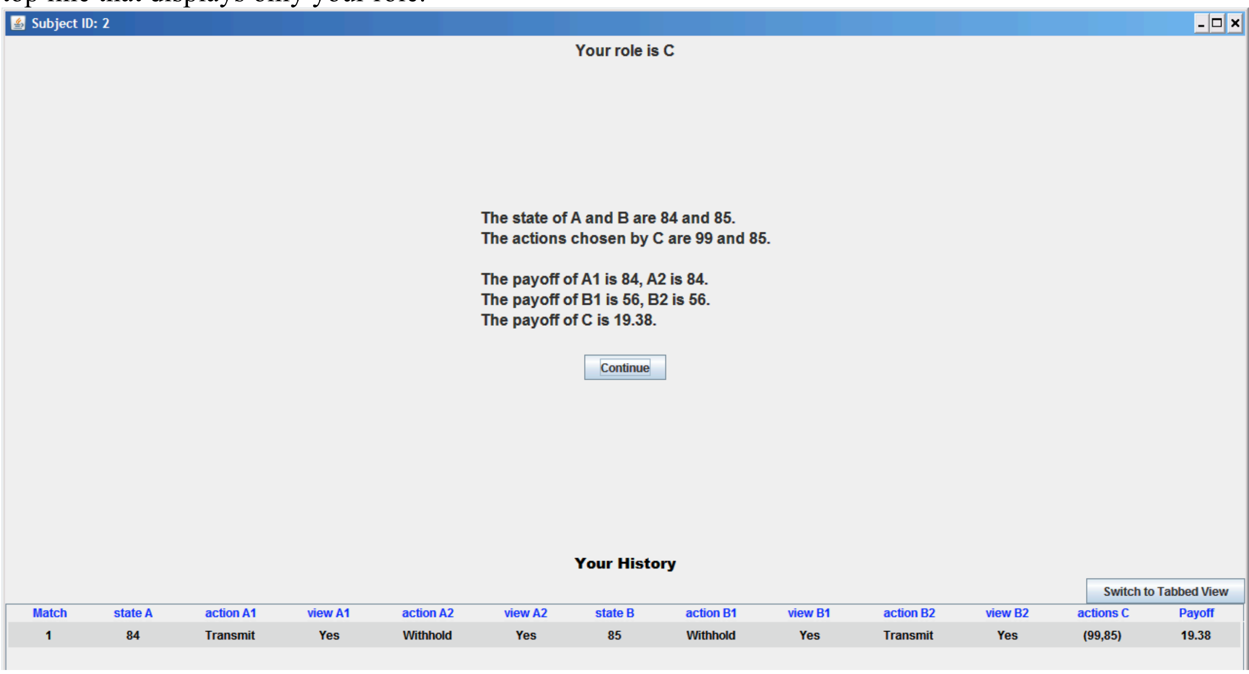


In this example, you viewed the decision of A1 who transmitted the state, so you learned that state A was 84. You also viewed the decision of A2 who chose to withhold the information. Finally, you chose action 99. Note that this is an illustration: the decisions and numbers only reflect a randomly generated behavior.

Now, you have the possibility to view the decisions of **B1 and B2**. Last, you must enter a number in the box and click “Submit”.

Display 4. Sample screenshot of the last screen

This is the last screen you see in the match. All participants see the exact same screen, except for the top line that displays only your role.



The screen shows the states A and B, the actions A and B chosen by the C participant and the payoffs of all participants in the group. To reach the next match, you need to click “Continue”.

Notice that at the bottom of the screen, you can also see the history of previous matches. For each match, the screen shows the states A and B, the decision of each A and B participant, whether C viewed the decisions of each of the A and B participants, and the actions A and B chosen by C. This history screen is important as it tracks the past behavior of each participant.

Recap

Here is a brief recap of the important things you will see, and how they affect your payoffs:

(1) Roles A know state A and can choose to “Transmit” or “Withhold” it to C. Similarly, Roles B know state B and can choose to “Transmit” or “Withhold” it to C.
(2) If C clicks on a participant’s button, C will learn the state if that participant chose “Transmit” and he will see “unknown” if that participant chose “Withhold”. Clicking on a participant’s button is costly.
(3) The payoff of an A participant is 50 + action A – action B + 20 if C views your decision. The payoff of a B participant is 50 + action B – action A + 20 if C views your decision. In both cases, the participant does not get the extra 20 points if C does not view his decision.

(4) The payoff of C depends on the states, his own actions and the total cost of viewing the decisions of A and B participants. It is maximized by reporting the expected value of each state based on the information observed.

Are there any questions?

RECORD SHEET

Subject ID: ___________

TOTAL EARNINGS: $______

Name:_________________________ Date:_________________________

Amount received:_______________

School ID #:____________________ Signature:______________________

[THE NEXT PAGE ONLY FOR THE EXPERIMENTER]

[PAUSE to answer questions]

We will now begin the Practice session and go through 1 practice match to familiarize you with the computer interface and the procedures. During the practice match, **please do not hit any keys until you are asked to**, and when you enter information, please do exactly as asked. Remember, you are not paid for the practice match. At the end of the practice match you will have to answer some review questions. Everyone must answer all the questions correctly before the experiment can begin.

[AUTHENTICATE clients]

Please double click on the icon on your desktop that says ________. When the computer prompts you for your name, type your First and Last name. Then click SUBMIT and wait for further instructions.

[START game]

You now see the first screen of the experiment on your computer. Raise your hand high if you do. Please do not hit any key.

[PAUSE TO BE SURE EVERYONE HAS THE CORRECT SCREEN]

At the top left of the screen you see your **subject ID**. Please record that on your record sheet now. Some of you have Role A, some have Role B and some have Role C. If you have Role A or B, the screen looks similar to the screenshot in display 1. If you have Role C, you are instructed to wait. In all cases, at the bottom of the screen you can see a history panel with all the information relevant for each match.

If you have Role A or B, and your subject ID is even, click on the "Transmit" button. If it is odd, click on the "Withhold" button. Note that it does not matter which one you choose since you will not be paid for this match.

If you have Role C, you should now see a screen similar to the screenshot in display 2. If you have Roles A or B, you are instructed to wait. Click on the buttons to see A1's decision then type the last two digits of your social security number and click "Submit".

If you have Role C, you should now see a screen similar to the screenshot in display 3. If you have Roles A or B, you are instructed to wait. Click on the buttons to see B2 and B3's decisions. Now, type the last two digits of your year of birth and click "Submit".

You should now all see a screen similar to the one in display 4. It displays the states, the actions of C and the payoffs of all participants in your group.

Now click "Continue". The practice match is over. Please complete the review questions before we begin the paid session. Once you answer all the questions correctly, click submit. After all participants in your group have answered all questions correctly, the quiz will disappear from your screen. Raise your hand if you have any question.

[WAIT FOR EVERYONE TO FINISH THE QUIZ]

Are there any questions before we begin with the paid session?

We will now begin with the paid matches.

Remember, in the next matches, for the participant in role C, the cost of viewing decisions of A and B participants are as follows. For the first decision of an A participant you view, the cost is **5** points and for the second decision of an A participant you view, the cost is **30** points. For the first decision of a B participant you view, the cost is **10** points and for the second decision of a B participant you view, the cost is **50** points.

[at the end of GAME ____]

The first part of the experiment is now finished. The second part of the experiment is identical to the first part except for the cost of viewing the decisions of A and B participants for the C participant. For the first decision of an A participant you view, the cost is now **10** points and for the second decision of an A participant you view, the cost is **50** points. For the first decision of a B participant you view, the cost is **5** points and for the second decision of a B participant you view, the cost is **30** points.

[at the end of GAME ____]

This was the last match of the experiment. You will be paid the payoff you have accumulated in the ____ paid matches. The payoff appears on your screen. Please write this payoff in your record sheet and remember to CLICK OK after you are done.

[CLICK ON WRITE OUTPUT]

We will now pay each of you in private in the next room in the order of your Subject ID number. Remember you are under no obligation to reveal your earnings to the other participants.

Please put the mouse behind the computer and do not use either the mouse or the keyboard. Please remain seated until we call you to be paid. Do not converse with the other participants or use your cell phone. Thank you for your cooperation.

[CALL all the participants in sequence by their ID #]

[Note to experimenter: use the "pay" file to call and pay subjects]

Could the person with ID number 1 go to the next room to be paid?

FCC – EXPERIMENT 2 (groups of 7) – INSTRUCTIONS – 01.17.2011

Thank you for agreeing to participate in this research experiment on group decision making. During the experiment we would like to have your undistracted attention. Do not open other applications on your computer, chat with other students, use your phone or headphones, read, etc.

For your participation, you will be paid in cash from a research grant, at the end of the experiment. Different participants may earn different amounts. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance. It is very important that you listen carefully, and fully understand the instructions. You will be asked some review questions after the instructions, which you will have to answer correctly before we can begin the experiment.

If you have questions, don't be shy about asking them. If you have a question, but you don't ask it, you might make a mistake which could cost you money.

The entire experiment will take place through computer terminals. All interaction between you and other participants will take place through the computer interface. It is important that you not try to communicate with other participants during the experiment, except according to the rules described in the instructions.

We will start with a brief instruction period. During this instruction period, you will be given a complete description of the experiment and will be shown how to use the computers. At the end of the session, you will be paid the sum of what you have earned in all matches. Everyone will be paid in private and you are under no obligation to tell others how much you earned. Your earnings during the experiment are denominated in **points**. At the end of the experiment you will be paid $1.00 for every **_160_ points** you have earned.

At the beginning of the experiment, you will be grouped with **six** other participants. Since there are ____ subjects in today's session, there will be ____ groups of **seven**. You are not told the identity of the participants you are grouped with. Your payoff depends only on your decision and the decisions of the participants you are grouped with. What happens in the other groups has no effect on your payoff and vice versa. Your decisions are not revealed to participants in the other groups.

In each group, there will be three types of roles, Role A, Role B and Role C. There will be **three** participants in Role A, called **A1, A2, A3** participants, **three** participants in Role B, called **B1, B2, B3** participants and one participant in Role C, called C participant. You will have either role A, role B or role C. Which role you have is randomly selected at the beginning of the experiment and is clearly displayed on the screen. You will keep the same role and will be in the same group with the same participants for the entire duration of the experiment.

The experiment will consist of several matches. In each match, the computer will draw two numbers. Each of these numbers can be any number between 0 and 100 and all numbers are equally likely. These numbers are called **state A** and **state B**.

What to do

If your role is **A1, A2 or A3** (you are an A participant) the computer will disclose state A to you but not state B. Similarly, if your role is **B1, B2 or B3** (you are a B participant) the computer will disclose state B to you but not state A. All A participants see the same state A, and all B participants see the same state B. You will then have to choose whether to "Transmit" or "Withhold" the state.

You will not see the decision selected by any of the other A or B participants when you make your decision. You will then be instructed to wait.

If you are a C participant, you will be instructed to wait until all A and B participants have each chosen an action ("Transmit" or "Withhold"). Then, you will see **six** buttons that hide the decision of each A and B participant.

You will first have the possibility to view the decision of each A participant. If you click on one of the A buttons (**A1, A2 or A3**), the computer will reveal state A if that A participant chose "Transmit" and state "unknown" if that A participant chose "Withhold". You can then view the decision of another A participant, and so on. Notice that if two **or more** A participants decided to "Transmit" and you view their decisions, the same number is revealed to you, namely state A. It is entirely your decision to view none, one **or more** decisions of the A participants. If you choose to view the decision of one A participant, it is also your choice whether to view the decision of **A1, A2 or A3**. Finally, there are costs of viewing these decisions. When you decide to not view any more decisions of A participants, you must take **action A**, which consists in typing a number between 0 and 100. You then need to click "Submit".

You will then repeat the same steps regarding B participants. The only difference is that the costs of viewing the decisions of the B participants are different, as explained after. When you decide to not view any more decisions of B participants, you must take **action B**, which consists in typing a number between 0 and 100. You then need to click "Submit".

When the C participant has made his decisions, the computer reveals the states A and B and displays the actions A and B selected by the C participant. Each participant can also see the payoffs of all the participants in the group.

When all groups have finished the match and have seen the results, we proceed to the next match. For the next match, the computer randomly selects two new numbers between 0 and 100 which correspond to the new states A and B. In the new match, you will be in the same group with the same participants and you will keep the same Role. Also, at the bottom of the screen you will see a History summarizing what has happened in the past matches of your group: which A and B participants chose to transmit and which ones chose to withhold, which decisions of As and Bs the C participant chose to view, what were the states A and B and what were the actions A and B taken by the C participant.

How much you get

If you are an A participant, your payoff is **50** plus the difference between action A and action B. Furthermore, if C viewed your decision, then you also get an extra **20** points. Therefore, you want C (i) to view your decision (for 20 points), (ii) to choose an action A as high as possible, and (iii) to choose an action B as low as possible.

If you are a B participant, your payoff is **50** plus the difference between action B and action A. Furthermore, if C viewed your decision, then you also get an extra **20** points. Therefore, you want C (i) to view your decision (for 20 points), (ii) to choose an action B as high as possible, and (iii) to choose an action A as low as possible.

If you are a C participant, your payoff depends on both states and on both actions, and it is decreased by the total cost of viewing decisions of A and B participants. It is equal to:

120 – (state A – action A)^2 / **40** – (state B – action B)^2 / **40** – cost of viewing As and Bs decisions.

Note that you maximize your earnings if you choose each action equal to the expected value of the corresponding state. To see this, suppose for simplicity there is only state A, and suppose there is 50% chance that state A is 20 and 50 % chance it is 40, the amount you earn in expectation is:

$$120 – 0.5(20\text{- action A})^2 / 40 – 0.5(40\text{- action A})^2 / 40 \text{ –cost of viewing As and Bs decisions}$$

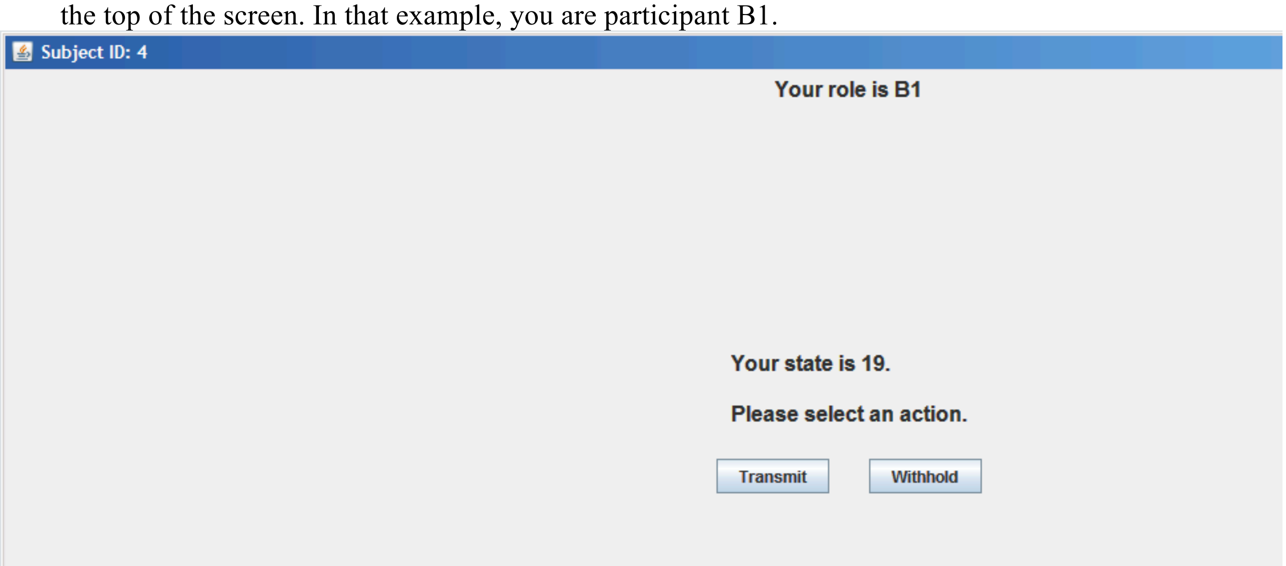
Therefore if you choose action 20 or 40, your payoff is 115 – cost of viewing As and Bs decisions. Instead, if you choose 30 (that is, 20*0.5 + 40*0.5), your payoff is 117.5 – cost of viewing As and Bs decisions. Naturally, if you know one of the states for sure, then you should choose the action for that state equal to the state.

The cost of viewing the decisions of A and B participants are as follows. In the first part of the experiment, the first decision of an A participant you view costs _**5**_ points (it is the same cost for viewing the decisions of **A1, A2 or A3**). The second decision of an A participant you view costs _**30**_ points. **You cannot view the decision of all three A participants.** Similarly, the first decision of a B participant you view costs _**10**_ points, and the second decision of a B participant you view costs _**50**_ points. **You cannot view the decision of all three B participants.** The costs in the second part of the experiment will be reversed, and will be clearly explained when we reach that stage.

There will be one practice match. The points accumulated in this match do not count towards your final dollar earnings. The practice match is similar to the matches in the experiment.

Before the practice match, we will present the game using screenshots. It is important that you understand this information. If you have a question during this presentation, raise your hand and we will answer you.

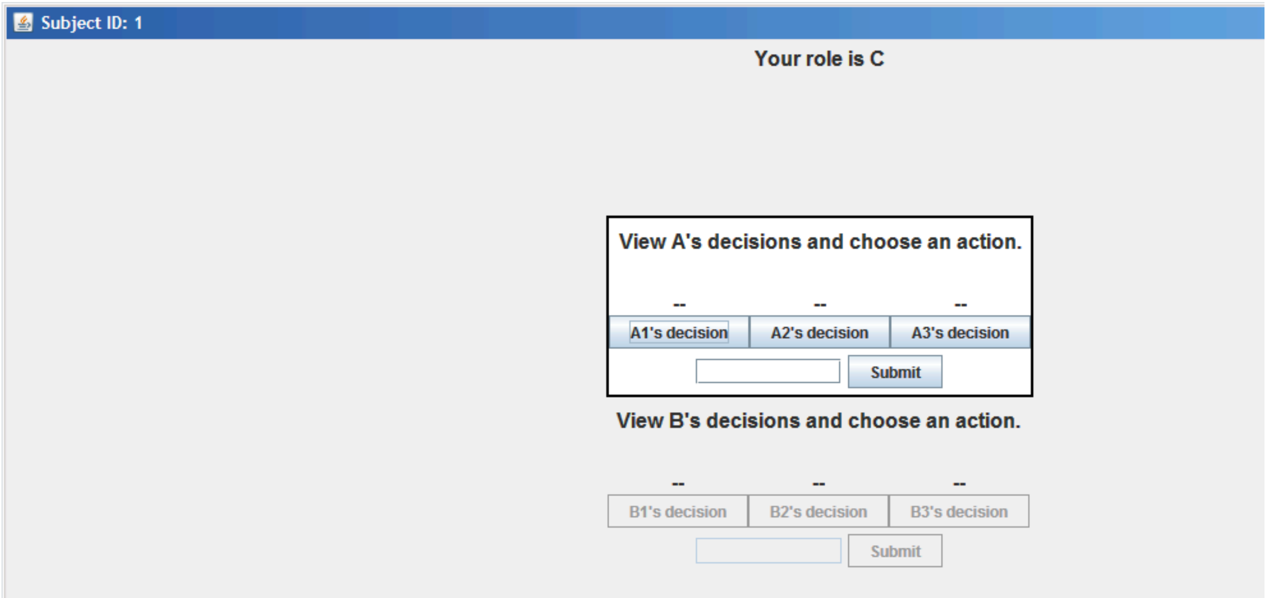
Display 1. Sample screenshot for A and B participants
This screen is displayed to you if you are either an A or a B participant. The exact Role is displayed at the top of the screen. In that example, you are participant B1.



In that match, state B is 19. You have to choose between "Transmit" or "Withhold" the state. You simply need to click the corresponding button.

Display 2. First sample screenshot for C participant

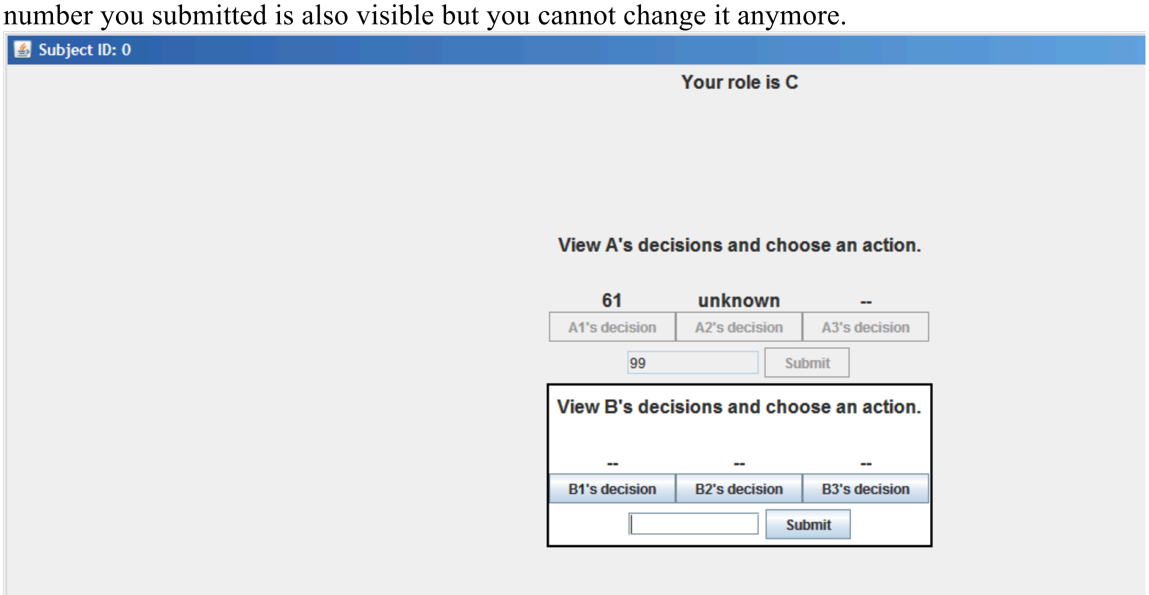
This screen is displayed to you if you have Role C and after all A and B participants have made their decisions.



You have the possibility to view the decisions of **A1, A2 and A3**. You must then enter a number in the box and click "Submit". Notice that below those boxes are buttons to view the decisions of B participants, but they are disabled at this point.

Display 3. Second sample screenshot for C participant

This screen is the second screen you see when you have Role C. Once you have submitted your decision regarding state A, the buttons to view the decisions of A participants are disabled. The number you submitted is also visible but you cannot change it anymore.

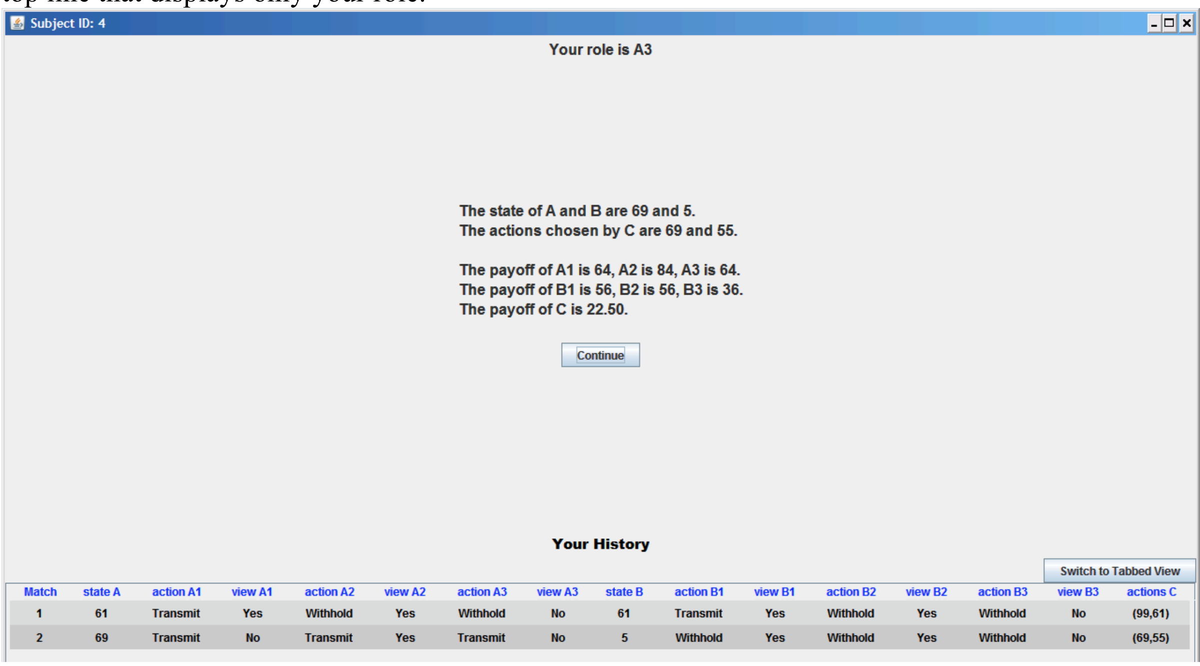


In this example, you viewed the decision of A1 who transmitted the state, so you learned that state A was 61. You also viewed the decision of A2 who chose to withhold the information. Finally, you chose action 99. Note that this is an illustration: the decisions and numbers only reflect a randomly generated behavior.

Now, you have the possibility to view the decisions of **B1, B2 and B3**. Last, you must enter a number in the box and click “Submit”.

Display 4. Sample screenshot of the last screen

This is the last screen you see in the match. All participants see the exact same screen, except for the top line that displays only your role.



The screen shows the states A and B, the actions A and B chosen by the C participant and the payoffs of all participants in the group. To reach the next match, you need to click “Continue”.

Notice that at the bottom of the screen, you can also see the history of previous matches. For each match, the screen shows the states A and B, the decision of each A and B participant, whether C viewed the decisions of each of the A and B participants, and the actions A and B chosen by C. This history screen is important as it tracks the past behavior of each participant.

Recap

Here is a brief recap of the important things you will see, and how they affect your payoffs:

(1) Roles A know state A and can choose to “Transmit” or “Withhold” it to C. Similarly, Roles B know state B and can choose to “Transmit” or “Withhold” it to C.
(2) If C clicks on a participant’s button, C will learn the state if that participant chose “Transmit” and he will see “unknown” if that participant chose “Withhold”. Clicking on a participant’s button is costly.

(3) The payoff of an A participant is 50 + action A – action B + 20 if C views your decision. The payoff of a B participant is 50 + action B – action A + 20 if C views your decision. In both cases, the participant does not get the extra 20 points if C does not view his decision.
(4) The payoff of C depends on the states, his own actions and the total cost of viewing the decisions of A and B participants. It is maximized by reporting the expected value of each state based on the information observed.

Are there any questions?

RECORD SHEET

Subject ID: ___________

TOTAL EARNINGS: $______

Name:_________________________

Date:_________________________

Amount received:_______________

School ID #:____________________

Signature:______________________

[THE NEXT PAGE ONLY FOR THE EXPERIMENTER]

[PAUSE to answer questions]

We will now begin the Practice session and go through 1 practice match to familiarize you with the computer interface and the procedures. During the practice match, **please do not hit any keys until you are asked to**, and when you enter information, please do exactly as asked. Remember, you are not paid for the practice match. At the end of the practice match you will have to answer some review questions. Everyone must answer all the questions correctly before the experiment can begin.

[AUTHENTICATE clients]

Please double click on the icon on your desktop that says ________. When the computer prompts you for your name, type your First and Last name. Then click SUBMIT and wait for further instructions.

[START game]

You now see the first screen of the experiment on your computer. Raise your hand high if you do. Please do not hit any key.

[PAUSE TO BE SURE EVERYONE HAS THE CORRECT SCREEN]

At the top left of the screen you see your **subject ID**. Please record that on your record sheet now. Some of you have Role A, some have Role B and some have Role C. If you have Role A or B, the screen looks similar to the screenshot in display 1. If you have Role C, you are instructed to wait. In all cases, at the bottom of the screen you can see a history panel with all the information relevant for each match.

If you have Role A or B, and your subject ID is even, click on the “Transmit” button. If it is odd, click on the “Withhold” button. Note that it does not matter which one you choose since you will not be paid for this match.

If you have Role C, you should now see a screen similar to the screenshot in display 2. If you have Roles A or B, you are instructed to wait. Click on the buttons to see A1’s decision then type the last two digits of your social security number and click “Submit”.

If you have Role C, you should now see a screen similar to the screenshot in display 3. If you have Roles A or B, you are instructed to wait. Click on the buttons to see B2 and B3’s decisions. **Notice that once you have seen the decisions of two B participants you cannot click on the decision of the third.** Now, type the last two digits of your year of birth and click “Submit”.

You should now all see a screen similar to the one in display 4. It displays the states, the actions of C and the payoffs of all participants in your group.

Now click “Continue”. The practice match is over. Please complete the review questions before we begin the paid session. Once you answer all the questions correctly, click submit. After all participants in your group have answered all questions correctly, the quiz will disappear from your screen. Raise your hand if you have any question.

[WAIT FOR EVERYONE TO FINISH THE QUIZ]

Are there any questions before we begin with the paid session?

We will now begin with the paid matches.

Remember, in the next matches, for the participant in role C, the cost of viewing decisions of A and B participants are as follows. For the first decision of an A participant you view, the cost is **5** points and for the second decision of an A participant you view, the cost is **30** points. For the first decision of a B participant you view, the cost is **10** points and for the second decision of a B participant you view, the cost is **50** points. **You cannot view the decision of all three A participants or all three B participants.**

[at the end of GAME ____]

The first part of the experiment is now finished. The second part of the experiment is identical to the first part except for the cost of viewing the decisions of A and B participants for the C participant. For the first decision of an A participant you view, the cost is now **10** points and for the second decision of an A participant you view, the cost is **50** points. For the first decision of a B participant you view, the cost is **5** points and for the second decision of a B participant you view, the cost is **30** points. **You cannot view the decision of all three A participants or all three B participants.**

[at the end of GAME ____]

This was the last match of the experiment. You will be paid the payoff you have accumulated in the ____ paid matches. The payoff appears on your screen. Please write this payoff in your record sheet and remember to CLICK OK after you are done.

[CLICK ON WRITE OUTPUT]

We will now pay each of you in private in the next room in the order of your Subject ID number. Remember you are under no obligation to reveal your earnings to the other participants.

Please put the mouse behind the computer and do not use either the mouse or the keyboard. Please remain seated until we call you to be paid. Do not converse with the other participants or use your cell phone. Thank you for your cooperation.

[CALL all the participants in sequence by their ID #]

[Note to experimenter: use the "pay" file to call and pay subjects]

Could the person with ID number 1 go to the next room to be paid?