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A Bayesian Examination of Anchoring Bias and Cheap Talk in Constructed Markets

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Abstract

We present a theoretical framework for understanding the relationship between anchoring bias, hypothetical bias, and cheap talk in constructed markets. In our theory, interviewers provide agents with signals such as cheap talk and bid values while eliciting the value for nonmarket goods. In response to these signals, agents revise their prior distributions over the value of the good. Previous empirical studies have failed to account for the interaction between cheap talk and anchoring during this updating process, leading researchers to incorrectly assess the effects of cheap talk in reducing hypothetical bias. In particular, we predict that cheap talk will appear to be more effective for relatively large bids. We test our theory in an experimental setting where agents are asked to make a hypothetical voluntary contribution to a public good. The experimental results, as well as several recent empirical studies, are consistent with the theory.

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1 Introduction

Over the past three decades, research into nonmarket valuation methods has grown at a frenzied pace.[1] One of the more popular of these methods is contingent valuation (CV), which uses constructed markets to elicit agents' maximum willingness to pay (WTP). A central problem with the CV method is that by participating in constructed rather than real markets, agents are prone to hypothetical, strategic, and framing biases.

In response to these problems, researchers have proposed a number of possible remedies. Examples include combining revealed and stated preference data (see Adamowicz, Louviere and Williams (1994)), randomizing opening bids for WTP (see Bishop and Heberlein (1990)), and informing agents upfront that they may be subject to hypothetical and strategic biases, with the hope that they will self correct. This latter method is commonly referred to as "cheap talk" (see Cummings and Taylor (1999)).[2] A common criticism of cheap talk is that it is ad hoc and not well grounded in economic theory.

The primary purpose of this paper is to lay a theoretical foundation for understanding why agents are subject to these types of framing issues and how they might react to instruments such as cheap talk. It is natural within a constructed model to treat this reaction process as a Bayesian-updating problem, since agents are being provided with new information, which they can use to revise their WTP for the nonmarket good.[3] We therefore begin with an abstract theory in which agents are prone to biases associated with formulating their WTP, due to a lack of experience with the good or a tendency to overvalue the good in a hypothetical situation. The bias is modeled as a stochastic component of utility (and thus WTP) over which agents form priors. The priors are updated in a Bayesian manner as the interviewer presents the agent with signals, such as cheap talk and an opening bid.

[1] For an overview of this literature see Brookshire, Thayer, Schulze and D'Arge (1982), Hausman (1993), Mitchell and Carson (1989), and Cummings, Brookshire and Schulze (1986).

[2] The term "cheap talk" originates from the game-theory literature, where agents may send non-binding signals prior to commitment.

[3] Herriges and Shogren (1996) and McLeod and Bergland (1999) also use a Bayesian approach to examine the issues of starting-point bias and incentive incompatibility, respectively. Our study is different because it focuses instead on the dual issues of cheap talk and starting-point bias.

The agent then forms a rational, updated estimate of the distribution of this stochastic bias term and uses the estimate to calibrate her WTP response. By casting the CV problem in this setting, we are able to sort out previously conflicting empirical results associated with anchoring bias, hypothetical bias, and cheap talk. We also extend our theory to double-bounded dichotomous-choice (DBDC) formats and discuss the attendant issue of incentive incompatibility.

The key insight from the paper is that agents choose to rationally anchor their WTP estimates to the announced bid in a manner that depends on whether they receive cheap talk. This dependence is important because the effectiveness of cheap talk in reducing hypothetical bias is tested by comparing the actions of those receiving cheap talk (treatment group) with those who do not (control group). Consequently, differences between the treatment and control groups that are attributed solely to cheap talk may instead reflect differences in how agents anchor their WTP estimates to the announced bids.

In the next section, we present our theoretical framework for the Bayesian-updating problem. Section 3 briefly discusses the recent cheap-talk literature. In Section 4, we present the experimental design used to test our theory. Section 5 presents our econometric methods and results. Section 6 extends our theory to a DBDC format, where the issue of incentive incompatibility is explored. Section 7 summarizes our main findings.

2 Theoretical Framework

Assume a continuum of agents indexed on the unit interval. Representative agent $i \in (0,1)$ maximizes utility

$$u_i = u(z_i, G(\eta_i); \theta_i) \tag{1}$$

by choosing a vector of private goods, z_i. Each agent's valuation of the public good, G, depends on a stochastic component η_i (discussed below). θ_i is a vector of individual-specific characteristics excluding income level. The agent's budget constraint is

$$m_i \geq p'z_i + g_i \tag{2}$$

where m_i is income, p is a vector of prices corresponding to z, and $g_i \geq 0$ is an exogenously determined lump-sum payment toward the provision of $G = \int_i g_i di$.

We invoke the standard assumption that utility is strictly increasing and concave in both the private and public goods. The term η_i reflects the notion that agents are not always capable of accurately assessing their subjective value of the public good due to inherent uncertainty and potential hypothetical bias. In particular, agents with $\eta_i > 0$ tend to overestimate their WTP for G, agents with $\eta_i < 0$ tend to underestimate their WTP for G, while agents with $\eta = 0$ accurately assess their WTP for G. As we show below, although agents attempt to correct for these biases via their interactions with the interviewer, they do not necessarily have adequate information to completely eliminate them.

Let $z_i^* = z(p, m_i - g_i, G(\eta_i); \theta_i)$ represent the agent's optimal choice of the private good vector, implying indirect utility level $u_i^* = u(z_i^*, G(\eta_i); \theta_i)$. The corresponding minimum expenditure function, defined with respect to net income, $m_i - g_i$, is

$$e_i = e(p, G(\eta_i), u_i^*; \theta_i) = m_i - g_i. \tag{3}$$

Using (3), the agent's WTP for G is derived as

$$WTP_i = e(p, G = 0, u_i^*; \theta_i) - e(p, G(\eta_i), u_i^*; \theta_i), \tag{4}$$

which is the difference between the minimum expenditure required to achieve utility level u_i^* without and with the public good. Due to the presence of η_i, (4) reflects the agent's perceived, rather than true, WTP for the public good. Accordingly, we characterize WTP as "true" WTP, $WTP_i(\eta_i = 0)$, plus the term δ_i:

$$WTP_i = WTP_i(\eta_i = 0) + \delta_i, \tag{5}$$

where δ_i has density function $p(\delta_i)$ with population mean

$$\mu = \int \delta_i p(\delta_i) d\delta_i. \tag{6}$$

We assume that δ_i is a random variable that reflects the agent's innate tendency to incorrectly estimate his WTP for the public good. While agents do not know $p(\delta_i)$, they do hold prior beliefs regarding the distribution for δ_i. Based on this subjective probability distribution for δ_i, they form a corresponding expectation denoted by $E_i(\delta_i)$. This expectation represents the agent's initial evaluation of his personal bias. For example, if $\delta_i > E_i(\delta_i) = 0$, then the agent does not recognize that he is overvaluing the public good and thus a positive bias exists. Another possibility is that $\delta_i > E_i(\delta_i) > 0$, in which case the agent recognizes that he is overvaluing the public good, but only partially corrects for the bias.

We refer to the agent's initial perceived WTP as WTP_i^0, which is given by (5). However, as he receives information from the interviewer, the agent revises his WTP in an attempt to reduce the influence of δ_i and bring perceived WTP closer to true WTP. The agent thus forms

$$WTP_i^1 = E(WTP_i|s_i) = WTP_i^0 - E_i(\delta_i|s_i), \tag{7}$$

where $E_i(WTP_i|s_i)$ is agent i's expectation of WTP_i conditional upon the information contained in the signal vector s_i. From (5) and (7), we see that clear signals provided by the interviewer regarding the population mean of δ_i are, on average, likely to bring perceived WTP closer to true WTP.

2.1 Eliciting WTP

To elicit her WTP for the public good in the dichotomous-choice format, the interviewer presents the agent with a hypothetical bid τ_i. The agent then compares WTP_i^1 to τ_i, accepts if $WTP_i^1 > \tau_i$ and declines otherwise. Prior to offering the bid τ_i, however, the interviewer presents the agent with an additional signal, represented as the draw $c_i \in \{0, \mu\}$. A draw of $c_i = 0$ represents no additional signal, while a draw of $c_i = \mu > 0$ informs the agent of δ_i's population mean. The latter type of signal is similar in spirit to the cheap talk of Cummings and Taylor (1999).

2.2 Bayesian Updating

Each agent faces a Bayesian-updating problem with a subjective prior distribution for δ_i, $h_i(\delta_i)$. We assume each agent has the non-informative prior $h_i(\delta_i) = 0.5/\bar{\delta}$ over $-\bar{\delta} < \delta_i < \bar{\delta}$, and $h_i(\delta_i) = 0$ elsewhere. As a consequence, the agent's initial estimate of δ_i is $E_i(\delta_i) = 0$ and the agent perceives herself as being immune to potential bias in her valuation of the public good. After receiving the signal $s_i = \{c_i, \tau_i\}$ from the interviewer, the agent then uses Bayes' formula

$$k_i(\delta_i|s_i) = \phi_i(s_i, \delta_i)h_i(\delta_i) \tag{8}$$

to update her beliefs regarding the distribution of δ_i, where $\phi_i(s_i, \delta_i)$ is the updating function and $k_i(\delta_i|s_i)$ is the posterior distribution. The function $\phi_i(s_i, \delta_i)$ captures the essence of the revisions to beliefs about δ_i by directly accounting for the interaction between δ_i, c_i and τ_i.[4] Assuming a quadratic loss function, the agent then responds "rationally" to s_i by forming an updated expectation of δ_i using[5]

$$E_i(\delta_i|s_i) = \int_{-\bar{\delta}}^{\bar{\delta}} \delta_i \; k_i(\delta_i|s_i)d\delta_i. \tag{9}$$

Based on c_i, we therefore have two scenarios to consider.

2.2.1 No Hypothetical-Bias Signal

We begin by considering the case where the agent receives the signal $s_i^0 = \{c_i = 0, \tau_i\}$. Because no signal is sent prior to the bid, revisions to δ_i are exclusively due to information contained in τ_i. For this scenario, we assume

$$E_i(\delta_i|s_i^0) = \alpha(WTP_i^0 - \tau_i) \tag{10}$$

[4] In accordance with Bayes' formula, the updating function $\phi(\cdot)$ is the ratio of the joint distribution of c_i and τ_i conditional on δ_i to the unconditional joint distribution of c_i and τ_i.

[5] See Hogg and Craig (1978) for a discussion of Bayesian updating and estimation.

where $0 < \alpha < 1$. Equation (10) states that in revising her bias estimate, the agent considers the bias to be a fraction of the difference between her initial WTP estimate and the bid. Implicit in (10) is the fact that the agent perceives τ_i as a signal that the interviewer has private information regarding the true WTP distribution. Substituting (10) into (7), we obtain an updated WTP (WTP_i^1) via the function

$$WTP_i^1 = (1 - \alpha)WTP_i^0 + \alpha\tau_i. \tag{11}$$

This updating function is equivalent to the one presented in Herriges and Shogren (1996). There is strong evidence to support the notion of anchoring, beginning with Tversky and Kahneman (1974) and discussed more recently by McFadden (2001).

To clarify, consider the following intuition. Suppose the agent begins with an initial perceived valuation of the public good, WTP_i^0, which is based on her noninformative prior and initial expectation of bias $E_i(\delta_i) = 0$. She is then confronted with a bid such that $\tau_i > WTP_i^0$. The agent interprets this information as indicating that her true WTP value is likely to be somewhere between her WTP_i^0 and τ_i. As a result, she now places a larger probability on outcomes where $\delta_i < 0$ and infers that her perceived distribution for δ_i needs to be shifted to the left. This implies that she revises, or anchors, her perceived WTP upward toward τ_i, resulting in $WTP_i^1 > WTP_i^0$. Conversely, when $\tau_i < WTP_i^0$, the agent assumes it is now more probable that $\delta_i > 0$ and that her initial WTP was biased upward. In this case, the agent anchors her perceived WTP downward toward τ_i, resulting in $WTP_i^1 < WTP_i^0$. Finally, when s_i^0 does not reveal any new information (i.e., when $c_i = 0$ and $\tau_i = WTP_i^0$), the agent does not revise her initial expectations and sets $WTP_i^1 = WTP_i^0$.

2.2.2 A Signal About The Mean of Hypothetical Bias

Next, consider the case where the agent receives the sequential signal $s_i^1 = \{c_i = \mu, \tau_i\}$ from the interviewer. In other words, prior to receiving the bid the agent receives the signal that δ_i has population mean μ. Keep in mind, this does not imply that the agent now knows

her value of δ_i with certainty, only that it is drawn from a distribution with mean μ.

We assume that in response to the initial signal $c_i = \mu$, the agent revises her estimate of δ_i so that $E_i(\delta_i|c_i = \mu) = \mu$.[6] The agent therefore estimates that her inherent bias is equal to the average bias in the population. Next, the agent compares her adjusted WTP ($WTP_i^0 - \mu$) to τ_i and uses a variation of equation (10) to update her estimate of δ_i:

$$E_i(\delta_i|s_i^1) = \mu + \gamma(WTP_i^0 - \mu - \tau_i),$$

where $0 < \gamma < 1$. This implies

$$WTP_i^1 = (1-\gamma)(WTP_i^0 - \mu) + \gamma\tau_i. \tag{12}$$

To test whether the cheap-talk signal $c_i = \mu$ is effective in eliminating hypothetical bias, the relevant measure is

$$\begin{aligned} \Delta_i &\equiv E_i(WTP_i|s_i^1, WTP_i^0) - E_i(WTP_i|s_i^0, WTP_i^0) \\ &= (\alpha - \gamma)(WTP_i^0 - \tau_i) + (\gamma - 1)\mu. \end{aligned} \tag{13}$$

If $\Delta_i = -\mu$, the researcher concludes that cheap talk successfully reduced agent i's WTP bias by μ. We now discuss several different cases that depend on the relative values of α, γ, WTP_i^0 and τ_i.

Case 1. Common Anchoring Structure ($\gamma = \alpha$) We begin with the case where $\gamma = \alpha$, that is, the agent anchors to τ_i in the same fashion whether he receives cheap talk or not. Equation (13) then collapses to $\Delta = (\gamma - 1)\mu$, which implies that even when cheap talk reduces initial WTP by exactly μ, anchoring makes it appear to the researcher that cheap talk was only partially effective (i.e., $\Delta > -\mu$). Furthermore, as $\alpha = \gamma \to 1$, cheap

[6] Some may argue that agents are unlikely to adjust their WTP perfectly to the signal $c_i = \mu$. For simplicity, we assume perfect adjustments, however, it is important to recognize that the subsequent results are robust to partial adjustments where $0 < E_i(\delta_i|c_i = \mu) < \mu$.

talk appears to have no effect because the anchoring completely overshadows the cheap-talk adjustment.

Figure 1 depicts the interaction between cheap talk and anchoring bias for Case 1, assuming $WTP_i^0 - \mu > \tau_i$. Panel A shows the prior and posterior distributions for δ_i when the agent receives the signal s_i^1. The agent begins with the noninformative prior distribution $h_i(\delta_i)$. After receiving the signal $c_i = \mu$, the agent then revises his distribution to $k_i(\delta_i|c_i = \mu)$, leading to a revised WTP equal to $WTP_i^0 - \mu$. Next, the agent receives the bid τ_i and further revises his distribution to $k_i(\delta_i|s_i^1)$ with conditional mean WTP_i^1. In Panel B, the agent begins with the same noninformative prior, receives bid τ_i without having been subjected to any cheap talk, and then revises his distribution for δ_i to $k_i(\delta_i|s_i^0)$. In comparing Panels A and B, note that although WTP_i^1 is farther to the left in Panel A than in Panel B, the difference between the two is less than μ. As a result, when testing for cheap talk, the researcher incorrectly concludes that cheap talk only partially eliminates the bias μ.

To clarify, consider the following numerical example. Suppose the agent's $WTP_i^0 = \$10$ and the cheap-talk signal is $c_i = \mu = \$4$. The agent then adjusts his initial WTP to be consistent with the first signal (i.e., $WTP_i^0 - \mu = \$6$) and compares this to the bid, which we assume is $\tau_i = \$2$. Letting $\alpha = \gamma = 0.5$, $WTP_i^1 = 0.5(6 + 2) = \$4$ with an anchoring effect of $\$4 - \$6 = -\$2$. By comparison, when $c_i = 0$ the agent sets $WTP_i^1 = 0.5(10 + 2) = \$6$, implying an anchoring effect of $\$6 - \$10 = -\$4$. Note that although cheap talk reduces initial WTP exactly as anticipated, because of the interaction with anchoring bias, cheap talk appears to be only partially effective (i.e., $\Delta_i = \$4 - \$6 > -\mu = -\$4$).

Case 2. Dual Anchoring Structures ($\gamma \neq \alpha$) We now consider three scenarios where the anchoring parameter is different with and without the cheap-talk signal. In particular, we assume throughout that the anchoring effect associated with τ_i is weakened by the presence of a cheap-talk signal (i.e., $\gamma < \alpha$). It is important to recognize that by assuming $\gamma < \alpha$, we are not claiming that the *total* effect of cheap talk and anchoring on WTP is necessarily smaller than without cheap talk, only that the *marginal* contribution of anchoring

is weakened by the presence of cheap talk.

Case 2a. $WTP_i^0 > \tau_i$. In this case, the agent receives a *relatively* low bid τ_i. When $c_i = 0$, the agent then anchors downward toward τ_i. If instead the agent receives the cheap-talk signal $c_i = \mu$ prior to receiving the bid, then depending upon the size of μ, the agent may either anchor downward toward the bid (when $WTP_i^0 - \mu > \tau_i$), anchor upward toward the bid (when $WTP_i^0 - \mu < \tau_i$) or not anchor at all (when $WTP_i^0 - \mu = \tau_i$). In each situation, the measured cheap-talk effect is given by equation (13). Because $\gamma < \alpha$ and $WTP_i^0 > \tau_i$, the first term in (13) is unambiguously positive so that the measured cheap-talk effect will either be a smaller negative value than in Case 1, or possibly even positive. The researcher will therefore conclude that cheap talk is either partially effective or ineffective in eliminating the hypothetical bias. Worse yet, the researcher may even conclude that cheap talk exacerbates the bias.

Case 2b. $WTP_i^0 = \tau_i$. This is a situation of one-sided anchoring, i.e., where anchoring occurs only for those who receive the signal $s_i = \mu$. As in Case 1, (13) simplifies to $\Delta = (\gamma - 1)\mu$, implying that cheap talk will not appear to be fully effective. This occurs because the anchoring effects are different with and without cheap talk, leading researchers to mistakenly conclude that cheap talk is only partially effective in correcting for hypothetical bias, when in fact it reduces initial WTP by exactly μ.

Consider another numerical example. Suppose again that $WTP_i^0 = \$10$ and the cheap-talk signal is $c_i = \mu = \$4$. The agent then adjusts his initial WTP to be consistent with the cheap-talk signal (i.e., $WTP_i^0 - \mu = \$6$) and compares this to the bid $\tau_i = \$10$. This time letting $\alpha = 0.5$ and $\gamma = 0.25$, $WTP_i^1 = 0.75(6) + 0.25(10) = \$7$ with an anchoring effect of $\$7 - \$6 = \$1$. By comparison, when $c_i = 0$ the agent sets $WTP_i^1 = 0.5(10 + 10) = \$10$, implying an anchoring effect of $\$10 - \$10 = \$0$. As in Case 1, cheap talk reduces initial WTP exactly as anticipated but it appears to be only partially effective (i.e., $\Delta_i = \$7 - \$10 > -\mu = -\$4$).

Case 2c. $WTP_i^0 < \tau_i$. In this case, the agent receives a relatively high bid τ_i. After receiving the signal s_i^0, the agent then anchors upward toward τ_i. If the agent instead receives the signal $c_i = \mu$ prior to receiving the bid, the agent similarly anchors upward toward the bid (note that $WTP_i^0 < \tau_i$ implies that $WTP_i^0 - \mu < \tau_i$ as well). The measured cheap-talk effect is again given by (13). Because $\gamma < \alpha$ and $WTP_i^0 < \tau_i$, the first term in (13) is unambiguously negative and the measured cheap-talk effect is more negative than in Case 2a. The researcher therefore concludes that cheap talk reduces hypothetical bias, however, Δ_i could be either larger, equal to, or smaller than $-\mu$.[7]

Returning to our numerical example, we consider a case where $\tau_i = \$18$. As in the previous examples, the agent's initial revised WTP with cheap talk is \$6. Again, letting $\alpha = 0.5$ and $\gamma = 0.25$, we see that with cheap talk $WTP_i^1 = 0.75(6) + 0.25(18) = \$9$, with an anchoring effect of $\$9 - \$6 = \$3$. With no cheap talk, the agent's $WTP_i^1 = 0.5(10 + 18) = \$14$, with an anchoring effect of $\$14 - \$10 = \$4$. In this case, the researcher concludes that cheap talk overcorrects for hypothetical bias (i.e., $\Delta_i = \$9 - \$14 < -\mu = -\$4$).

Before turning to an experiment that enables us to formally evaluate our theory, we briefly review the recent cheap-talk literature.

3 A Quick Review of the Cheap-Talk Literature

The empirical evidence is mixed on whether cheap talk is an effective means of eliminating hypothetical bias in CV and field experiments. At one end of the spectrum, Cummings and Taylor (1999) find that a long cheap-talk script is effective in eliminating hypothetical bias. List (2001) and Lusk (2003) use a script similar to that of Cummings and Taylor and find that cheap talk only works for inexperienced consumers. This pattern is consistent with a Bayesian updating framework, where experienced consumers have "tightened" their posterior WTP distribution to the point where cheap talk is no longer effective. Poe, Clark, Rondeau and Schulze (2002) report that a shorter cheap-talk script is ineffective in

[7] The critical value for $(WTP_i^0 - \tau_i)$ is $\mu\gamma/(\gamma - \alpha)$. If $(WTP_i^0 - \tau_i) < \mu\gamma/(\gamma - \alpha)$, then $\Delta_i < -\mu$. If $(WTP_i^0 - \tau_i) > \mu\gamma/(\gamma - \alpha)$, then $\Delta_i > -\mu$.

eliminating hypothetical bias, while Loomis, Gonzalez-Caban and Gregory (1994) and Neil (1995) find that reminders about budget constraints and substitutes are also ineffective. Aadland and Caplan (2003) find that, although cheap talk is ineffective overall, it successfully reduces hypothetical bias for certain groups of respondents. On the other end of the spectrum, Cummings, Harrison and Taylor (1995) and Aadland and Caplan (forthcoming) use a shorter script and find that cheap talk may even exacerbate the hypothetical bias.

Three recent papers – Brown, Azjen and Hrubes (2003); Murphy, Stevens and Weatherhead (2005) and Cherry and Whitehead (2004) – find that the effectiveness of cheap talk depends upon the bid level. Indeed, the dependence reported in all three papers is consistent with our theory: cheap talk appears to be effective at relatively high bid levels but ineffective at low bid levels.

In sum, although the pattern of effectiveness for various cheap-talk scripts is unclear, our Bayesian updating theory is capable of explaining several of the apparent anomalies found in the recent literature.

4 Experimental Design

Our experiment is designed to capture the notions of valuation uncertainty, hypothetical bias, anchoring, and cheap talk within a controlled laboratory setting.[8] The experiment took place on the University of Wyoming (UW) campus during May 2005. Approximately 300 participants were recruited via email using a comprehensive list of students provided by the UW Registrar's Office. The experiment consisted of three treatments – revealed preference (RP), stated preference with no cheap talk (NCT), and stated preference with cheap talk (CT). The RP treatment was included to test for hypothetical bias.[9]

Each of the treatments was comprised of three sessions ranging from 20 to 30 students per session. In each treatment, participants were given \$10 to "invest" either for real (in the RP treatment) or hypothetically (in the NCT and CT treatments). As participants entered

[8] The full CT experimental design is available at www.uwyo.edu/aadland/research/recycle/experiment.pdf.

[9] Prior to the actual sessions, a trial version of the RP and CT treatments were run with 10 students per session.

the room, they received $10 in cash, an instruction page, the first page of the experiment, and a demographic questionnaire. The instruction page, along with an example, were then read aloud to the participants and any questions regarding the experiment were answered. Participants then completed the first page of the experiment (which elicited a continuous measure of their initial WTPs) – it was collected and a second page was distributed. The second page elicited the participants' dichotomous investment choices. For the RP treatment, we also collected each participant's investment. The total class contribution was then calculated and "returns on investment" were calculated and announced. Participants were then paid (RP treatment) and excused. The entire experiment lasted between 10 and 15 minutes per session.

The instructions and payout chart from page 1 of the NCT and CT experiments are provided in the Appendix. Focusing on the payout chart, note that while the cooperative outcome to the investment game – everyone investing between $8 and $10 – results in the highest expected return for the participants, the noncooperative solution of no investment is the dominant strategy for all individuals. This captures the notion of potential free-riding associated with public goods. Also note that valuation uncertainty (δ) is captured by imposing a random payout range with a $2 interval.

From page 1 of the experiment we obtain a continuous value for WTP_i^0, where participants are asked, "As an initial guess, how much of your $10 do you think you would be willing to invest?" Page 2 then follows-up this question with a referendum, "Would you be willing to make an investment of $xx?", where each participant was given a different randomly selected $xx amount from the set of bids {$1, $3, $5, $7, $9}. In the case of the CT treatment, the referendum was preceded by the following cheap-talk script,

> Before answering the next question please note that in previous runs of this experiment we found that people typically overstate their true willingness to invest by approximately $2.00 when asked to do so in a hypothetical setting like this. Please keep this in mind when answering the next question.

We now turn to the econometric analysis of the experimental data.

5 Econometric Methods and Results

Begin by focusing on the descriptive statistics. As Table 1 indicates, the average initial WTP is \$3.60, while the average bid is \$4.95 with 48% of respondents saying "yes" to the bid. Across the NCT and RP treatments (N = 127), 55% of participants made hypothetical investment decisions while the remaining 45% made real investment decisions. Within the stated preference treatments (N = 153), there is also a nearly even split, with 54% receiving cheap talk (CT) and 46% receiving no cheap talk (NCT). Overall, the averages for the demographic variables appear to be typical of the UW student population.

5.1 Econometric Methods

We have two sources of experimental information on WTP – a continuous measure of initial WTP, WTP_i^0, and a dichotomous-choice response to bid τ_i. Begin with the following model for WTP_i^0:

$$WTP_i^0 = X_i'\beta + \nu_i \tag{14}$$

where $i = 1, ..., N$ indexes individual observations, X_i is a vector of demographic characteristics, β is the corresponding vector of coefficients, and ν_i is an i.i.d. normally distributed error term with a zero mean.

As is common in the cheap-talk literature, we specify an empirical model for our (latent) WTP_i^1 variable which allows us to estimate a constant cheap-talk coefficient[10]

$$WTP_i^1 = WTP_i^0 + \Delta C_i + \beta_\tau \tau_i + \epsilon_i \tag{15}$$

where ϵ_i is an i.i.d. normally distributed error term with a zero mean and variance σ_ϵ^2, C_i is a

[10] Recall that the cheap-talk meaure Δ_i in (13) varies across all agents. Here, we are interested in specifying an estimable equation with a constant cheap-talk coefficient, Δ, that is similar to that commonly estimated in the literature and that will enable us to highlight the biases associated with failing to recognize the interaction between cheap talk and anchoring. Also, note that although Δ_i in (13) is defined as the difference of expected values (with and without cheap talk) for the same agent, the econometric analysis will contrast the expected WTP of one set of agents that receive cheap talk (treatment group) with a different set of agents that do not receive cheap talk (control group), holding all other observable factors constant.

dummy variable set equal to one if the i^{th} agent receives cheap talk and zero otherwise, and Δ and β_τ are parameters capturing potential cheap-talk and anchoring effects, respectively. Substituting (14) into (15), we arrive at an alternative estimable equation

$$WTP_i^1 = X_i'\beta + \Delta C_i + \beta_\tau \tau_i + (\epsilon_i + \nu_i). \tag{16}$$

We then define the binary variable $ACCEPT_i$, which equals one if the agent invests at his given bid level τ_i and zero if he does not. As is standard in the literature, we assume that $ACCEPT_i = 1$ responses imply $WTP_i^1 > \tau_i$ and $ACCEPT_i = 0$ responses imply $WTP_i^1 \leq \tau_i$.

Next, we define the necessary probabilities for maximum-likelihood estimation. Using (15), the probability that agent i will accept bid τ_i is

$$\begin{aligned} P_i &= \Pr[ACCEPT_i = 1] \\ &= \Pr[WTP_i^1 > \tau_i] \\ &= \Pr[\epsilon_i > -WTP_i^0 - \Delta C_i + (1 - \beta_\tau)\tau_i] \\ &= \Phi\left(\frac{1}{\sigma_\epsilon}[WTP_i^0 + \Delta C_i + (1 - \beta_\tau)\tau_i]\right) \end{aligned}$$

for $i = 1, ..., N$, where Φ is the standard normal cumulative density function. The associated log likelihood function is

$$\log L = \sum\nolimits_{i=1}^{N} \left\{ACCEPT_i \ln(P_i) + (1 - ACCEPT_i) \ln(1 - P_i)\right\}. \tag{17}$$

As mentioned in Section 3, the existing cheap-talk literature reports mixed results regarding estimates of Δ. Some studies have found that cheap talk is effective (i.e., estimates of Δ are negative and statistically significant), while others have found estimates of Δ that are statistically indistinguishable from zero or possibly even positive. Based on our theory, estimates of Δ from equation (15) or (16) are likely to be biased because they do not account for the interaction of anchoring and with cheap talk. As highlighted in Cases 2a

and 2c, if $WTP_i^0 < (>)\tau_i$ we expect estimates of Δ will be biased upward (downward) in magnitude.

To explore this possibility, we partition our sample into those who received *relatively* low bids ($WTP_i^0 > \tau_i$) and those who received *relatively* high bids ($WTP_i^0 \leq \tau_i$). We then estimate equation (15) for these two subsamples. Our theory predicts that the estimate of Δ for the high-bid sample will be negative and less than the estimate for the low-bid sample.

5.2 Econometric Results

We present econometric results based on two different samples – the full sample (Table 2) and a sample including only upperclassmen – juniors, seniors and graduate students – or those with GPAs higher than 3.5 (Table 3).[11] Begin by focusing on the results from the full sample reported Table 2. Model 1, which corresponds to equation (14), is estimated using ordinary least squares (OLS). Student characteristics such as rank, GPA, gender, age, income and sensitivity to risk are only able to explain about 7% of the variation in initial WTP. Despite the low overall explanatory power, however, we find that those who are risk averse and upperclass display a significantly lower initial WTP. Model 2 tests for hypothetical bias using a probit model on the RP and NCT treatment data. The coefficient on HYP, although positive, is not statistically different than zero, suggesting that there is no evidence of significant hypothetical bias in the full sample (as we will discuss below, however, there is some evidence of hypothetical bias in Table 3).[12]

Models 3 through 5 estimate the effect of cheap talk on WTP, again using a probit model. Model 3 does so for the full sample, while models 4 and 5 split the samples into the relatively high- and low-bid groups, respectively. To save on degrees of freedom in the partitioned samples, all three models are estimated with initial WTP on the right-hand side, that is, using (15) rather than the full set of demographic variables in (16). The

[11] We consider the latter sample based on the presumption that these participants may have more experience and/or aptitude in dealing with such analytical exercises.

[12] This result is robust to the type of heteroscedasticity suggested by Haab, Huang and Whitehead (1999).

results are qualitatively similar using either approach. Most importantly, note that the cheap-talk dummy variable in model 3, while negative, is not statistically different than zero.[13] This is consistent with much of the recent cheap-talk literature, which finds mixed evidence that cheap talk is effective. However, in model 4 cheap talk is effective for those receiving relatively high bids, while in model 5 it is ineffective (even positive) for those receiving low bids. These results support our hypotheses in Cases 2a through 2c.

Finally, consider the results from Table 3 using the upperclass/high GPA sample. For the most part, the results from Table 3 are similar to those in Table 2, with two primary differences. First, we find significant evidence of hypothetical bias in this sample, indicating that participants are either more likely to (i) overcontribute to the public good in hypothetical settings and/or (ii) not contribute in the real settings. Second, although the ordering of the coefficients on the cheap-talk (C) variable in models 3 through 5 are consistent with our theory, the coefficient in model 4 is not statistically different than zero. In part, this may reflect the smaller sample size as compared with the full sample.

6 DBDC Formats and Incentive Incompatibility

Although the Bayesian-updating process described in Section 2.2 is based on the single-bounded dichotomous choice format, our framework naturally extends to multiple-bounded dichotomous-choice formats. For example, in a double-bounded format the agent receives the signal $s_i = \{c_i, \tau_{1i}, \tau_{2i}\}$ sequentially from the interviewer, where τ_{1i} and τ_{2i} represent the initial and follow-up bids, respectively. In this case, the agent uses Bayes' formula twice to update her beliefs regarding the distribution of δ_i – first using (8) based solely on c_i and τ_{1i}, followed by a revision of beliefs again using (8) but based instead on c_i, τ_{1i} and τ_{2i}. The agent then forms sequentially updated expectations of δ_i using (9). In the technical appendix, we form a measure of cheap-talk effectiveness similar to that presented in Section 2.2, and distinguish the cases based on the relative values of the anchoring parameters,

[13] Because of the possible anchoring effects refected by the coefficient β_τ in (15), we are not able to identify the parameter σ_ϵ^2 as in Cameron and James (1987). Fortunately, identification of σ_ϵ^2 is not necessary to contrast the estimation results from the relatively high- and low-bid samples.

WTP_i^0, τ_{1i} and τ_{2i}.[14]

In the context of the DBDC format, the question of incentive incompatibility arises.[15] In specific, do the follow-up bids induce a "structural shift" in the agent's stated WTP away from his underlying true WTP (in either the positive or negative direction)? Previous studies laying out the theoretical underpinnings of this question include Alberini, Kanninen and Carson (1997) and Carson, Groves and Machina (1999). Whitehead (2002) finds empirical evidence in support of the existence of incentive incompatibility in the double-bounded format.[16] Whitehead presumes that the agent's initial WTP represents her true underlying WTP. As a result, any shift away from initial WTP induced through the iterative bidding process represents perforce incentive incompatibility. However, for most goods in which CV analysis is applied, agents are unlikely to know their true WTP with certainty. Recall from (5) that WTP_i^0 represents the agent's perception of his true WTP rather than true WTP itself. Therefore, the shift from WTP_i^0 to WTP_i^1 that results in the DBDC format represents the agent's rational updating of the uncertainty associated with what he believes to be his true WTP. Whether this updating brings the agent closer to his true WTP or not depends on the information contained in the signal. Once one takes this Bayesian perspective of WTP formation, the recent discussion of the incentive incompatibility of DBDC formats changes markedly.

[14] The technical appendix is available upon request from the authors.

[15] The early literature on incentive incompatibility in CV studies (Cummings, Elliot, Harrison and Murphy (1997); Cummings, Harrison and Rutstrom (1995)) appears to characterize incentive incompatibility more broadly than some of the more recent studies. For example, Cummings, Harrison and Rutstrom (1995) on page 260 state that incentive incompatibility "implies that subjects will answer the CVM's *hypothetical* question in the same way as they would answer an identical question asking for a *real* committment." While Whitehead (2002) in a more recent study states on page 287 that in DBDC formats "if the follow-up questions are not incentive incompatible, stated willingness to pay will be based on true willingness to pay with a shift parameter."

[16] In a subsequent article, Aadland and Caplan (2004) find that incentive incompatibility "shift parameters" will be inconsistently estimated if certain restrictions associated with the nature of starting-point bias are not incorporated.

7 Summary

In this paper, we develop a Bayesian approach to model the elicitation of WTP for nonmarket goods and services. Many individuals have limited experience in trying to formulate a precise value for the types of public and environmental goods often examined under nonmarket valuation studies. In these situations, it seems more natural to model agents' WTP as being derived from a Bayesian-updating process rather than from a deterministic process. In a Bayesian framework, agents begin with a prior distribution over their uncertain WTP and use this distribution to form an initial WTP estimate. Agents are then provided with signals from the interviewer such as bids amounts and cheap-talk scripts. This information is used by agents to update their priors as they "grope" for their true WTP. One important implication of this process is that from an econometric standpoint, previous tests for the effectiveness of cheap talk are likely to be biased. In dichotomous-choice formats, the direction and magnitude of the bias depends on the distribution of initial WTPs relative to the opening bids. If a bid is high relative to an agent's initial WTP, then standard econometric methods are likely to find a significant or exacerbated cheap-talk effect. A bid that is low relative to an agent's initial WTP leads to a measured cheap-talk effect that is mitigated, non-existent, or even counterintuitive. Because agents' initial WTPs are typically unknown in nonmarket valuation studies, it is difficult *a priori* to predict the direction and magnitude of the potential bias.

We present two sources of information to test our theory. First, we highlight three recent papers that find weak overall cheap-talk effects, but as predicted by our theory, show that cheap talk appears effective for those receiving relatively high bids and ineffective for those receiving relatively low bids. We interpret this evidence as being consistent with the interaction between anchoring and cheap talk in a Bayesian updating framework. Second, we present evidence that the same phenomena occurs in an experimental setting, where we are better able to control for external influences. When taken together, neither of the two sets of evidence allow us to reject our theory. Consequently, our Bayesian interpretation of the valuation for goods with substantial nonmarket components remains a plausible

interpretation for the mixed empirical results in the cheap-talk literature.

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Table 1. Variable Names, Definitions and Descriptive Statistics

Variable	Definition	Descriptive Statistics		
		Sample Size	Mean	SD
WTP^0	Initial WTP	286	3.60	2.89
WTP^1	Yes to Bid = 1; No to Bid = 0	153	0.48	0.50
τ	Bid	153	4.95	2.84
C	Cheap Talk = 1; No Cheap Talk = 0	153	0.54	0.50
Hyp	Stated Preference = 1, Revealed Preference = 0	127	0.55	0.50
Female	Female = 1, Male = 0	286	0.53	0.50
Old	(Age $\geq$ 22) = 1,Otherwise = 0	286	0.47	0.50
Upperclass	Junior/Senior/Grad = 1, Otherwise = 0	286	0.63	0.48
GPA	Cumulative College GPA	286	3.27	0.50
GPA^2	--	286	10.92	3.17
High Income	(Inc. > \$20K) = 1, Otherwise = 0	286	0.08	0.27
Risk Averse	Risk Averse = 1, Otherwise = 0	286	0.56	0.50

Notes. SD = Standard Deviation. Varying sample sizes reflect different models where the variables are used.

Table 2. Econometric Results

Variables	WTP^0 Dependent (OLS)		WTP^1 Dependent (Probit)											
	Model #1 Demographics		Model #2 Hypothetical Bias			Model #3 Cheap-Talk Effect			Model #4 High-Bid Sample CT Effect			Model #5 Low-Bid Sample CT Effect		
	Coef	SE	Coef	SE	ME	Coef	SE	ME	Coef	SE	ME	Coef	SE	ME
WTP^0						0.16***	0.03	0.06	0.50***	0.10	0.16	-0.06	0.06	-0.02
τ			-0.12***	0.04	-0.05	-0.11***	0.03	-0.04	-0.27***	0.06	-0.09	0.23**	0.16	0.08
C						-0.22	0.20	-0.05	-0.52**	0.28	-0.09	0.33	0.35	0.07
Hyp	0.27	0.42	0.19	0.27	0.04									
Constant	-3.56	5.21	-3.38	3.85	--									
Upperclass	-0.78*	0.44	-0.24	0.30	-0.06									
GPA	5.26	3.35	2.53	2.44	0.71									
GPA^2	-0.83	0.53	-0.37	0.39	--									
Female	-0.00	0.34	-0.01	0.23	-0.00									
Old	-0.23	0.44	-0.11	0.30	-0.02									
High Income	-0.05	0.64	0.89**	0.53	0.03									
Risk Averse	-0.96***	0.34	-0.32*	0.24	-0.07									
Summary Statistics	$R^2 = 0.07$ N = 286		Log L = -79.37 N = 127			Log L = -91.63 N = 153			Log L = -40.36 N = 104			Log L = -28.27 N = 49		

Notes. SE = Standard Error. ME = Marginal Effect. CT = Cheap Talk. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level.

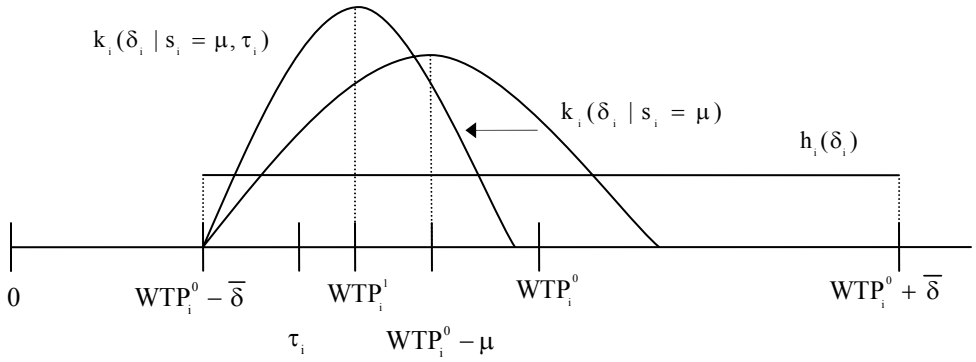
Table 3. Econometric Results (High GPA/Upperclass Sample)

Variables	WTP^0 Dependent (OLS)		WTP^1 Dependent (Probit)											
	Model #1 Demographics		Model #2 Hypothetical Bias			Model #3 Cheap-Talk Effect			Model #4 High-Bid Sample CT Effect			Model #5 Low-Bid Sample CT Effect		
	Coef	SE	Coef	SE	ME	Coef	SE	ME	Coef	SE	ME	Coef	SE	ME
WTP^0						0.21***	0.04	0.08	0.55***	0.12	0.15	0.02	0.07	0.01
τ			-0.19***	0.05	-0.07	-0.15***	0.03	-0.06	-0.32***	0.07	-0.09	0.17	0.13	0.06
C						-0.28	0.23	-0.06	-0.36	0.33	-0.06	0.03	0.39	0.01
Hyp	0.71	0.51	0.39*	0.29	0.09									
Constant	3.68***	0.61	0.98***	0.46	--									
Female	-0.18	0.40	0.14	0.29	0.03									
Old	-0.31	0.41	-0.32	0.30	-0.08									
High Income	-0.20	0.73	0.91*	0.57	0.03									
Risk Averse	-1.09***	0.40	-0.48***	0.29	-0.10									
Summary Statistics	$R^2 = 0.05$ N = 210		Log L = -52.35 N = 90			Log L =-63.50 N = 118			Log L = -30.26 N = 77			Log L = -23.31 N = 41		

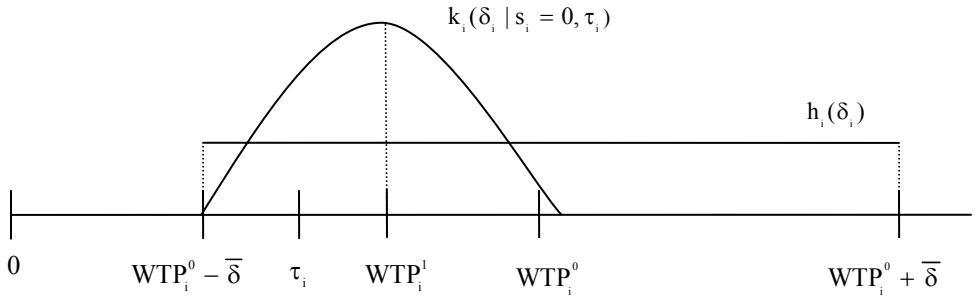
Notes. SE = Standard Error. ME = Marginal Effect. CT = Cheap Talk. * Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level.

Figure 2. Stylized Representation of Hypothesis #3 ($WTP_i^0 - \mu > \tau_i$)

Panel A. Directed Cheap Talk



Panel B. No Cheap Talk



Appendix. Page 1 of the Experiment for NCT and CT Treatments

Directions. Use the payout chart below to decide whether to hypothetically invest all, part, or none of your $10. If this experiment were for real, your payout range would determined by your investment choice and the average investment of the group. (Note that if the total group investment is zero, the payout is zero to everyone.) The exact payout would be determined by the roll of a die. For both the YES and NO columns, if a 1 or 2 is rolled the Min is paid; if a 3 or 4 is rolled the Mid is paid; and if a 5 or 6 is rolled the Max is paid.

PAYOUT CHART

Average Group Investment	Range of Payouts Based on Your Investment Choice					
	"YES, I'll invest"			"NO, I won't invest"		
	Min Payout	Mid Payout	Max Payout	Min Payout	Mid Payout	Max Payout
Greater than $0; Less than or equal to $2	$0	$1	$2	$1	$2	$3
Greater than $2; Less than or equal to $4	$3	$4	$5	$4	$5	$6
Greater than $4; Less than or equal to $6	$6	$7	$8	$7	$8	$9
Greater than $6; Less than or equal to $8	$9	$10	$11	$10	$11	$12
Greater than $8; Less than or equal to $10	$12	$13	$14	$13	$14	$15

QUESTION #1

As an initial guess, how much of your $10 do you think you'd be willing to invest? _____