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Abstract

Language is an imperfect and uneven means of communicating information about a complex and nuanced world. We run an experimental investigation of a setting in which the messages available to the sender imperfectly describe the state of the world, however the sender can improve communication, at a cost, by increasing the complexity or elaborateness of the message. As is standard in the communication literature, the sender learns the state of the world then sends a message to the receiver. The receiver observes the message and provides a best guess about the state. The incentives of the players are aligned in the sense that both sender and receiver are paid an amount which is increasing in the accuracy of the receiver's guess. As would be expected, we find that larger communication costs are associated with worse outcomes for both sender and receiver. Consistent with the communication literature, albeit in very different setting, we find that there is overcommunication. For the receiver, there is a positive relationship between the payoffs relative to the equilibrium predictions and communication costs. This relationship is negative for the senders. We also find that the response time of both the sender and receiver are positively related to their payoffs.

JEL: C72, C91, D82
Keywords: communication, cheap talk, overcommunication

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1 Introduction

Words exhibit properties very different from those of real numbers. For instance, it is not the case that there exists a word with a meaning *between* any two words. However, words are used to construct statements which convey information about a complex and nuanced reality. One can use words to express more and more detailed and nuanced information, but only at a cost to the sender. So it is our view that language is an imperfect and uneven means of communicating information about a complex and nuanced world. We run an experimental investigation of a setting in which the language available to the sender imperfectly describes the state of the world, however the sender can improve communication, at a cost, by increasing the complexity or elaborateness of the message. Although we find that senders overcommunicate, we also find that senders conserve expensive signals and that receivers anticipate this effect.

Hertel and Smith (2010) provides a theoretical account of communication where an informed party faces a restricted message space and can send a more elaborate message by incurring a larger cost of communication. Specifically, the sender has a set of message elements with which to compose a message. The sender can send a more elaborate message, by composing a message containing more message elements, where the cost is increasing in the number of elements. This would seem to be a natural way to model costly and discrete communication.[1] Hertel and Smith characterize the equilibria, of which there are many. The authors introduce an out-of-equilibrium condition, whereby under this condition only the most informative class of equilibria remains. The paper makes the prediction that more costly signals will be conserved (sent on smaller regions of the state space) and that communication outcomes for both sender and receiver are decreasing in communication costs incurred by the sender. The present paper can be viewed as an experimental test of the setup and predictions of Hertel and Smith (2010).

In this experiment, the subjects are anonymously divided into pairs, one as a *sender* and one as a *receiver*. As is standard in the communication literature, the sender learns the state

[1] See Hertel and Smith (2010) for further discussion of the modeling choices.

of the world then sends a message to the receiver. The receiver observes the message and selects an action which affects the payoffs of both players. The incentives of the players are aligned in the sense that both sender and receiver are paid an amount which is increasing in the accuracy of the receiver's action.

We make two notable departures from the literature. First, the set of messages imperfectly relate to the underlying state space. Second, in order to transmit a more elaborate message, a larger communication cost is incurred by the sender. Here the state space is an integer between -3 and 3. The sender can send a costless message, which we refer to as the empty message.[2] Additionally, the sender can compose a costly message consisting of two possible elements "High" and "Low." Given our state space, these message elements would seem to provide a natural ordering. The cost of a message is then a function of the number of elements in the message. Therefore, the empty message can be transmitted at a cost of 0; the messages "High" and "Low" can be transmitted at a cost of c; and the messages "High High," "High Low," "Low High" and "Low Low" can be transmitted at a cost of $2c$, where we vary c.

We find that the equilibrium predictions do rather poorly, because the senders are over-communicating. We find that there is a negative relationship between the sender's payoffs relative to the equilibrium payoffs and the communication costs. However, we find a positive relationship between the receiver's payoffs relative to the equilibrium payoffs and the communication costs. We also find that the response time is positively related to the payoffs relative to the equilibrium payoffs, for both sender and receiver.

2 Related Literature

There is a literature which tests existing communication models in general and the Crawford and Sobel (1982) model in particular. Perhaps the first paper testing Crawford and Sobel was Dickhaut et. al. (1995) whereas more recent examples include Cai and Wang (2006), and

[2] Throughout the paper we describe the costless message as *empty* rather than the condition of having not received a message. This is because, it might not be easy to distinguish between the sender having decided not to send a message and the sender having not yet sent a message. To rule out this confusion we describe the costless message as empty.

Kawagoe and Takizawa (2009). Due to the limited ability of subjects to find complex equilibria in novel situations, testing communication equilibria typically uses simplified versions of the model. A natural way to accomplish this simplification is to specify the state space as a set of integers rather than the unit interval. For instance, Dickhaut et. al. specifies the state space as the integers between 1 and 4 and Cai and Wang specifies the state space as an integer between 1 and 9. We select a state space as the set of integers between -3 and 3 in order to render the signal elements of "High" and "Low" relatively meaningful. Further, we hoped that the empty message would be used to denote the set around the state 0. This would seem to aid in the coordination problem[3] between the sender and receiver. Also note that in Dickhaut et. al. (1995), Cai and Wang (2006), and Kawagoe and Takizawa (2009) there is a one-to-one relationship between the state and the set of feasible signals. By contrast, for sufficiently high communication costs (c), in out paper there is no such profitable relationship.

Studies of cheap talk communication have found that the senders often overcommunicate.[4] Relatedly there is a literature which finds that subjects can have an aversion to lying.[5] Again, this literature finds that senders overcommunicate. Note that our subjects never have an incentive to mislead the sender because the sender and receiver have identical preferences over the action of the receiver. Despite the fact that our experimental environment is quite different from the setting in these two literatures, we also find that the senders overcommunicate. Given that we observe similar behavior in such different settings, we argue that overcommunication is a robust phenomenon.

Economists have recently become interested in studying the response times of subjects.[6] Research has found that longer response times are associated with more strategic and less automatic reasoning. Consistent with this research, we find that longer response times are associated with higher per period payoffs relative to equilibrium payoffs, for both sender and receiver.

[3] Prior work finds that subjects can resolve similar coordination problems (Blume et. al., 1998, 2001; Blume and Gneezy, 2000; Kreps, 1990). However this is not the focus of our paper.

[4] For example, see Cai and Wang (2006) and Kawagoe and Takizawa (2009).

[5] For instance, Gneezy (2005), Hurkens and Kartik (2009), and Sanchez-Pages and Vorsatz (2007, 2009).

[6] For instance, Brañas-Garza and Miller (2008), Piovesan and Wengström (2009), and Rubinstein (2007)

3 Equilibrim Predictions

We now present a discussion of the equilibria as predicted by Hertel and Smith (2010), which admits only the most informative equilibria. Recall that our state space is $s \in \{-3, -2, -1, 0, 1, 2, 3\}$. Our message space is $m \in \varnothing \cup (\cup_{i=1}^{2}\{High, Low\}^i)$. The communication costs $c(m)$ are a function of the number of elements transmitted. The receiver has an action space of $a \in \{-3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3\}$. Both the sender and receiver prefer the receiver to select the action as close to the state as possible. Specifically, in each period, the payoff to the receiver was the nonnegative integer closest to:

$$U_R = 100 - 25(a - s)^2. \tag{1}$$

In each period, the payoff to the sender was the integer closest to:

$$U_S = U_R - c(m). \tag{2}$$

For $c \in [0, 12.5]$, any fully revealing equilibria will exist. Specifically, each message is used and a single message is sent for each state. For $c \in [0, 25]$ then all fully revealing equilibria will exist, with the exception that adjacent states do not have a difference in communication cost of $2c$. In each of these fully revealing equilibria, the ex-ante payoffs are identical: the expected payoff for the receiver in each equilibria is $EU^R = 100$ and the expected payoff for the sender in each equilibria is $EU^S = EU^R - \frac{10}{7}c$.

For $c \in [25, 94]$, the equilibria is such that the messages with two elements are not used. Messages "High" and "Low" are each sent on 2 adjacent states and the empty message is sent on 3 adjacent states. The expected payoff of the receiver is $EU^R = \frac{100}{7} + 2 \cdot \frac{75}{7} + 4 \cdot \frac{94}{7}$. The expected payoff for the sender is $EU^S = EU^R - \frac{4}{7}c$. It should be noted that the equilibrium predictions are identical within each of the intervals mentioned. Therefore, the predictions for equilibrium behavior are the same whether $c = 26$ or 93.

For $c \in [94, 100]$ then the equilibria is such that the messages with two elements are not used. Messages "High" and "Low" are each sent on the extreme states, 3 and -3. The empty message is sent on the remaining states. Given the empty message, the receiver is indifferent between selecting -0.5 and 0.5. The expected payoff to the receiver is $EU^R = 2 \cdot \frac{94}{7} + 2 \cdot \frac{44}{7} + 2 \cdot \frac{100}{7}$. The expected payoff to the sender is $EU^S = EU^R - \frac{2}{7}c$. Note that the receiver is indifferent between selecting -0.5 and 0.5 but not 0. If the sender is pooling on more than 3 states, the expected payoff of selecting -0.5 or 0.5 is $2 \cdot \frac{94}{7} + 2 \cdot \frac{44}{7} = \frac{286}{7}$ and the expected payoff of selecting 0 is $\frac{100}{7} + 2 \cdot \frac{75}{7} = \frac{250}{7}$. Therefore, selecting an integer action yields a lower payoff.

For $c > 100$ then the only equilibria is one in which the sender only sends the empty message for all states and the receiver has no additional information about the state and is therefore indifferent among selecting -1.5, 0.5, 0.5 and 1.5. The expected payoffs are then $EU^R = EU^S = 2 \cdot \frac{94}{7} + 2 \cdot \frac{44}{7}$.

4 Experimental Design

A total of 48 subjects participated in the experiment. The subjects were both undergraduate and graduate students at Rutgers University-Camden. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). Sessions lasted from 90 to 120 minutes.

In each period, the sender was shown the state, which we referred to as the "secret number." The state s consisted of an integer between -3 and 3. In order to inform the receiver of its content, the sender was able to transmit a possibly costly message. The message "Empty message" cost $c(m) = 0$, the messages "High" and "Low" each cost $c(m) = c$, the messages "High High," "High Low," "Low High," and "Low Low," each cost $c(m) = 2c$, where $c \in \{10, 30, 50, 96\}$. Upon observing the message, the receiver selected a best guess about the state. The receiver's action a was selected from the action space of half integers between -3 and 3.

The per period payoff to the receiver was the nonnegative integer closest to $100 - 25(a - s)^2$. The per period payoff to the sender was the integer closest to the receiver's payoffs minus $c(m)$.

In order to aid in the estimation of their payoffs, the subjects were given a table indicating the payoffs associated with each state and action selected by the receiver.[7] The subjects were given a \$5 show up fee and \$1 for every 300 points accumulated.[8]

Sender and receiver were matched and played the game for 15 periods where c was held fixed. After the 15 periods, each subject was rematched with a different opponent, each switched role as sender and receiver, and played with a new value of c. Each trial consisted of 4 rounds of 15 periods. The subjects were made aware of these matching procedures. We ran two treatments which consisted of 8 subjects and two treatments of 16 subjects. Therefore, we have a total of 1440 data points for both sender and receiver.

A few comments on our methodology are in order. Since we expected overcommunication, even though only the senders incurred the communication costs, we designed the experiment to reduce the social preferences of the sender towards the receiver. First, we emphasized the differences in the payoffs by displaying the per period payoff of both subjects. Second, we emphasized the anonymous matching whereby after each round of 15 periods, the players would be rematched with a new partner. This was done in order to discourage any implicit reciprocal play. Finally, many experimental communication papers rematch the subjects after each period. However, we decided not to rematch, as there is a reasonably difficult coordination problem, which would be aggravated by rematching after every period.

5 Results

In each of the four rounds, the subjects exhibited learning across periods 1-15. Across all periods, the relationship between the sender's payoffs and the period in which it was obtained is very significant ($p = 0.01$). However, within periods 5-15, the relationship is not significant ($p = 0.7$). Therefore, within each round, we exclude from consideration the data obtained in periods 1-4.

[7] See the appendix for this table.

[8] The total amount earned in the experiment ranged from \$6.29 to \$20.54, with an average of \$15.62.

Overall, the equilibrium predictions do rather poorly. Within each communication cost treatment, there is a significant difference between the sender's payoffs and the equilibrium prediction. In all but the highest cost treatment, there is a significant difference between the receiver's payoffs and the equilibrium prediction. This data is presented in Table 1.

	Sender		Receiver	
	Equilibrium	Actual	Equilibrium	Actual
$c = 10$	85.71	67.13**	100.00	81.03**
$c = 30$	72.29	47.16**	89.43	84.09**
$c = 50$	60.86	29.60**	89.43	76.00**
$c = 96$	40.57	−6.14**	68.00	69.86

Table 1: Equilibrium predictions of payoffs and actual mean payoffs for senders and receivers according communication costs. Results of one-sample t-tests each with 263 degrees of freedom, where ** indicates significance of a one-sided test at $p < 0.01$.

Recall that the receiver's payoffs correspond to the accuracy of the receiver's action and the sender's payoffs correspond to this accuracy minus communication costs. A glance at Table 1 suggests that as communication costs increase, the actions are becoming more accurate yet the senders are doing worse relative to the equilibrium predictions. This suggests that the senders are overcommunicating. In particular, the sender's payoffs vary too much with communication costs and the receiver's payoffs do not vary enough. This is confirmed by the following regressions with the dependent variable of actual payoffs minus equilibrium payoffs. In regressions $(S1) - (S5)$ of Table 2, the dependent variable is the sender's actual payoffs minus the sender's equilibrium payoffs and in regressions $(R1) - (R5)$ of Table 3, the dependent variable is the receiver's actual payoffs minus the receiver's equilibrium payoffs. The independent variables included the communication costs faced by the sender, the time in which it took the subject to select their decision. Regressions $(S1) - (S4)$ and $(R1) - (R4)$ do not account for possible fixed effects in our panel data, however regressions $(S5)$ and $(R5)$ perform a subject specific fixed effect regression.

	$(S1)$	$(S2)$	$(S3)$	$(S4)$	$(S5)$
Intercept	-15.23^{**}	-87.15^{**}	-71.55^{**}	-61.55^{**}	-56.30^{**}
	(2.81)	(6.83)	(7.15)	(12.44)	(9.16)
Communication Costs	-0.33^{**}	–	-0.31^{**}	-0.50^{*}	-0.31^{**}
	(0.050)		(0.049)	(0.20)	(0.08)
Response Time	–	2.46^{**}	2.40^{**}	1.97^{**}	2.04^{**}
		(0.29)	(0.28)	(0.52)	(0.29)
Interaction	–	–	–	0.0083	–
				(0.0085)	
Fixed Effects	No	No	No	No	Yes
n	1056	1043	1043	1043	1043
R^2	0.039	0.066	0.10	0.10	0.27

Table 2: Results of regressions where the dependent variable is the sender's actual payoffs minus sender's equilibrium payoffs, and ** indicates significance at $p < 0.01$ and * indicates significance at $p < 0.05$.

	$(R1)$	$(R2)$	$(R3)$	$(R4)$	$(R5)$
Intercept	-18.41^{**}	-36.51^{**}	-48.03^{**}	-39.95^{**}	-56.30^{**}
	(1.88)	(4.63)	(4.88)	(8.12)	(9.16)
Communication Costs	0.20^{**}	–	0.21^{**}	0.049	0.42^{**}
	(0.033)		(0.033)	(0.13)	(0.054)
Response Time	–	1.23^{**}	1.30^{**}	0.94^{**}	1.07^{**}
		(0.20)	(0.20)	(0.35)	(0.20)
Interaction	–	–	–	0.0073	–
				(0.0058)	
Fixed Effects	No	No	No	No	Yes
n	1056	1041	1041	1041	1041
R^2	0.034	0.035	0.072	0.074	0.23

Table 3: Results of regressions where the dependent variable is the receiver's actual payoffs minus receiver's equilibrium payoffs and ** indicates significance at $p < 0.01$.

The number of observations is not constant in either table because, for regressions involving response time, we only included observations with response times greater than 0.[9] First, note that in Table 2, every specification involving communication costs has a negative and significant estimate. This suggests that as communication costs increase, the senders do worse relative to the equilibrium predictions. We note the opposite effect the receivers. Table 3 shows that in $(R1)$, $(R3)$, and $(R5)$, the estimates for the coefficient for communication costs

[9] The z-Tree output included negative response times.

are positive and significant. In ($R4$) the coefficient is estimated to be positive but it is not significant. Therefore, as the communication costs increase, the receivers do better relative to the equilibrium predictions.

Also note the results of Tables 2 and 3 involving the time it took the subject to make the choice. In all 8 specifications involving response time, the estimate is significant and positive. Consistent with the literature, we find a relationship between response time and performance. We account for the subject specific fixed effects in ($S5$) and ($R5$), where we find that the response time variable remains significant. These results rule out the claim that the previous response time results are driven by the heterogeneity of the subjects. Also note that for each specification, the estimates for the sender are larger than that for the receiver. This suggests that the sender's problem is more difficult than the receiver's. Therefore, additional time considering choice as a sender is more productive than that as a receiver.

Although the equilibrium predictions do rather poorly, the subjects do exhibit some degree of sophistication. Perhaps, this is best appreciated by the inference of the empty signal by the receiver as a function of the communication costs. We perform a binomial probit with the communication costs as an independent variable and the probability that the empty message leads to an action of 0 as the dependent variable. The results of this probit are listed in Table 4.

Intercept	1.997^{**}
	(0.234)
Communication costs	-0.0205^{**}
	(0.0030)
$-LL$	131.27
χ^2	45.28^{**}
n	274

Table 4: Binomial probit of subjects selecting the action 0 upon observing the empty message, where ** indicates significance at $p < 0.01$

The results of the probit analysis suggest that there is a negative relationship between the probability that the receiver plays the action 0 after observing the empty message and the communication costs faced by the sender. Recall, our discussion of the equilibrium predictions.

In equilibrium for low communication costs, the sender sends the empty message on a single state, the focal state being 0. In equilibrium for intermediate costs, the sender sends the empty message for 3 states, the focal states being -1, 0, and 1. In equilibrium, for large costs, the sender sends the empty message, effectively for all states. While the senders do not behave exactly as in equilibrium, in our experiment there is a relationship between the number of states on which the empty message is sent and communication costs. Further, the receivers are inferring that qualitative behavior and therefore there is a negative relationship between selecting the action 0 after observing the empty message and the communication costs faced by the sender.

6 Conclusions

We run an experiment where the messages available to the sender imperfectly describe the state of the world, however the sender can improve communication, at a cost, by increasing the complexity or elaborateness of the message. The incentives of the players are aligned in that both sender and receiver are paid an amount which is increasing in the accuracy of the receiver's action. Although the equilibrium predictions of Hertel and Smith (2010) do rather poorly, our experimental results do corroborate some of the qualitative predictions. In particular we find that the payoffs of both sender and receiver are negatively related to the communication costs incurred by the sender. We also find that, expensive signals are conserved when communication is expensive and that and that receivers infer this relationship.

Consistent with the communication literature, albeit in very different setting, we find that there is overcommunication. For the receivers, there is a positive relationship between the payoffs relative to the equilibrium predictions and communication costs. This relationship is negative for the senders. We also find that the response time of both the sender and receiver are positively related to payoffs, implying that more thought on the part of our subjects leads to better communication outcomes.

We view the results of this paper to be a confirmation of the robustness of the overcommunication found in previous communication experiments which were conducted in very different settings. In these cheap talk experiments, the sender and receiver have different preferences over the action of the receiver. Therefore, overcommunication in these experiments takes the form that the senders do not do not conceal the truth enough. Unlike the overcommunication found these settings, the senders in our experiment *say too much*. Given that we observe similar behavior in such different settings, it would seem that overcommunication is a robust phenomenon.

7 References

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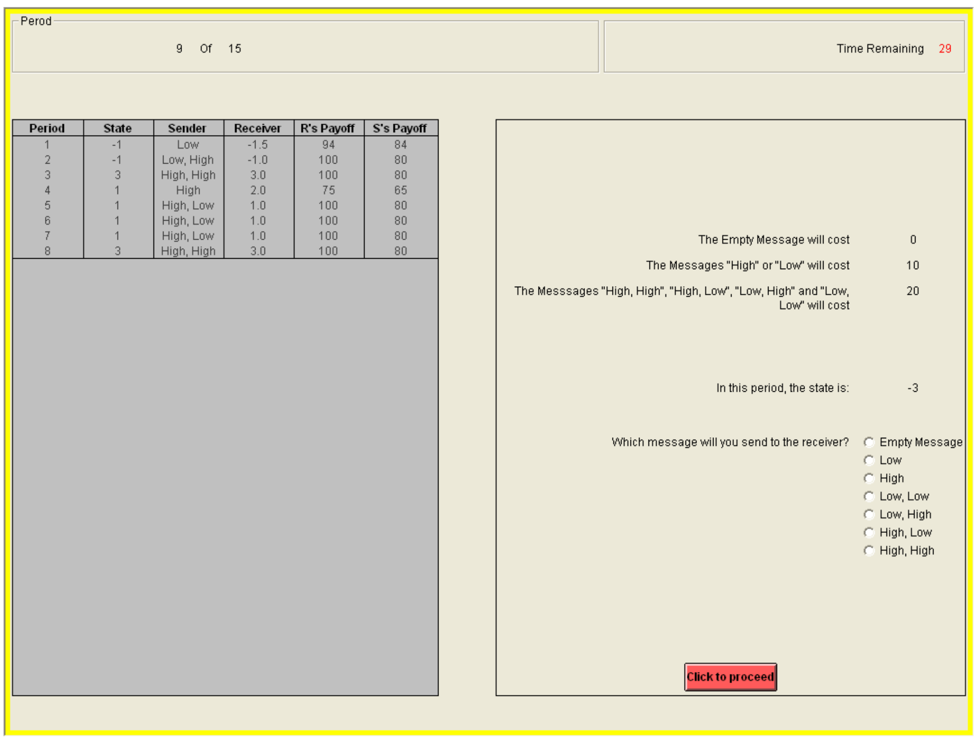
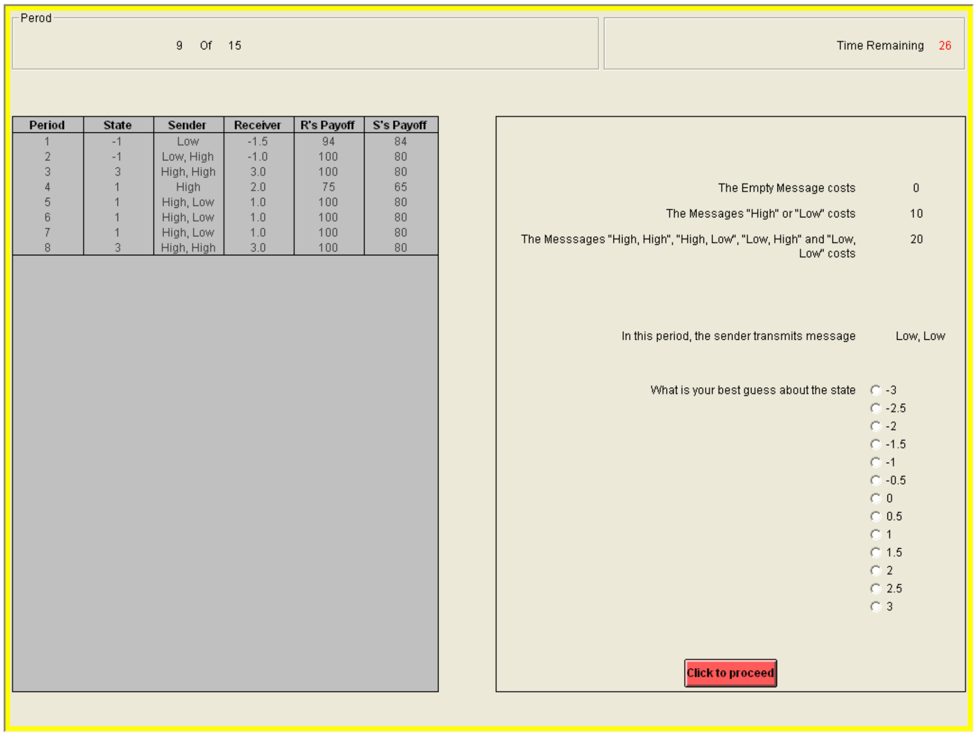
8 Appendix

Although the payoffs were specified by equations (1) and (2), the subjects were also presented with the following table.

		Action												
		-3	**-2.5**	**-2**	**-1.5**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**
	-3	100	94	74	44	0	0	0	0	0	0	0	0	0
	-2	75	94	100	94	74	44	0	0	0	0	0	0	0
	-1	0	44	75	94	100	94	74	44	0	0	0	0	0
State	**0**	0	0	0	44	75	94	100	94	74	44	0	0	0
	1	0	0	0	0	0	44	75	94	100	94	74	44	0
	2	0	0	0	0	0	0	0	44	75	94	100	94	75
	3	0	0	0	0	0	0	0	0	0	44	75	94	100



Sender's Screen



Receiver's Screen

8.1 Outcomes

Messages sent by the senders given the state observed and communication costs

$c = 10$		Messages						
		Empty	High	Low	Low Low	Low High	High Low	High High
	-3	1	1	1	31	3	2	0
	-2	1	1	21	4	19	1	0
States	-1	0	0	16	0	14	3	0
	0	34	0	1	0	1	0	0
	1	0	4	14	0	7	18	0
	2	1	19	0	1	2	9	3
	3	0	9	0	0	0	0	22

$c = 30$		Messages						
		Empty	High	Low	Low Low	Low High	High Low	High High
	-3	0	1	5	26	0	1	0
	-2	0	0	27	5	5	3	0
States	-1	6	1	10	0	11	2	0
	0	27	4	1	0	2	2	0
	1	16	7	4	0	6	10	1
	2	2	29	0	0	1	11	0
	3	0	12	0	0	0	0	26

$c = 50$		Messages						
		Empty	High	Low	Low Low	Low High	High Low	High High
	-3	2	0	23	14	0	0	2
	-2	1	1	32	0	3	0	0
States	-1	16	0	16	1	7	0	0
	0	36	0	2	1	0	0	0
	1	18	4	8	1	1	4	0
	2	3	29	0	0	2	9	0
	3	0	15	1	0	0	0	12

$c = 96$		Messages						
		Empty	High	Low	Low Low	Low High	High Low	High High
	-3	4	2	20	18	1	1	0
	-2	8	0	12	1	2	2	0
States	-1	20	0	13	2	5	0	0
	0	35	0	0	0	0	0	0
	1	25	4	3	0	0	5	0
	2	13	27	0	1	0	1	0
	3	5	18	0	0	0	0	16

Action selected by the receivers given the message and communication costs

$c = 10$		Action												
		-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3
	Empty	0	0	0	0	0	0	36	1	0	0	0	0	0
	High	0	0	0	0	0	0	0	0	1	2	22	7	2
	Low	3	2	19	11	6	3	1	1	6	1	0	0	0
Messages	Low Low	30	2	0	0	2	0	0	1	1	0	0	0	0
	Low High	3	3	14	4	10	1	1	0	6	3	0	1	0
	High Low	0	0	3	0	2	0	0	0	15	7	6	0	0
	High High	0	0	0	0	0	0	0	0	0	0	0	4	21

$c = 30$		Action												
		-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3
	Empty	0	0	0	0	0	2	49	0	0	0	0	0	0
	High	0	0	0	0	0	0	1	0	3	8	22	17	3
	Low	2	6	20	9	6	0	1	0	2	0	1	0	0
Messages	Low Low	28	0	1	0	0	0	1	0	1	0	0	0	0
	Low High	0	0	4	1	11	1	1	0	5	0	2	0	0
	High Low	0	0	4	1	2	0	2	0	9	4	7	0	0
	High High	0	0	0	0	0	0	0	0	0	1	0	0	26

$c = 50$		Action												
		-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3
	Empty	0	1	2	0	1	2	59	5	4	1	1	0	0
	High	1	0	1	0	0	0	0	0	6	3	15	15	8
	Low	6	12	16	18	20	2	2	0	3	3	0	0	0
Messages	Low Low	14	1	0	0	2	0	0	0	0	0	0	0	0
	Low High	0	0	2	0	6	0	0	2	2	1	0	0	0
	High Low	0	0	0	0	0	1	0	0	2	2	7	1	0
	High High	1	1	0	0	0	0	0	0	0	0	0	0	12

$c = 96$		Action												
		-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3
	Empty	3	4	1	7	4	4	58	8	8	6	4	1	2
	High	0	1	1	0	0	0	1	1	3	2	17	9	16
	Low	11	6	12	3	8	1	0	0	5	0	0	2	0
Messages	Low Low	18	1	0	0	1	0	0	1	0	0	0	0	1
	Low High	0	0	1	0	6	0	0	1	0	0	0	0	0
	High Low	0	0	0	0	2	0	0	0	5	1	1	0	0
	High High	0	0	0	0	0	0	0	0	0	0	0	1	15