Cheap Talk in the Game of Chicken: An Experimental Investigation.

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Abstract

Following the suggestion that cheap talk can help players to coordinate on Nash equilibria in Chicken, an experimental test was undertaken to test this claim. In pairs, participants (n=180) played an endowment version of Chicken involving either no communication, one-way communication, or two-way communication. Participants were each given a sum of money which they could either *Invest* or *Not Invest*. Based on both participants' decisions, the initial amount of money could be increased or decreased. Although cheap talk did not significantly increase the proportion of equilibria outcomes, one-way and two-way cheap talk influenced participants' behaviour in opposing ways. In the one-way condition, senders used their messages to take charge of the game while two-way communication elicited greater cooperativeness between participants. These findings support the idea that two messages can create a focal point even when they do not constitute a Nash equilibrium. Explanations for these findings, the applicability of level-k model predictions, and also practical applications of this research are discussed.

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1 Introduction

Jim Stark: *"What's a chickie-run?"*

Buzz Gunderson: *"She signals, we head for the edge, and the first man who jumps is a chicken."*

-Characters in the film, *Rebel without a Cause.*

Whether in international relations, business or even romantic relationships, situations involving conflict are commonplace in everyday life. Reminiscing over 2014; protests in Hong Kong, tensions with the Islamic State (IS), and the Russian-Ukrainian crisis were, albeit, a few of the numerous instances of conflict that occurred across the world. In order to better understand the essence of such conflicts, game theorists have used simplified game models to uncover the factors that govern behaviour in these settings. One type of conflict that has been modelled by game theorists is called the Game of Chicken (hereinafter known as Chicken). The origins of Chicken are often traced back to Nicholas Ray's 1955 film *Rebel without a cause* starring James Dean, in which teenagers played a game involving cars being driven off a cliff. With one driver in each car, the winner of this version of Chicken was the person who jumped out of their car at the last moment. Conversely, the person who jumped out first was condemned the 'Chicken'. Nowadays, however, the most common portrayal of Chicken involves two motorists driving towards each other on an open road. Both drivers have two options. Either they can swerve (i.e. be the Chicken) to avoid the collision or they can continue straight ahead and potentially win the game. A typical payoff matrix for Chicken is presented in Figure 1.1.

Although Chicken has been traditionally associated with games of bravado involving motor vehicles, game theorists use Chicken to describe numerous situations of conflict (Giordano, Fox, & Horton, 2013). One of the quintessential features of a Chicken game is that players face the choice between a risky option with potentially very high gains or losses and that of a more conservative option with moderate gains and losses. As a result, conflicts such as the Cuban Missile Crisis, the 2001 Californian energy crisis (see Tutzauer, Chojnacki, & Hoffmann, 2006), and even market share battles between Google and Microsoft have been modelled using Chicken (Rasmusen, 2001). However, it would be remiss to suggest that Chicken games only occur on a global scale as feuds between children, work colleagues, and married couples can also mimic Chicken games.

		Player 2	
		Straight	Swerve
Player 1	Straight	P, P	T, S
	Swerve	S, T	R, R

Figure 1.1: Typical Game of Chicken where (T>R>S>P)

The ubiquity of Chicken games highlights the importance of understanding the dynamics governing peoples' behaviour in this game. Despite being hailed as one of the classic games of social life (Hargreaves-Heap & Varoufakis, 2002), researchers have yet to reach a consensus for how to predict behaviour in Chicken. Prediction difficulties arise because Chicken has two pure Nash equilibria that appear equally likely to occur. In Chicken, if a player believes that their opponent is going to swerve, then their best response is to continue straight. Conversely, if they believe that their opponent will continue straight, then swerving is the best response. Indeed, concepts such as Pareto efficiency, risk dominance (Harsanyi & Selten, 1988), and focal points (Schelling, 1960) help to choose between multiple equilibria in certain games, yet these concepts do not aid predictions in Chicken. These concepts offer little insight because the multiple Nash equilibria in Chicken are symmetric, making the mathematical analysis of this game relatively futile. As a result, players desire a tie-breaking feature that allows them to overcome the symmetry of their roles.

Recently, Giordano, Fox, & Horton (2013) have suggested that non-binding communication between players can act as a tie-breaking feature in Chicken. That is, Giordano et al. (2013) suggest that communication can break the symmetry in Chicken by eliminating one of the outcomes and thereby making a single Nash equilibria salient. This claim goes against the accepted belief that non-credible threats should have no impact on players' decisions since non-binding communication has traditionally been disregarded as mere "cheap talk" (Crawford, 1998). Conventional thinking suggests that if a player communicates that they intend to drive straight when playing Chicken, they can always still renege by choosing to swerve at the last moment. Adherents to this viewpoint, such as Rasmusen (2001), suggest the communication should not impact players' behaviour in Chicken. Despite claims rendering cheap talk as ineffective, experimental research shows that cheap talk can influence behaviour in certain settings (i.e. Cooper, DeJong, Forsythe, & Ross, 1989, 1992). When researchers have tested the impact of cheap talk in Chicken, however, inconsistent results have been produced (see Swingle & Santi, 1972; Duffy & Feltovich, 2002). In addition, there exists an unsettled theoretical debate between Farrell & Rabin (1996) and Aumann (1990) over the necessary conditions for influential cheap talk. As a result, little consensus exists when predicting the influence of cheap talk in Chicken.

In this thesis, an experimental test was undertaken to help uncover the role of cheap talk in Chicken. To the best of my knowledge, this research is the first attempt at formally assessing the impact of cheap talk in Chicken using three communication structures. The intended contributions of this research are threefold. Firstly, this research looks to provide an experimental account of peoples' behaviour in Chicken when either no communication was permitted, one player could communicate or both players could communicate. Secondly, this research is intended to help resolve the theoretical debate between Farrell & Rabin (1996) and Aumann (1990) over the necessary conditions for cheap talk to be influential. Thirdly, the results of this experiment will be used to assess the ability of recent game theoretical models to predict the outcomes of this game. The main finding of the research is that cheap talk did appear to influence participants' decisions; however, it did not have a significant impact on the number of equilibrium outcomes that prevailed. In addition, one-way and two-way communication had materially different effects on the messages and decisions selected by participants. The findings from this research provide an insight into how cheap talk influences behaviour in Chicken, which has important implications for real-world situations modelled by this game.

This thesis begins with a review of the cheap talk literature and also recent research that has made predictions regarding the role of cheap talk in Chicken. This section is then followed by a justification of the chosen methodology and also an explanation of the design employed in this experiment. The results of the experiment are then presented, followed by the discussion section that explains the key findings of the experiment, as well as potential practical applications. The discussion section ends with an evaluation of the limitations associated with this research and also suggestions for future research. Finally, the conclusion section summarises the main findings of this thesis.

2 Literature Review

2.1 Cheap talk: An Overview

Researchers have long inquired into the role of communication in games (i.e. Loomis, 1959); however, the term "cheap talk" has only become pervasive in economics literature since the mid-1980s (see Farrell, 1987). Unlike signalling whereby messages entail costs for the sender, cheap talk messages are synonymous with costless, non-verifiable communication. Originating from the American proverb "*talk is cheap, but it costs money to buy whisky*", the notion of cheap talk captures an important distinction between binding and non-binding communication. Binding communication, as the name implies, is a form of communication whereby a person has committed to following through on their message. Since a person must follow through on their message, binding communication is credible and will impact a game. Conversely, with non-binding communication, there is no factor that makes a person commit to their message, hence why this type of communication has been rendered cheap talk. Without any cost or commitment associated with cheap talk messages, there is nothing to ensure their credibility. As a result, the traditional view in economics has been that cheap talk messages will exert no influence on a game (Crawford, 1998).

Although cheap talk messages were initially regarded as non-influential, early research overlooked this belief. Instead, researchers offered theoretical explanations surrounding the mechanisms through which cheap talk may, in fact, impact players' behaviour. One of the first pieces of research to initiate interest into cheap talk was by Crawford & Sobel (1982) when they developed a simple model whereby cheap talk messages could convey the sender's private information. The model showed that when players have perfectly opposing preferences, cheap talk messages cannot convey any useful information about the sender's private information. This finding demonstrated the element of truth in the term "cheap talk". However, the model also showed that if players' preferences were close enough, cheap talk messages could be informative. With this research challenging the fundamental notion of cheap talk, it provided an impetus for other researchers to explore the prospect of influential cheap talk in other situations. For example, Farrell (1987) developed a model showing how cheap talk could help players to achieve partial coordination in situations such as the Battle of the Sexes (BoS) (see Figure 2.1). In this paper, Farrell (1987) argued that if two players communicated intended actions that constituted a Nash equilibrium, then players would

Player 2

Player 1		Ballet	Opera
	Ballet	2, 1	0, 0
	Opera	0, 0	1, 2

(a) BoS Game

Player 2

Player 1		Stag	Hare
	Stag	10, 10	0, 8
	Hare	8, 0	8, 8

(b) SH Game

Figure 2.1: The Battle of the Sexes and Stag Hunt games

follow these messages due to the Nash equilibrium becoming a focal point. However, Farrell (1987) noted that this coordination is never perfect if players have diverging preferences over the different Nash equilibria present in a game such as BoS. To prove this, Farrell (1987) showed that as the number of periods of pre-play communication increased, then players would put increasingly high probabilities on proposing their favourite equilibrium in early rounds of communication. As a result, the probability of two players achieving an agreement is bounded below one, even in the limit. (See also Rabin, 1994; Costa-Gomes, 2002, for further theoretical extensions for how cheap talk may influence peoples' behaviour).

With theoretical models suggesting that cheap talk could aid coordination in certain scenarios, game theorists proceeded to test whether cheap talk would, in fact influence the outcomes in experimental settings. The seminal study of cheap talk in experimental game theory was conducted by Cooper, DeJong, Forsythe, & Ross (1989) when they tested the role of pre-play communication in a one-shot BoS game. The authors had 99 (9 cohorts of 11) university students play a series of one-shot BoS games against anonymous opponents in one of the three communication structures: no communication, one-way communication, and two-way communication. The results showed that the proportion of efficient outcomes in the one-way condition (.95) and the two-way condition (.55) were significantly greater compared to the no-communication condition (.48).[1] In addition, when two players communicated messages that constituted a Nash equilibrium, this equilibrium was reached 80 per cent of the time in line with Farrell's

[1] Cooper et al. (1989) used the term "efficient outcomes" to refer Nash equilibria outcomes.

(1987) predictions. Similarly, disequilibrium announcements resulted in 39 per cent equilibrium play, close to the 37.5 per cent predicted by Farrell (1987). In a subsequent experiment, Cooper et al. (1992) also tested the role of pre-play communication in a coordination game called the Stag Hunt (SH) (see Figure 2.1). The results showed that average coordination on the Pareto dominant equilibrium increased from 0 per cent in the without communication condition to 53 per cent when one-way communication was allowed, and further to 91 per cent with two-way communication. Following the research of Cooper et al. (1989, 1992) there have been numerous other cheap talk experiments across a myriad of different games and settings (see, for example, Blume, 1998; Blume & Ortmann, 2007; Burton & Sefton, 2004; Charness, 2000; Charness & Grosskopf, 2004; Clark, Kay, & Sefton, 2001; Duffy & Feltovich, 2002).

2.2 Cheap Talk and Game Structure

The experiments of Cooper et al., (1989, 1992) showed that cheap talk can influence players' behaviour and aid coordination, yet they also demonstrated how impact of cheap talk is not the same for every game. In the BoS game, which contains two symmetric Nash equilibria, one-way communication was most effective in helping players to coordinate on a Nash equilibria outcome. Understandably, this was almost always the sender's preferred equilibria, following the sender's message indicating that they would play their favourite action. However, in the SH where Pareto-ranked Nash equilibria exist, two-way communication was most effective in helping players coordinate on the Pareto dominant equilibrium. In his survey of cheap talk experiments, Crawford (1998) highlights the varied purposes that cheap talk serves in different types of games. In games with symmetrical payoffs, such as the BoS, Crawford (1998) argued that cheap talk needs to provide a "symmetry-breaking" function. Since one-way communication breaks the symmetry amongst players, it tends to be the most effective in these types of games. Camerer (2003) further acknowledged this point when stating that one announcement allows the sender to "take charge" and break the symmetry of players' roles while two announcements would merely create an argument. However, Crawford (1998) noted that in the SH, cheap talk plays a reassurance role in helping players to coordinate on the risky Pareto dominant equilibrium that both players have a mutual interest in attaining. Two-way communication is most effective in the SH since players require reassurance from one another that they both intend to reach the Pareto dominant equilibrium.

While Chicken and BoS are both mixed-motive games containing two symmetrical Nash equilibria, there are some key differences in the structure of Chicken that may alter the impact of communication in this game. Rapoport & Chammah (1966) authored one of the first papers to formally introduce Chicken and analyse the game structure. The authors held that players have the option to either *Cooperate* (C) or *Defect* (D). A Chicken game has the following payoff matrix whereby T > R > S > P, while the prisoner's dilemma (PD) differs only in that P > S (see Figure 2.2 below). The payoff structures of Chicken and the PD differ only by the final inequality. This difference means that although players in the PD game possess a dominant strategy, no dominant strategy exists for players in Chicken. As a result, Chicken has two symmetrical pure Nash equilibria, C_1D_2 and D_1C_2 whilst also a mixed-strategy Nash equilibria (see also Butler, Burbank, & Chisholm, 2011, for a more recent discussion surrounding the structure of Chicken).[2] Analysing the structure of Chicken also reveals that this game differs from the BoS in an important way, due to the magnitude of the non-equilibrium payoffs. Despite both being mixed-motive games, in the BoS players prefer either Nash equilibria to the non-equilibria outcomes. However, in Chicken players have one preferred Nash equilibria, while the next best outcome for players is the mutually cooperative outcome. A larger conflict of interest over equilibria is present in Chicken, meaning that cheap talk may have a different impact on the BoS and Chicken games.[3]

Player 1 \ Player 2	Defect	Cooperate
Defect	P, P	T, S
Cooperate	S, T	R, R

Figure 2.2: The Chicken and the PD games

[2]Let p denote the probability that a player defects and $(1-p)$ denote the probability that a player cooperates. It follows that the mixed strategy Nash equilibria occur when $p = \frac{R-T}{P-S-T+R}$.

[3]Sobel (2013) recently authored a paper suggesting ten possible communication experiments. Sobel's (2013) first experimental suggestion was to test the impact of communication when players possess a conflict of interest over equilibria, such as in Chicken.

With the effect of cheap talk contingent on the structure of a game, Farrell and Rabin (1996) put forth two conditions intended to capture the extent to which cheap talk messages are likely to be influential. The first of these two conditions is self-commitment as initially suggested by Farrell (1988, 1993). According to the authors, a message is *self-committing* when a sender's message formulates part of a Nash equilibrium. By definition, the sender will have an incentive to comply with the message if the sender believes it. In the BoS, for example, all messages are self-committing; if the receiver is expected to believe the message and, therefore, best respond to it, then the sender should follow through on their message. Conversely, in the PD, the message to *cooperate* is not self-committing since in no case is it a best response for the receiver to play *cooperate*. The second condition put forth by Farrell and Rabin (1996) is *self-signalling* as initially suggested by Aumann, (1990). A message is self-signalling if the sender only intends to play the signalled action to the receiver's anticipated best response to the message. Consider, for example, the SH game. The message *Stag* is self-signalling because a receiver's best response to this message gives the sender a higher payoff only if the sender honours the the message by playing *Stag*.

The influence of cheap talk largely depends on the distinction between self-committing and self-signalling messages (Crawford, 1998). As a result, it is important to formalise the credibility properties put forth by Farrell and Rabin (1996).[4] There are two players, 1 and 2. Each player i has a finite action set A_i. A complete information game is described by a pair of payoff functions (g_1, g_2), with each g_i: A$\rightarrow \mathbb{R}$ (where A= $\mathrm{A}_1 \times \mathrm{A}_2$). Following the work of Baliga and Morris (2002), it is assumed that $\mathrm{g}_i(a) \neq \mathrm{g}_i(a')$, for all $a, a' \in A$ with $a \neq a'$. This restriction places the focus on generic complete information games and means that pure strategy best response functions, $b_i : A_j \rightarrow A_i$ are well defined. That is:

$$b_i(a_j) \equiv arg\ max\ g_i(a_i, a_j) \tag{1}$$

The following examples will consider the credibility of statements by only player 1.

DEFINITION 1: Action a_1 is *self-committing* if $g_1(a_1, b_2(a_1)) > g_1(a_1', b_2(a_1))$ for all $a' \in A$.

This definition holds that if player 1 believes their message a_1 will be best responded

[4]The following formalisation of the credibility properties builds on the previous work of Baliga & Morris (2002).

to by player 2, then it is a best response for player 1 to follow through on their message and play a_1. This will be the case if $(a_1, b_2(a_1))$ constitutes a strict, pure strategy Nash equilibria in g.

A message is considered to be self-signalling if the sender only intends to play the signalled action to the receiver's anticipated best response. This condition is expressed below.

DEFINITION 2: Action a_1 is *self-signalling* if $g_1(a_1', b_2(a_1)) < g_1(a_1', a_2')$ for all $a_1' \in A_1$ and $a_2' \in A_2$ where $a_2' \neq b_2(a_1)$.

Definition 2 holds that if Player 2 best responds to player 1's message a_1, whilst player 1 reneges by playing a_1', then this must result in a lower payoff for player 1 compared to the outcome where player 1 reneges from their message and Player 2 does not best respond to the message. In essence, this implies that if player 1 intends to renege from their message, then they would not want Player 2 to best respond to the message they initially sent.

There is a consensus that messages that are both self-signalling and self-committing will be truthful and believed; however, there is debate over the impact of messages only meeting the self-committing condition. On one hand, Farrell and Rabin (1996) contend that even when a message only meets the self-committing condition, the message will still aid coordination in a game. However, Aumann (1990) rejected the idea that messages only meeting the self-committing condition will induce efficient outcomes in a game because he claimed these messages are uninformative.[5] That is, when messages are not self-signalling, Aumann (1990) argued that communication cannot affect the outcome of a game since the sender has a strict preference over their opponent's strategy choice. (Known as "Aumann's conjecture" which first appeared in Farrell (1988). In such a case, a player always wants their opponent to choose a particular strategy regardless of the action they intend to select themselves. As such, Aumann (1990) argued that messages that do not meet the self-signalling condition will not exert an influence on a game.[6]

[5](See also Blume, 1998; Blume & Ortmann, 2007, for additional challenges to Farrell and Rabins, 1996 claims.)

[6]In a response to Aumann's conjecture, Farrell (1988) holds that the matter comes down to the temporal order by which players choose their messages and actions. See the discussion section for a more detailed analysis of this point.

The impact of cheap talk in Chicken delicately hinges on the distinction between self-committing and self-signalling messages, and specifically, Aumann's conjecture. In Chicken, the message *Defect* is self-committing since if the receiver believes the messages and plays *Cooperate*, then the sender get the highest payoff from following through on their message. According to Farrell and Rabin's (1996) viewpoint, this cheap talk message will aid coordination in Chicken based on this message solely meeting the self-committing condition. However, the message *Defect* does not meet the self-signalling condition since the sender will always communicate this message regardless of whether they intend to follow it or not. In effect, this implies that it is dominant for people to send the message *Defect* in Chicken as suggested by Rasmusen (2001). Due to this, Aumann (1990) argued that such a message conveys no information about what players intend to do, but only information about what they want their opponents to do. According to this perspective, the message *Defect* in Chicken is merely conveying the sender's preference for the receiver to play the move *Cooperate*. However, since it is already common knowledge to both players that they prefer their opponent to play *Cooperate*, Aumann (1990) suggested that this message would be meaningless.[7]

Researchers have put the validity of Aumann's conjecture to the test experimentally in order to determine whether the self-committing condition is sufficient for cheap talk to influence a game. In the research of Charness (2000), 252 participants played Aumann's (1990) variant of the SH game whereby Aumann held that cheap talk messages ought to be uninformative. The results showed that the senders' messages had a large influence in helping to achieve efficient outcomes, contradicting Aumann's viewpoint (see also Zultan, 2013, for similar results). Despite the research of Charness (2000) rejecting Aumann's conjecture, the experimental results of Clark et al. (2001) led to a different conclusion. In this research, participants (n=160) played game 1 or game 2 (depicted in Figure 2.3 below) with either no communication or one-way communication. The results showed that in game 1, where messages were self-committing but not self-signalling, communication had some effect on outcomes; however, its effect was considerably muted. In addition, Clark et al. (2001) found that players broke agreements to play Nash equilibria more often than not. This finding led the authors to conclude that the effect of communication was sensitive to small changes in the payoffs, which was consistent with Aumann's viewpoint (See also Lo, 2007, for similar findings).

[7] Overlooking the fact that it is dominant for players to send a *Defect* message in Chicken, it is interesting to note that the message to *Cooperate* is both self-committing and self-signalling.

As a result of these contradictory findings, there is still little consensus about whether the self-committing condition is sufficient by itself to cause cheap talk messages to be influential.

		Player 2	
		Blue	Red
Player 1	Blue	800 800	0 800
	Red	800 0	1000 1000

(a) Game 1

		Player 2	
		Blue	Red
Player 1	Blue	700 700	0 900
	Red	900 0	1000 1000

(b) Game 2

Figure 2.3: Variants of the Stag Hunt game played in Clark et al. (2001)

2.3 Cheap Talk in Chicken

Without a consensus over Aumann's conjecture, it is hard to predict the impact of cheap talk in Chicken on the basis of theory alone. However, there have been a few attempts at experimentally testing the role of cheap talk in Chicken. Swingle and Santi (1972) (after this known as SS) explored the impact of forced communication, optional communication, or no communication on cooperation levels in PD, Chicken, or power games (see Figure 2.4 for the Chicken payoff structure used by SS). Participants (n=180) played one of the games for 100 trials and in the forced and optional conditions, the participants were either required or permitted to write a note to the other player every fifteenth trial. In the forced condition, both players sent messages while, in the optional condition, either one, two or both of the players would send messages. The message content was unstructured but was coded into three categories: cooperative requests (23%), appeals to equity (28%), and irrelevant content (42%). To assess the impact of the communication conditions, SS (1972) compared the mean percentage of cooperative-cooperative outcomes during the 15 periods prior to first communicative opportunity against the initial five trials following the first communication. The results showed that both forced and optional communication were equally effective in enhancing the instances of cooperative outcomes in the Chicken game.

In a more recent study, Duffy and Feltovich (2002) (after this known as DF) compared the effects of cheap-talk and observation of a player's past behaviour in three one-shot strategic games. Participants (n=180) played ten rounds of PD, SH, and Chicken under one of the three information treatments: no information about opponents, cheap talk, or observation of opponents' previous-round actions (see Figure 2.4 for the Chicken payoff structure used by DF, 2002). In the cheap talk treatment, one member of each pair of players was randomly selected to send a costless, non-binding message to the other player. This message was sent prior to the choice of actions and indicated the action the sender intended to play in that round. In the observation treatment, one player was randomly selected to be informed of their opponent's actions in the previous round when matched with a different player. The authors argued that the results of the experiment were consistent with the credibility properties put forth by Farrell and Rabin (1996). When the structure of the game implied that cheap talk ought to credible (i.e. self-signalling), such as the SH, cheap talk was found to be more effective than observation. Moreover, when cheap talk was predicted to be less credible, such as in PD or Chicken, observation was more effective than cheap talk. Specifically, cheap talk exerted little impact on the frequency of cooperation or payoff efficiency in the Chicken game.[8]

An evaluation of the design features in the studies of SS (1972) and DF (2002) provides potential explanations for why these studies reached different conclusions regarding cheap talk in Chicken. For comparative purposes, the forced communication condition used by SS (1972) was effectively a two-way condition. The optional condition could have been either a no, one-way or two-way condition depending on the messages that players sent. Since DF (2002) only employed one-way communication, it is feasible that the difference in results is due to this. However, the results were contrary to what one might have expected following Crawford's (1998) claim that one-sided cheap talk tends to be more effective when symmetry breaking is necessary. If Crawford's (1998) claim is correct, cheap-talk ought to have had a greater impact in the DF (2002) experiment when, in fact, this was not the case. As such, a reconcili-

[8]Although DF (2002) held that these results were consistent with the claims of Farrell and Rabin (1996); it seems that they are also consistent with Aumann's conjecture. That is, Aumann (1990) held that *Defect* messages would be uninformative in Chicken as was predominantly found by DF (2002). On the other hand, Farrell and Rabin (1996) argued that messages only meeting the self-committing condition, such as *Defect*, could still be influential.

Player 2

Player 1		Coop.	Defect
	Coop.	3 3	4 0
	Defect	0 4	Reset Reset

(a) Chicken game in SS

Player 2

Player 1		Coop.	Defect
	Coop.	70 70	80 50
	Defect	50 80	40 40

(b) Chicken game in DF

Figure 2.4: Chicken games played in the experiments of SS (1972) and DF (2002)

ation of the observed results may be due to different payoffs being offered in both of the experiments. Firstly, DF (2002) used the binary lottery procedure in an attempt to induce risk neutral behaviour (see Roth & Malouf, 1979), whereas SS (1972) paid participants half a cent per point. Secondly, in DF (2002) the payoffs did not offer a severe punishment if the outcome (*Defect, Defect*) prevailed. Conversely, if the outcome (*Defect, Defect*) occurred in SS (1972), players' cumulative point totals would reset to zero, representing a potentially very significant loss. Referring to the generic Chicken game in Figure 2.2, social psychologists use the payoff difference [P-S] to measure the fear motive present in a game (Simpson, 2006). In Chicken, this fear motive is negative suggesting that risk aversion should promote cooperation. Since DF (2002) attempted to induce risk neutrality while also having a smaller fear motive present in their game, it is understandable how communication had a negligible impact in eliciting cooperative behaviour. The larger fear motive may also help to explain why communication elicited a higher proportion of cooperative behaviour in the study of SS (1972).[9]

2.4 Predicted Impact of Cheap Talk in Chicken

Researchers have made predictions about the role of cheap talk in Chicken, despite little consensus over its anticipated impact. Giordano et al. (2013) suggested that

[9]Similar to the conflicting results that have presented when researchers have enquired into the role of personal cheap-talk in Chicken, researchers have also found the impact of third-party cheap-talk to be somewhat ambiguous. (See Bone, Drouvelis, & Ray, 2012; Duffy & Feltovich, 2010; McAdams & Nadler, 2005, for studies where third-party cheap talk was influential. See Cason & Sharma (2007) for an experiment when third-party cheap talk was ineffective at influencing players' behaviour.)

communication, by way of a threat from one player, can eliminate one of the outcomes and make a single Nash equilibria salient in Chicken. Such a threat may involve player 1 communicating that they intend to *defect* to deter player 2 from playing *defect*. As a result of player 1's threat, it is suggested that the outcome (*Cooperate, Defect*) will be eliminated and the equilibrium (*Defect, Cooperate*) with the payoff (T, S) becomes prominent. However, an objection to the claim of Giordano et al. (2013) is that a person who communicates a *defect* message, always has the option to renege by instead choosing *cooperate*. In the road version of Chicken, Kahn (1965) argued that a person who communicates that they will drive straight but subsequently witnesses their opponent rip off their steering wheel would certainly revert to playing swerve. Furthermore, Aumann's conjecture suggested that it is in a player's best interest to send the message *defect*, even that player intended to play *cooperate*. This argument implies that it is dominant for players to send an *defect* message (Rasmussen, 2001).

Giordano et al. (2013) are somewhat ambiguous over the mechanism by which this threat derives its credibility. However, different lines of research offer potential explanations for why a threat may be influential in Chicken. In the seminal work *The Strategy of Conflict*, Schelling (1960) noted that a threat to drive straight (analogous to *Defect*) with the intention of preventing the opponent from also continuing straight puts the initiative of the receiver to the test. That is, the sender's deterrent threat is passive, making the decision to collide up to the receiver. If the receiver issues a subsequent threat to drive straight if the sender does not choose swerve, then Schelling (1960) holds that the receiver has not gained the advantage. The decision to collide still rests with the receiver and the sender enjoys deterrence. Following this argument, the opportunity to issue a threat may entail a first-mover advantage that shifts the burden of responsibility for a collision prominently onto the receiver, thus enticing them to swerve. The impact of cheap talk in Chicken will, however, be contingent on both players' perceptions of any potential first-mover advantage that a sender may achieve as a result of being able to issue a threat.

Psychological theories also provide some insight into why cheap talk messages may influence players' behaviour even when messages lack credibility (Croson, Boles, & Murnighan, 2003). For example, research on persuasion hinges on the belief that costless talk can help to shift peoples' opinions closer to those of a speaker (i.e. Eagly & Chaiken, 1993). In addition, cognitive biases such as the concept of anchoring (see Tversky & Kahneman, 1973) have also been used to support the notion of influential cheap talk. Croson et al. (2003) suggested that the presentation of a number by a bargaining opponent such as the list price of a house can lead other people to anchor on that number. In this context, an anchor has the potential to influence peoples' future behaviour such as the price they might offer for the house. Consequently, it is feasible how the threat to play the move *Straight*, which is intended to make the receiver play *Swerve*, may have this impact due to the receiver anchoring on this outcome. However, other psychological research relating to reciprocity and guilt aversion suggests that players may not send a *Straight* message in the first instance. Sender's may communicate the message *Swerve* with the expectation that the receiver will reciprocate this act of cooperation by also deciding to *Swerve*. This follows from the large body of evidence indicating that reciprocity is a powerful determinant of human behaviour (i.e. Falk & Fischbacher, 2006; Fehr & Gächter, 2000; Kahneman, Knetsch, & Thaler, 1986). Moreover, guilt aversion, which presumes that decision makers experience guilt if they believe they have let others down, may provide an avenue through which people follow through on *Swerve* messages with *Swerve* decisions. A player might feel a considerable degree of guilt if they were to renege by driving straight since this would create a lesser outcome for their opponent, relative to the opponent's expected outcome. However, a player's anticipated guilt must be greater than the potential gains of reneging in order for the player to feel compelled to *Swerve*.

With the growing union between psychology and game theory (See Camerer, 2003; Camerer & Ho, 2015, for reviews), behavioural models are also now being used to make predictions in cheap talk games. One such model that is gaining traction in game theory is called the *level-k* model (see also Camerer, Ho, & Chong, 2004, for the closely related *cognitive hierarchy model*.) The origins of the level-k model date back to Harsanyi and Selten's (1988) "tracing procedure" and also the works of Stahl & Wilson (1994, 1995) and Nagel (1995). The level-k model posits decision rules that reflect an iterated process of strategic thinking (Camerer, 2003). Based on the number of steps of iterated reasoning undertaken, players are characterised into different thinking types according to their level of strategic sophistication. The most naïve player in the model is the level zero thinker (L_0), who uses zero steps of thinking. Since these players undertake zero steps of thinking, they do not reason strategically at all (Camerer & Ho, 2015). Players using one-step of strategic reasoning (L_1) believe they are playing against all L_0 thinkers. As a result, (L_1) players use thought experiments to best respond to the anticipated actions of L_0 thinkers. It follows that players who use k thinking steps believe that all others use from zero to *k-1* steps (i.e. L_2 best respond to L_1, L_3 best respond to L_2 etc.) and all best respond to their anticipated opponents accordingly.

There have been many applications of the level-k model in game theory, yet it has only recently been applied to the issue of cheap talk (see Crawford, Costa-Gomes, & Iriberri, 2013, for an overview).[10] Adapting the earlier work of Crawford (2007), Ellingsen & Östling (2010) (henceforth known as EÖ) apply the level-k model to study the effectiveness of one-round of one-sided and two-sided communication in games where communication has varying roles.[11] The objectives of EÖ's research were predominantly motivated by Farrell and Rabin's (1996) credibility conditions. Namely, it attempted to uncover when communication improves coordination, why communication matters even if it is not self-signalling, and why bilateral communication may generate more coordination than unilateral communication. In order to answer these questions, EÖ applied the level-k model to dominance solvable games (i.e. the PD game), coordination games (i.e. the SH) and also mixed-motive games (i.e. BoS and Chicken). Through their analysis, EÖ provided one of the first attempts at predicting the impact of pre-play communication in Chicken using the level-k model. However, their analysis rested heavily on several critical assumptions. Firstly, EÖ assumed that L_0 senders and receivers randomise uniformly over their messages and decisions. Secondly, it is assumed that all thinker types have a preference for honesty when they are otherwise indifferent about which message to send (see Gneezy, 2005; López-Pérez, 2012, for justification). The intuition underlying EÖ's prediction in the no-communication condition is anchored to the assumption that L_0 thinkers randomise uniformly over decisions. Assuming the option to *Cooperate* is risk dominant, EÖ hold that L_1 thinkers will respond by playing *Cooperate*, and L_2 thinkers will respond by playing *Defect*. This pattern continues whereby odd-level thinkers (i.e. L_1, L_3... L_{n+1} etc.) are predicted to play *Cooperate* while even-level thinkers (i.e. L_2, L_4... L_{2n} etc.) are predicted to play *Defect*. In the one-way condition, L_0 thinkers are predicted to randomise uniformly over decisions and messages. Moreover, L_1 and L_2 senders are expected to communicate and play messages consistent with the decisions in the no-communication condition. Apart from L_0 receivers who are still expected to randomise, all other thinking types are assumed to be credulous and are therefore expected to re-

[10]For applications of the level-k model, see Arad & Rubinstein (2012); Burchardi & Penczynski (2014); CostaGomes, Crawford, & Iriberri (2009); Crawford & Iriberri (2007); Dugar & Shahriar (2012); Kawagoe & Takizawa (2009, 2012).

[11]Whilst EÖ do make predictions regarding the impact of two-way communication, this discussion will predominantly focus on the predicted impact of one-way communication.

spond to messages with the optimal action. The action profiles for thinker types in this Chicken experiment are presented Table 2.1 below.[12] From the action profile, it is evident that EÖ predicted that there would be many instances of discoordination without communication in Chicken, yet when one-way communication is allowed and players of L_1 or higher are present, perfect coordination will occur. Furthermore, EÖ predicted that two-way communication would produce several instances of discoordination. However, more coordination would be expected with two-way communication relative to when no communication is present.[13]

Table 2.1: Action profiles in Chicken as suggested by EÖ

G(No communication)				Γ_1(G)(One-way communication)			
Thinker	L_0	L_{odd}	L_{even}		L_{0R}	L_{1R}	$L_{\geq 2R}$
L_0	Uniform	$\frac{1}{2}$DC,$\frac{1}{2}$CC	$\frac{1}{2}$CD,$\frac{1}{2}$DD	L_{0S}	Uniform	$\frac{1}{2}$CD, $\frac{1}{2}$DC	$\frac{1}{2}$DC, $\frac{1}{2}$CD
L_{odd}	$\frac{1}{2}$CD,$\frac{1}{2}$CC	CC	CD	L_{1S}	$\frac{1}{2}$CD,$\frac{1}{2}$CC	CD	CD
L_{even}	$\frac{1}{2}$DC,$\frac{1}{2}$DD	DC	DC	$L_{\geq 2S}$	$\frac{1}{2}$DC,$\frac{1}{2}$DD	DC	DC

D=Defect, C=Cooperate, S=Sender, R=Receiver

[12]Note that only the action profiles for the NC and one-way conditions have been presented.
[13]Note that these actions profiles hold when *Cooperate* is risk dominant.

3 Method

3.1 Methodology

Given the difference in opinion between researchers over the theoretical impact of cheap talk in Chicken, it is necessary to test experimentally whether cheap talk influences behaviour in this game. There are other methodologies that could be employed to understand the role of communication in Chicken; however, several limitations of these methodologies make the experimental method preferable. For instance, Tingley & Walter (2011) have noted that observational data involving real-life versions of Chicken could be collected and analysed. However, this data is not only problematic to obtain, but it can also be difficult to isolate the effects of communication from other confounding variables present in these situations. Consider if a researcher collected data of political disputes representing Chicken games. One way to evaluate cheap talk across these scenarios would be to analyse the transcripts of press announcements of the political leaders involved, in order to discern the cheap talk messages. However, numerous factors such as the tone and content of messages would likely differ while unpublicised private communication could have also been occurring simultaneously. As such, it would be difficult to ascertain the sole impact of communication on the outcome of this situation. Following Foster's 2006 research, one could also employ another approach involving the examination of case studies. This approach, however, would still make it difficult to separate the effects of communication from other extraneous factors. In addition, the findings would not necessarily be generalisable to other situations that are modelled as Chicken games (Tingley & Walter, 2011).

The benefit of using an experimental approach is that a researcher can more precisely uncover the effects of communication on peoples' behaviour. Specifically, cause-and-effect relationships can be better determined because the research is taking place in a controlled setting. Communication and no-communication control groups can be established whereby one group of participants plays Chicken without communication, another group plays with one-way communication, and a final group plays with two-way communication. An important feature of this approach would be to ensure that the experimental procedure is identical across both conditions, with the only difference being the presence of the communication. Moreover, the researcher would have the ability to control the content of communication and also other extraneous factors that could influence the outcome of the game. As noted by Crawford (1998), this can be achieved by the researcher allowing players only to communicate specific messages to each other (called 'structured communication'). To control for, non-pecuniary influences, these messages would need to be communicated in written format without players physically seeing one another when communicating. As a result of keeping all aspects of the experiment constant, except for the communication (i.e. the independent variable), any difference in results across conditions can be attributed to the presence of communication.

Although there are many benefits to conducting laboratory experiments, they also have their limitations. One of the main limitations of experiments relates to their artificial nature. While controlling for all elements in an experiment allows the researcher to isolate the effect of communication on behaviour, the contrived nature of the experimental environment can itself exert an impact on participants' behaviour. That is, in a laboratory setting, participants are aware that their behaviour is being observed, hence often behave differently than they would in a natural setting. Moreover, if participants can discern the true purpose of the study, this can have an impact on their behaviour. Research has found that participants consciously change their behaviour to confirm what they believe to be the researcher's hypothesis (known as the "good participant effect") (Nichols & Maner, 2008). In other cases, participants have intentionally acted in a manner that was inconsistent with the researcher's hypothesis (known as the "screw-you effect") (Masling, 1966). In addition, undergraduate university students, who are not necessarily representative of the wider population, typically fulfil the role of participants in experiments. (Tingley & Walter, 2011). As a result, the generalisability of experimental findings to other settings is always questionable (Croson, 2014).

The benefits of the experimental method appear to outweigh its limitations for the purposes of this study. As noted by Croson (2014), most experimentalists view the laboratory as a test-bed for theories (analogous to the chemists' bench, or the engineer's wind tunnel), rather than a final evaluative tool. The experimental method is the best way to uncover the fundamental mechanics of the relationship between cheap talk and behaviour in Chicken. Prior to the experimental method becoming widely accepted in game theory, the observational method was used to test theories. However, as noted by Croson (2014), this method was problematic for testing theories since if game theoretical predictions did not present in observational data, this did not mean game theory was wrong. Rather, it would instead suggest that the game needed to be revised to match more precisely the situation that generated the observational data.

This problem is greatly overcome using the experimental method, hence better allowing for the testing of theories, such as the role of cheap talk in Chicken. Certainly, if a relationship between cheap talk and behaviour in Chicken can be established, other methodologies need to be consulted to understand further the pervasiveness of this relationship in real-world scenarios.

3.2 Design

Following the Cooper et al. (1989) study of cheap talk in the BoS game, a similar design was employed to test the role of cheap talk in Chicken. Participants (n=180) played one-shot versions of Chicken across one of the three communication structures: no communication, one-way communication, and two-way communication. For obvious reasons, the traditional version of Chicken involving participants driving motor vehicles could not be tested. However, Bornstein, Budescu, & Zamir (1997) provide a readily testable 'endowment' version of Chicken that was adapted for this experiment. In the endowment version of Chicken used by Bornstein et al. (1997), two participants had to each decide between investing or not investing a sum of money. The resultant payoff structure is presented in Figure 3.1 below.

		Player 2	
		Not Invest	Invest
Player 1	Not Invest	2 2	5 2
	Invest	2 5	0 0

Figure 3.1: Chicken game used in Bornstein et al. (1997)

Although this research will use an endowment version of Chicken similar to that of Bornstein et al. (1997), there are some important design features that make this experiment different. A characteristic of the payoff matrix used by Bornstein et al. (1997) is that the option *Not Invest* generates a player the payoff of 2, regardless of the other player's decision. To remain theoretically consistent with the original version of

Chicken, however, the property where T > R > S > P will be retained in this experiment (see figure 3.2). A second difference relates to the magnitude of payoffs offered in this experiment compared to those provided by Bornstein et al. (1997). In the research of Bornstein et al. (1997) participants played repeated games of Chicken whereby the payoffs corresponded to points. With 5 points roughly equivalent to US$0.40, the average total earnings for participants was $9.74. However, since participants only played a single-shot game of Chicken in this experiment, greater payoffs (representing New Zealand dollars) were used.[14]

		Player 2	
		Not Invest	Invest
Player 1	Not Invest	3 3	5 -2.5
	Invest	-2.5 5	-5 -5

Figure 3.2: Chicken game used in this experiment ($NZ)

Since this experiment offered monetary payoffs to participants, this research technically involved a *game-form* rather than a true *game* whereby the payoff matrix represents von Neumann-Morgenstern utilities. If an experiment offers participants monetary payoffs from the payoff matrix directly, then the results of the research are contingent on participants' perceptions of these payoffs. In the past, researchers have typically used Roth and Malouf's (1976) binary lottery procedure to elicit von Neumann-Morgenstern utilities in order to study a true game. In the binary lottery procedure, each subject is rewarded with a probability of winning a given amount of money (through receiving lottery tickets), which is a linear function of their payoff. However, the binary lottery procedure was not used in this experiment following Camerer's (2003) criticism of it. Camerer (2003) held that the binary lottery has been found to be ineffective in changing supposed risk aversion over money into risk neutrality over tickets (Camerer & Ho, 2015; Selten, Sadrieh, & Abbink, 1999). Given the pervasiveness of this procedure in experimental game theory, Camerer (2003) also noted that, "it is surprising that many experiments use the binary lottery procedure

[14] At the time of the research, the NZ-USD exchange rate was approximately 0.75.

despite so little careful evaluation of when it does induce risk-neutrality (and given the evidence that it doesn't) ... Faith in the procedure seems to be a triumph of hope over data" (p. 41). Consequently, this experiment undertook the simpler route of using monetary payoffs and making the assumption that participants were risk-neutral as suggested by Camerer (2003).

In order to mitigate the influence of social preferences so that the monetary payments offered more closely matched participants' utilities, several design features were implemented. Following the recommendation of Crawford (1998), face-to-face interactions during the game were avoided by having players communicate their messages by passing cards through the experimenter.[15] Having participants communicate using pre-typed cards is an essential feature since communication has the potential to exacerbate the influence of social preferences (see, for example, Sally, 1995; Rothstein, 2005). In addition, face-to-face interaction has also been found to develop rapport, thereby enhancing cooperation in mixed-motive conflicts (Drolet & Morris, 2000). The design also controlled for non-verbal factors among participants for (i.e. tone, body language, confidence) since participants could not see one another when they were passing messages. The importance of this measure is evident as the research of Sah, Moore, & MacCoun (2013) showed how factors such as confidence can affect the persuasiveness of cheap talk messages (see also Zultan, 2012). Moreover, participants were publicly told that they should attempt to maximise their monetary payoff as in Ellingsen, Östling, & Wengstrm (2011) (see also Binmore, Shaked, & Sutton, 1985). This instruction represented a deliberate attempt to use experimenter demand effects to increase the experimental control of participants' preferences.

With the results of this research heavily reliant on the design of this experiment, there are several other aspects of the design that warrant justification. Firstly, a notable feature of the payoff structure used in this experiment was that participants stood to lose money. As was the case in McAdams and Nadler (2005), participants received a $5 show-up fee to use in the Chicken game, which could be increased or decreased based on the outcomes of the game. This potential for loss was incorporated because the motivation structure of many real-world Chicken games dictates that players must be offered a potential reward for winning the game while also some form of consequence for losing the game. An issue with the research of DF (2002) is that there was no real

[15]This follows research that has found face-to-face contact to foster cooperation in mixed-motive games (Drolet & Morris, 2000). However, see also Schotter, Zheng, & Snyder (2000).

potential for participants to experience a loss in this game since the lowest payoff was 40 points.[16] The worst-case scenario in this experiment was that participants left the experiment with $0 (i.e. lost their entire show-up fee), however, participants were explicitly told that the show-up fee was their money to use in the experiment. This attempt to elicit feelings of loss susceptibility is an important feature that helped this experiment better capture the essence of real-world Chicken scenarios whereby players face actual losses.

A second important design consideration relates to the type of communication that was permitted between players. Following Cooper et al. (1989), it was made clear to participants who of the two players was allowed to communicate, how often communication was allowed, and the message space available to players. Whilst research has allowed players to undertake uncontrolled conversations (i.e. Forsythe, Kennan, & Sopher, 1991; Swingle & Santi, 1972), this experiment restricted players to making announcements regarding their intended play (see also Cooper et al., 1989; Charness, 2000). Structured communication was allowed by way of participants passing a card displaying their intended actions (i.e. "Invest" or "Not Invest") to the researcher. The researcher would then present this card to the other player in a manner so that the other player could only see the card. An important assumption that surrounds complete information games such as Chicken is that information about the game (i.e. the players, moves, and potential outcomes) is common knowledge to all of the players involved. As a result, all of the rules of this experiment were publicly announced to both players prior to beginning the game. Publicly announcing this information helped to ensure this experiment met the common knowledge assumption (Crawford, 1998 and Croson, 2014). Moreover, the common knowledge assumption was also double-checked by having participants publicly answer a few brief questions about the game to ensure they understood it.[17]

A third feature of this experiment that makes it relatively unique is that participants played genuine one-shot games rather than repeated games as is the case with much of the previous research (i.e. Borstein et al., 1997; Burton & Sefton, 2004; Cooper et al, 1989; DF, 2002; SS, 1972). One of the key reasons that researchers use a repeated game design is that it often reduces the 'noise' associated with participants'

[16]At the same time, the highest payoff was 80 points in the DF (2002) experiment.

[17]By undertaking this process publicly, each participant knew that the other participant understood the game, and each participant also knew that the other participant knew that they understood the game (Croson, 2014).

responses as they learn from experience (Crawford, 2002). However, these carry-over effects have the potential to alter participants' behaviour over time, thus concealing valuable information about how people play a game. As such, Crawford (2002) notes that eliciting initial responses can help to identify the underlying strategic principles that govern decision-making in games. Conversely, in repeated play of a game, Crawford (2002) contends that participants converge to equilibrium regardless of what they are thinking. Although having participants play one-shot versions of Chicken offers benefits, it means forgoing repetition as a teaching device. In a one-shot game design, there is a heavier burden on participants' understanding of a game, with a premium on simplicity and clarity of design (Crawford, 2002). To ensure participants sufficiently understood the game, an ample amount of time was spent explaining and quizzing participants about the game prior to playing.

Another important design feature of this experiment is that physically present participants played the Chicken game, rather than having the experiment undertaken via computer terminals (i.e. De Heus, Hoogervorst, & Van Dijk, 2010). One of the key reasons computer terminals have been used in previous research is that they provide anonymity for players in a game, meaning that the impact of social preferences will be mitigated. In this experiment, however, two participants who did not know each other entered the experimental setting and were separated by a partition for the game. Although players could not see each other when they played the Chicken game, having participants play against a physically present opponent was an important aspect of the design. Previous research has found that communication by physically present participants increases agreement rates in bargaining games significantly more than when text-chat is used via computer terminals (Greiner, Caravella, & Roth, 2014). In addition, Greiner et al., (2014) found no-communication levels of agreement were significantly higher in a virtual world setting compared to a physical laboratory setting (see also Frohlich & Oppenheimer, 1998). With the impact of communication varying across experimental settings, Frohlich and Oppenheimer (1998) advised researchers to be cautious of the potential effects of using computer platforms in experiments. When deciding what design is most appropriate, it is recommended that consideration be given to the setting in which the research is being generalised (Frohlich and Oppenheimer, 1998). Since many Chicken games in the real-world will transgress in person, having physically present participants was deemed to be most appropriate for this research.

While using physically present participants was intended to add to the generalisability of this research, it meant that participants were not strictly anonymous since they briefly saw one another prior to beginning the experiment. As such, one criticism of this design may be that participants might think that they are playing a repeated game due to the anticipation of meeting their opponent at a future date on campus. For example, participants may have felt reluctant to choose a particular move because they were worried about future repercussions associated with their decision. If participants were evaluating potential consequences, then extraneous costs would have entered into the participant's decision frame. These costs would mean that the participant was no longer playing the original Chicken game put forth in this experiment. However, to combat this possibility, measures were implemented to ensure that participants would be unlikely to meet one another straight after the game. Participants were informed that they would not be told the outcome of the game and that they would receive their payoffs one at a time prior to leaving the experiment individually.[18] Following the advice of Camerer (2003), a short lag occurred between each payment while the researcher ensured the first participant had not waited outside the experiment room, prior to paying the second participant. The lag was intended to reduce participants' inferences of potential social costs if they perceived that they were playing a repeated game.

3.3 Procedure

Participants (n=180) were invited to play a simple decision-making game (Chicken) against another participant, which involved making the decision to invest or not invest a $5 show-up fee initially given to each participant. In this game, the two participants stood to increase or decrease their show-up fee based on the decisions of both participants in the game. Participants were recruited from the Massey University Albany library over several days between December 2014 and March 2015. It was ensured that participants undertaking the experiment together did not know each other, while an equal number of male-male, female-male, and female-female matchups were undertaken in all of the conditions. When the participants arrived at the experiment, the rules of the Chicken game were publicly explained, after which both participants answered a few verbal questions about the game to ensure that they understood it. Following the

[18] Based on their decisions and payoffs, participants could infer what move their opponent had made after receiving their payoff.

design of Ellingsen et al. (2011), the following exert was read to participants prior to playing the game in order to try and reduce the impact of social preferences:

> "When you play this game, you might ask yourself how we want you to act. For the scientific value of the experiment, it is important that all participants set out to maximise their own individual payoffs. Therefore, we ask you to simply focus on getting as high payoffs as possible for yourself."

In the no-communication condition, the experimenter directed both participants to parallel desks, separated by a partition so that they could not see one another. On the desks, participants had a game matrix and two cards; one with the text "invest" typed on it, and the other with the text "not invest" typed on it. The experimenter then told both participants to make their decision to either invest or not invest their money by leaving the card with their chosen action face up and the other card face-down. When participants made their decisions, the experimenter was turned away for 30 seconds in the far corner of the experimental room. The experimenter subsequently observed and recorded the decisions of both participants based on the cards that were facing upwards on participants' desks. The participants then received an envelope containing their resulting payoff from the game and were escorted from the experimental room individually. In the one-way condition, the experiment proceeded in the same manner with the exception that one randomly selected participant had to communicate their intended action to the other participant prior to participants making their decisions in the game. This player (the sender) communicated their intended message by passing their chosen card to the researcher, who displayed it to the other participant, before handing it back to the sender. Participants were both told that the sender was under no obligation to follow-through on their message. After this message had been communicated, the experiment proceeded as in the no-communication condition. The two-way condition followed the same path as the one-way condition, with the only exception being that both participants were allowed to send messages.[19]

3.4 Measures

There are several important outcomes that were observed in this research, which facilitated analysis similar to that undertaken by Cooper et al. (1989). Simply, the

[19]See appendix A for the participant information sheet and appendix B for the experimental instructions that were narrated to participants by the experimenter.

messages and decisions of participants and the resulting outcome of the Chicken game were observed. Since the Chicken game played in this experiment could be depicted by a matrix such as that presented in figure 3.2, the researcher merely underlined the decision of each participant. In addition, the researcher recorded any message sent and also circled the resulting outcome in the game (see appendix C for an example). Participants' genders were also recorded to so that gender could be controlled for in the results analysis.

3.5 Participants

Participants (n=180) were recruited from Massey University's Albany campus through being approached on campus by an experimental assistant. The experimental assistant informed participants that student participation was requested for a decision-making game. Prospective participants were told that they would be paid money on arrival that could be increased or decreased dependent on their decisions and the decisions of their opponent in the game. It was ensured that the two participants did not know one another before undertaking the experiment. One of the limitations of this method of enlisting participants is that there is a potential sampling bias. That is, the students approached by the experimental assistant in order to participate in this research may have some unique characteristics that make them different from the wider student population. For example, the fact that the students recruited were on campus means that they may differ in some systematic way from students who were not on campus. The sample used would likely impact the generalisability of the findings (see conclusion section for a further discussion surrounding limitations.).

3.6 Ethical Approval

It was necessary to obtain ethical approval before undertaking this research since this experiment involved human participants and also monetary rewards. An ethics application was made to the Northern Massey University Human Ethics Committee (MUHEC) prior to commencing this research. This application outlined several ethical issues associated with this experiment. Justification was provided for why the selected design was necessary for this research. Moreover, the application also highlighted how measures in the experimental design were intended to mitigate consequences associated with unavoidable ethical issues. After attending a meeting with the MUHEC at Massey University's Albany campus, ethical approval was given for this research (See appendix D for the approval letter from MUHEC).

4 Results

4.1 Preliminary Analysis

To determine whether the data could be pooled for player 1 and player 2, a difference-of-proportions test (Z-test) was conducted. Pooling of the data is appropriate for the no-communication (NC) and the two-way condition since player 1 and player 2 have identical roles in these conditions. The data cannot be pooled for the one-way condition since player 1 acts as the sender while player 2 is the receiver. The Z-test revealed there were no significant differences at the 5% level in the action chosen by player 1 and player 2 in the NC condition. In addition, at the 5% level, there were no significant differences in the messages communicated and the action chosen by player 1 and player 2 in the two-way condition. Consequently, the results presented have been pooled across player 1 and player 2 for all but the one-way condition as per Cooper et al. (1989). Since participants only played one round of the game in this experiment, there was no need to test for serial correlation of individual participant's results over time.

4.2 Comparing Communication Structures

Participants' behaviour in the NC condition provided a baseline to evaluate the impact of the other two communication conditions. Table 2 provides a summary of the proportion of *Not Invest* and *Invest* decisions made in the NC condition while Table 4.1 provides a summary of the proportion of various outcomes that prevailed.[20] As previously discussed, Chicken has two pure strategy Nash equilibria and also one mixed strategy Nash equilibria whereby the move *Not Invest* is played with the probability 0.56 and *Invest* is played with probability 0.44. The mixed strategy Nash equilibria can be interpreted as the probability distribution over decisions that would occur if a

[20]Note that the "cooperative outcome" is analogous to the outcome where both players chose to *Not Invest* while the "collision outcome" corresponds to the situation where both players selected *Invest*.

population of people played the game. From Table 4.1 it is evident that *Not Invest* was played with a slightly higher frequency than predicted by the mixed strategy Nash equilibria while the decision to *Invest* was played less than expected. Despite the slight departures from the mixed-strategy Nash equilibria, the proportion of *Invest* and *Not Invest* decisions did not significantly differ at the 10% level from the proportions predicted by the mixed-strategy Nash equilibria (Z= 0.9351, p-val.= 0.34720).

Table 4.1: Decision proportions vs. MSE predictions

Decision	NC	MSE[1]
Invest	0.35	0.44
Not Invest	0.65	0.56

[1]Mixed Strategy Nash Equilibria predictions

Based on the results presented in Table 4.2, it is evident that there exists a potential for players to achieve gains through greater coordination. That is, in the NC condition players only coordinated on the efficient Nash equilibria 47% of the time while the cooperative and collision outcomes were reached 40% and 13% of the time respectively. With the implementation of communication, the proportion of equilibria outcomes ranged from a low of just over 33% for the two-way condition to its highest point of 50% in the one-way condition. While there was little difference in the proportion of equilibria outcomes between the NC and one-way conditions, the presence of two-way communication lowered the proportion of equilibria outcomes by over 13% relative to the NC condition. However, using Z-tests, it was found that the differences in the proportion of equilibria outcomes across communication structures were not significant at the 10% level.

Table 4.2: Proportion of outcomes across conditions

Outcome	NC	One-Way	Two-Way
Equilibria	0.47	0.50	0.33
Cooperative	0.40	0.23	0.53
Collision	0.13	0.27	0.13

Although communication structure exerted little influence on the proportion of equilibria outcomes, it produced varied effects on the proportion of cooperative and collision outcomes. Compared to the proportion of cooperative outcomes in the NC condition (40%), cooperative outcomes only occurred 23% of the time in the one-way condition and 53% of the time in the two-way condition. These differences were not significant when compared with the NC condition. However, a significant difference existed at the 5% level when comparing the proportion of cooperative outcomes across the one-way and two-way conditions (Z= 2.3898, p-val.= 0.01684). Furthermore, there was variation in the number of collision outcomes relative to the NC condition due to the presence of one-way communication. This difference was not significant (Z= 1.291, p-val.= 0.1971); however, it is noteworthy that the proportion of collision outcomes doubled to 26.6% in the one-way condition compared to the 13.3% in the NC condition.

Table 4.3: Proportion of decisions across conditions

	NC	One-Way		Two-Way
		Sender	Receiver	
Invest	0.35	0.73	0.30	0.30
Not Invest	0.65	0.27	0.70	0.70

The impact of communication structure on participants' decisions is presented in Table 4.3 while Table 4.4 shows how participants' messages varied across communication structures. In both the NC and two-way conditions, participants selected *Invest* approximately one-third of the time while *Not Invest* was selected close to two-thirds of the time. Although a similar result occurred for the receiver in the one-way condition, a departure from this pattern can be seen by evaluating senders' decisions in the one-way condition. In this case, senders selected *Invest* 73% of the time while they chose *Not Invest* only 27% of the time. Senders' decisions in the one-way condition significantly differed from the decisions of participants in the NC condition (Z= 3.432, p-val.= 0.0006). Similarly, a very significant difference was found when assessing senders' decisions in the one-way condition relative to participants' decisions in the two-way condition (Z= 3.9, p-val.= 0.0001). From Table 5 it is evident that 83% of participants communicated that they intended to *Invest* in the one-way condition while only 17% of participants sent the message *Not Invest*. In the two-way condition, participants sent the message *Not Invest* two-thirds of the time and the message *Invest* only one-third of the time. The difference in the messages sent across both of the one-way and two-way conditions is significant at less than the 1% level (Z=4.4721, p-val.=0.0000).

Table 4.4: Proportion of messages across conditions

Message	One-Way	Two-Way
Invest	0.83	0.33
Not Invest	0.17	0.67

Following the research of Cooper et al. (1989), another means of assessing differences across communication structures is to compare the average earnings for participants in each of the conditions. Table 4.5 presents the average earnings of participants across the three conditions. From these results, it is evident that the average payoff in the NC condition was \$6.12 while the average payoffs were \$4.99 and \$6.35 in the one-way and two-way conditions respectively.[21] Despite, the total average payoffs decreasing quite markedly in the one-way condition, this decrease is solely due to a decrease in the average payoffs of receivers. That is, the average payoffs of senders increased to \$6.63 while the average payoffs of receivers almost halved to \$3.37. Although one-way communication had the effect of lowering total average payoffs for players relative to the NC condition, two-way communication had the opposite effect, by raising the average payoffs of players to \$6.35.

Table 4.5: Average payoffs for participants across conditions

Condition	Average Payoff
No Communication	\$6.12
One-Way	
Sender	\$6.63
Receiver	\$3.37
Total	\$4.99
Two-Way	\$6.35

In this experiment, participants' genders were also recorded to ascertain whether or not this may have influenced decisions and messages (see Table 4.6). Although male participants made the decision to *Invest* with a higher frequency relative to females in all three conditions, none of these differences were significant at the 10% level. However, when isolating senders in the one-way condition, males did play a higher proportion of *Invest* decisions relative to females. This difference was just significant at the 10% level (Z=1.6514, p-val.= 0.0989). Despite this, female participants sent a higher proportion

[21]Note that these averages include the \$5 show-up fee.

of *Invest* messages in both the one-way and two-way conditions relative to males. The difference in the messages sent across gender was significant at the 5% level for the two-way condition (Z=2.1909, p-val.= 0.02852) but not significant at the 10% level for the one-way condition (Z=1.4697, p-val.= 0.14156).

Table 4.6: Proportion of decisions and messages by gender across conditions

	Message		Decision	
	Not Invest	Invest	Not Invest	Invest
No Communication				
Male			0.60	0.40
Female			0.67	0.33
One-Way				
Sender				
Male	0.26	0.74	0.14	0.86
Female	0.07	0.93	0.40	0.60
Receiver				
Male			0.71	0.29
Female			0.69	0.31
Two-Way				
Male	0.80	0.20	0.67	0.33
Female	0.53	0.47	0.73	0.27

Table 4.7: Proportion of honest messages by gender

	Honest Messages
One-Way	
Sender	
Not Invest	0.20
Invest	0.72
Total	0.63
Two-Way	
Sender	
Not Invest	0.88
Invest	0.65
Total	0.80

The level of honesty associated with participants' messages and decisions was also assessed.[22] Table 4.7 presents the proportion of honest messages for both the one-way and two-way conditions after *Not Invest* and *Invest* messages were issued. From Table 4.7, it is clear that a higher proportion of honest messages occurred in the two-way condition (0.80) relative to the one-way condition (0.63). However, these results appear to be contingent on the messages sent. In the one-way condition, players honoured *Not Invest* messages only 20% of the time while *Not Invest* messages were honoured 88% of the time in the two-way condition. However, the opposite appears to be true for *Invest* messages. A higher proportion of honest *Invest* messages occurred in the one-way condition (0.72) relative to the two-way condition (0.65). Although the total proportion of honest messages across conditions only significantly differed at the 10% level (Z= 1.7089, p-val.= 0.08726), the honesty of *Not Invest* messages across conditions was significant at less than the 1% level (Z= 3.5576, p-val.= 0.00038).

4.3 Probit Regressions

Bivariate probit regressions were estimated to provide a further insight into participants' decision processes in this experiment.[23] These probit models, albeit relatively simple, help to better uncover the impact of communication structure on players' decisions in Chicken. In order to achieve this, the probit models estimate the probability

[22]A message was deemed honest if a participant made a decision consistent with their message. However, as noted in the discussion section, honouring a message need not necessarily reflect genuine honesty.

[23]The probit regressions were run using R-studio version 3.1.2.

that player i chose *Invest* as a function of the communication condition, messages, and gender. Since a participant's decision to either *Invest* or *Not Invest* was a discrete outcome, it would be inappropriate to treat their decision as approximately continuous and thereby run a standard linear probability model (LPM). Namely, two problems arise with the LPM when evaluating a discrete dependent variable. Firstly, fitted probabilities can be estimated to be greater than one or less than zero, both of which defy basic probability theory. Secondly, the partial effect of any level explanatory variable is constant regardless of its value. Instead of the LPM, it is most appropriate to specify a logit model or a probit model, both of which are binary response models of the form:

$$P(y = 1|\boldsymbol{x}) = G(\beta_0 + \beta_1 x_1 ... + \beta_k x_k = G(\beta_0 + \boldsymbol{x\beta}) \tag{2}$$

where G is a function that assumes values between 0 and 1 and $\boldsymbol{x\beta} = \beta_1 x_1 ... + \beta_k x_k$. In the Probit model, G is the standard normal cumulative distribution function (), which is expressed as:

$$G(z) = \Phi(z) \equiv \int_{-\infty}^{z} \phi(v) dv \tag{3}$$

where $\Phi(z)$ is the standard normal density function:

$$\phi(z) = (2\pi)^{-\frac{1}{2}} exp(-z^2/2). \tag{4}$$

The derivation of the probit model arises from an underlying latent regression of the form $y^\star = \beta_0 + \boldsymbol{x\beta} + e$ where y is one if $y^\star > 0$, and y is zero if $y^\star \leq 0$. In this experiment, the proclivity of participants to either *Invest* or *Not Invest* can be thought of as a latent variable since participants had to choose one decision or the other. As a result, participants' true preference over these decisions was unobserved.[24] It is assumed that errors (e) in the probit model are independent of $\mathbf{x}$ and follow a standard normal distribution. As noted by Wooldridge (2012), the probit model is more popular than the logit model in econometrics because the normality assumption associated with e is preferred over the logit model assumption that e follows a standard logistic

[24] For example, a participant may have only slightly preferred the *Not Invest* decision over the *Invest* decision. Since this participant could only choose one option, they would have selected the *Not Invest* decision. As a result, their actual preferences surrounding the decisions in the game would be concealed.

distribution. Specifically, the properties of the normal distribution allow for potential specification issues to be more easily analysed (see Cramer, 2005; Wooldridge, 2012, for a discussion). For this reason, the probit model was used for this research.[25]

Communication Structure

The first probit model estimated the probability that player i chose *Invest* ($y = 1$) or *Not Invest* ($y = 0$) as a function of the communication condition and gender. Four variables were included in the model: two dummy variables captured the communication condition *one-way* (1= one-way, 0= no communication) and *two-way* (1= two-way, 0= no communication) , the gender of the decider *gendec* (player i) (1=male, 0=female), and the gender of the opponent *genopp* (1=male, 0=female). The data was pooled for the NC condition and also the two-way condition (see earlier discussion) while the sender in the one-way condition was treated as player i. As a result, probit model 1 addressed whether one-way and two-way communication increased the likelihood that a sender would choose *Invest*, irrespective of any messages, relative to players in the NC condition. The output from probit model 1 is presented in Table 4.8 below.[26]

Table 4.8: Probit model 1: Impact of communication on participants' decisions

Variable	Estimate	Std. Error	z-value	P-val.
Intercept	-0.5460	0.2171	-2.515	0.0119*
One-way	0.9892	0.2985	3.314	0.0009***
Two-way	-0.1875	0.2385	-0.786	0.4317
Genopp	0.1394	0.2230	0.625	0.5319
Gendec	0.2663	0.2230	1.194	0.2324

$n = 150$, Pseudo $R^2 = 0.0927$, PCP= 68%, Log-likelihood=-92.28

X^2=18.86, df=4, P-val=.001

From Table 4.8 it is evident that the presence of one-way communication significantly increased the likelihood that a sender would make an *Invest* decision relative to players in the NC condition. That is, the coefficient for *one-way* was positive and also significant at less than the 1% level. Conversely, the coefficient for *two-way* was

[25] However, for completeness, logit model results have been presented in Appendix E. The logit output does not materially differ from the output of the Probit models.

[26] Significance codes: '$\star\star\star$' < 0.001, '$\star\star$' < 0.01,'$\star$' < 0.05, '.' < 0.10. PCP= per cent correctly predicted.

negative, suggesting that two-way communication decreased the likelihood of an *Invest* decision. However, the finding relating to the coefficient for *two-way* was not even remotely close to being significant. Although coefficients in the probit model give an indication of the direction of an effect, they cannot be used to assess the magnitude of effects. In order to estimate the *ceteris paribus* effects of explanatory variables on the likelihood that a player will invest, alternative measures must be consulted. One such measure is the average partial effect (APE), which looks to ascertain the average impact a change in one of the explanatory variables has on the dependent variable. For a continuous explanatory variable, the typical way to calculate the APE is:

$$\left(n^{-1} \sum_{i=1}^{n} g(\hat{\beta}_0 + \boldsymbol{x_i}\hat{\boldsymbol{\beta}}) \right) \hat{\beta}_j \tag{5}$$

where $g(\hat{\beta}_0 + \boldsymbol{x_i}\hat{\boldsymbol{\beta}}) = \phi(\hat{\beta}_0 + \boldsymbol{x_i}\hat{\boldsymbol{\beta}})$ in the probit model. However, this depends on a calculus approximation which is only appropriate if the explanatory variables are continuous. Since the explanatory variables in this probit model are not continuous, a discrete version of APE calculation was used (see Wooldridge, 2012). For a change in x_k from c_k to $c_k + 1$, the discrete calculation of the APE is:

$$n^{-1} \sum_{i=1}^{n} G[(\hat{\beta}_0 + \hat{\beta}_1 x_{i1} + ... + \hat{\beta}_k(c_k + 1)] - G(\hat{\beta}_0 + \hat{\beta}_1 x_{i1} + ... + \hat{\beta}_k c_k) \tag{6}$$

where G is the standard normal cdf. Equation 5 holds, that for every unit of i, we estimate the predicted difference in the probability that $y_i = 1$ when $x_k = 1$ and $x_k = 0$. For example, in this model y_i is participant i's decision while the APE is required for the variable *one-way*. As a result, the estimated difference in participants' decision probabilities can be calculated when *one-way*$= 1$ and *one-way*$= 0$, for all possible states of the world (i.e. all possible 0, 1 combinations of the other binary explanatory variables). Once the differences for all potential states of the model are calculated, they are added together and averaged to arrive at the APE for the explanatory variable of interest. For the variable *one-way* the discretely calculated APE was 0.3714. This APE suggests that, on average, senders in the one-way condition are 37.14% more likely to choose *Invest*, irrespective of their messages, compared to players in the NC condition.

The percentage of observations correctly predicted (PCP), McFadden's (1974) pseudo R^2, and the log-likelihood ratio were calculated to assess the quality of the model. The pseudo R^2 was very low, likely because only the *one-way* variable was contributing any explanatory power to the model. However, the log-likelihood ratio, which is a distributed chi-squared with degrees of freedom equal to the number of predictors in the model, was significant at the 0.001 percentage level. This indicates that probit model fits significantly better than an empty model. Moreover, the PCP of 68% was close to the 70% benchmark, suggesting that the model has some explanatory power according to this metric. However, as noted by Kennedy (2003), the PCP measure should be evaluated with caution since 'naive predictors' (i.e. always predicting the dependent variable to be 1) can often outperform more complex models according to this measure, despite these 'naive predictors' not being very useful in practice.[27] As a result Wooldridge (2012) held that PCP measures should be reported for each of the outcomes individually. For probit model 1, the PCP for *Not Invest* decisions was 67% while it was 73% for *Invest* decisions, suggesting that the model does relatively well at predicting both outcomes. A final limitation of the PCP measure is that it typically employs a threshold of 0.5 which can be inappropriate if one of the outcomes is unlikely to occur. However, this limitation is not particularly relevant to this analysis since the mixed-strategy equilibria for the Chicken game and the results of this experiment indicate that neither outcomes was particularly unlikely to occur.[28]

Following the observation that one-way communication and two-way communication exerted opposing effects on participants' willingness to make an *Invest* decision, a second probit model was used to better understand this relationship. Similar to the first probit model, the variable *two-way* was included in this model with it equal to 1 for the two-way condition and 0 for the one-way condition. The data for the one-way condition pertained to the decisions of senders while the data in the two-way condition was pooled for both players. The probit model output is presented in Table 4.9 below. From Table 4.9 it is apparent that two-way communication exerted a significant negative effect on the probability that a player would send an *Invest* message relative to senders in the one-way condition. This effect is significant at less than the 0.001 per

[27]Another limitation is that the PCP measure tends to be over-optimistic since it is computed by back-testing the data that was used to develop the model.

[28]However, see the discussion surrounding probit model 3.

cent level. In addition, the APE for the variable *two-way* was calculated to be -0.4433. This APE suggests that relative to senders in the one-way condition, participants who sent messages in the two-way condition were 44.33% less likely on average to make an *Invest* decision. For probit model 2, the pseudo R^2 was 0.16 while the log-likelihood ratio was significant at less than the 0.001 percentage level. In addition, probit model 2 correctly predicted 71.11% of the observations in this sample according to the PCP measure. In addition, the PCP for *Not Invest* decisions was 70% while it was 73% for *Invest* decisions. This result suggests that probit model 2 does predict both outcomes with comparative success. [29]

Table 4.9: Probit model 2: One-way vs. Two-way com. on participants' decisions

Variable	Estimate	Std. Error	z-value	P-val.
Intercept	0.3088	0.2985	1.034	0.301
Twoway	-1.2197	0.3074	-3.967	0.0007***
Genopp	0.4359	0.2933	1.486	0.137
Gendec	0.3039	0.2918	1.042	0.298

$n = 90$, Pseudo $R^2 = 0.16$, PCP= 71.11%, Log-likelihood=-51.95

X^2=19.76, df=3, P-val=.0002

Message content

While the previous probit models give an indication as to the influence of communication structure on the decisions of players, they did not explicitly control for the messages that players sent. As a result, subsequent probit models have been developed to explain how participants' messages in each of the communication conditions impacted their decisions. Table 4.10 presents the probit model output for senders in the one-way condition. The dependent variable was a sender's eventual decision while the explanatory variables included the gender of the players and also the message of the decision maker (1= invest message, 0= not invest message).[30] From the output in Table 4.10, one can see that the coefficient for *mesdec* was not even close to being significant at even the 10% level. Combined with a small APE (-0.07), this suggests that relative to players who sent *Not Invest* messages, sending an *Invest* message in the

[29] While neither of the gender explanatory variables was significant at less that the 10% level, they were not completely insignificant. As a result, these variables have been kept in the model to control for the gender of participants.

[30] A similar model was run replacing the decision of senders with that of receivers; however, no significant variables existed. This indicates that receivers in the one-way condition paid little attention to a sender's message when making their decision.

one-way condition did not significantly impact the probability that these players would make an *Invest* decision. However, one might interpret these results with slight caution due to the small portion of players that sent *Not Invest* messages in the one-way condition. That is, of the 5 participants that sent *Not Invest* messages, 4 reneged and made *Invest* decisions. Another interesting feature of the output is that the variable *genopp* was significant at less than the 5% level. Since the coefficient for this variable was positive, this suggests that participants were more likely to make an *Invest* decision when their opponent was male compared to female. Specifically, the APE for *genopp* was 0.3564 suggesting that participants were 35.64% more likely on average to make an *Invest* decision when their opponent was male relative to female. For probit model 3, the pseudo R^2 was 0.24 while the log-likelihood ratio was significant at less than the 0.05 percentage level. Although the PCP for probit model 3 was 80% it is important to note that the model was better at predicting *Invest* decisions relative to *Not Invest* decisions. The PCP for *Invest* decisions was 86% while the PCP for *Not Invest* decisions was only 63%. This result appears partially due to the lower number of *Not Invest* decisions relative to *Invest* decisions that occurred in the one-way condition.

Table 4.10: Probit model 3: Messages in the one-way condition

Variable	Estimate	Std. Error	z value	P-val.
Intercept	-0.0749	0.8206	0.091	0.927
Mesdec	-0.3425	0.8108	-0.422	0.673
Genopp	1.5716	0.6755	2.327	0.020⋆
Gendec	1.0191	0.6205	1.642	0.101

$n = 30$, Pseudo $R^2 = 0.27$, PCP= 80%, Log-likelihood=-12.68
X^2=9.44, df=3, P-val=.0239

The final probit model assessed how participants' messages in the two-way condition impacted the decisions of players. In addition to the decision makers' message, the message of the opponent was also included in this model. The results are presented in Table 4.11 below. Unlike the one-way condition whereby senders' messages were not significantly indicative of the senders' decisions, the results suggest that this is not the case in the two-way condition. That is, the coefficient for *mesdec* was positive and significant at less than the 0.001 percentage level suggesting the when players sent *Invest* messages relative to *Not Invest* messages, they were more likely to make *Invest* decisions. In addition, the APE for *mesdec* was 0.6502 suggesting that players were on average 65.02% more likely to *Invest* after sending an *Invest* message. This finding can also be interpreted from an alternative viewpoint that is more relevant given the results in the two-way condition. That is, following a *Not Invest* message, participants were very unlikely to renege and play *Invest*. Another interesting result present in Table 4.11 is that the gender of the decision maker also had a significant impact on decisions at less than the 5% level. The corresponding APE for *gendec* was 0.2492 suggesting that on average, male participants were 24.92% more likely to make *Invest* decisions relative to females. For probit model 4, the pseudo R^2 was 0.34 while the log-likelihood ratio was significant at less than the 0.001 percentage level indicating that the model is a good fit. The PCP for probit model 4 was 80% suggesting that the model has good explanatory power. However, the model was slightly better at predicting *Not Invest* decisions relative to *Invest* decisions due to the larger number of *Not Invest* decisions that occurred in the two-way condition. The PCP for *Not Invest* decisions was 83% while the PCP for *Not Invest* decisions was 71%.

Table 4.11: Probit model 4: Messages in the two-way condition

Variable	Estimate	Std. Error	z value	P-val.
Intercept	-2.4385	0.6669	-3.656	0.0003***
Mesdec	2.3485	0.5943	3.952	0.0008***
Mesopp	0.5895	0.4791	1.230	0.2185
Genopp	0.1626	0.4480	0.363	0.7167
Gendec	1.2176	0.5830	2.088	0.0368*

$n = 60$, Pseudo $R^2 = 0.34$, PCP= 80%, Log-likelihood=-24.28

X^2=24.75, df=4, P-val=.00005

5 Discussion

5.1 Comparison with Previous Research

In line with previous cheap talk research, the form of communication structure exerted different effects on participants' behaviour in the Chicken game played in this experiment. Following the finding that one-way communication has worked well in games that require symmetry-breaking, one might have expected one-way communication to be effective in helping players coordinate on a single Nash equilibria in Chicken. However, unlike in the BoS where one-way communication greatly helped players to coordinate on a Nash equilibria, the results of this experiment suggest that this finding does not translate to Chicken. There was no significant difference between the proportion of equilibria outcomes in the one-way condition relative to the no-communication condition, contrary to the expectation of Giordano et al. (2013). While it could be argued that these results are unique to this experimental design, similar findings occurred in a previous Chicken experiment conducted by DF (2002).[31] From Table 5.1 it is evident that a very similar proportion of equilibria outcomes occurred across studies in both the NC and one-way conditions, suggesting that both studies produced findings that contradict the claim of Giordano et al. (2013).

One-way communication had a negligible impact on the proportion of equilibria outcomes in this experiment and also the experiment conducted by DF (2002); yet, the presence of one-way communication had a varied impact on participants' decisions across experiments. One discrepancy is that one-way communication elicited a higher proportion of *Invest* decisions in this experiment whereas in the experiment undertaken by DF (2002), the opposite occurred. In addition to participants making a lower proportion of *Not Invest* decisions in the NC condition, one-way communication slightly increased the proportion of *Not Invest* decisions in the DF (2002) experiment (see Table 5.2). These differences, however, may be partly due to discrepancies in the mixed strategy Nash equilibria (MSE) for the Chicken games played across experiments. In the Chicken game played in DF (2002), the MSE dictates that players randomise uniformly over both of their decisions. In the Chicken game in this experiment, the MSE suggests that players make an *Invest* decision approximately 44% of the time and will choose *Not Invest* about 56% of the time. If the majority of players in both of these experiments are playing according to the MSE, then one would expect to see a lower

[31] Since SS (1972) did not distinguish between communication structures as in this experiment, the results of this experiment could not be directly compared with those of SS (1972).

Table 5.1: Proportion of equilibria outcomes compared to DF (2002)

Condition	Present Study	DF (2002)
No Communication	0.467	0.475
One-Way	0.50	0.532

Table 5.2: Proportion of *Not Invest* decisions compared to DF (2002)

Condition	Present Study	DF (2002)
No Communication	0.65	0.537
One-Way	0.483	0.564

proportion of *Not Invest* decisions in this experiment compared to that of DF (2002). In addition, further payoff differences across studies may have also contributed to differences in participants' decisions. Most notably, the payoff matrix in this experiment offers a severer punishment for mutual defection that may have caused players to act more conservatively. The larger fear motive present in this experiment would explain why players chose the *Not Invest* decision with greater regularity.

5.2 Outcomes across Communication Structures

One of the main findings from this experiment was the way in which one-way communication increased the tendency of senders to make *Invest* decisions relative to the NC condition. The results showed that senders made more than double the proportion of *Invest* decisions in the one-way condition relative to the NC condition. Furthermore, probit model 1 suggested that this tendency held regardless of the messages that senders communicated. In addition, the output from probit model 3 indicated that senders' messages in the one-way condition were largely uninformative with regards to senders' future decisions. Although this finding appears to be consistent with Aumann's conjecture, looking at the informativeness across the specific messages of players provides a better insight into this issue. That is, 72% of senders honoured *Invest* messages in the one-way condition implying that *Invest* messages were prescient with regards to the sender's future actions. If these messages had been truly uninformative, one might expect players to randomise uniformly over sending *Invest* and *Not Invest* messages while make decisions in a similar manner to in the NC condition. While *Invest* messages did appear to be informative; this was not the case for *Not Invest* messages. Only 20% of *Not Invest* messages were honoured, giving an insight into why probit model 3 indicated that messages (in aggregate) were not indicative of senders' decisions in the one-way condition.

There are plausible explanations for why senders' *Invest* decisions were informative in the one-way condition, despite the claims of Aumann (1990).[32] The predominant explanation may relate to Schelling's (1960) argument that one-way communication in Chicken, gives the sender a first mover advantage since it puts the initiative of the receiver to the test. As a result of being able to send an *Invest* message, the sender may feel like they had the upper-hand. The perception of an upper-hand may have resulted from senders believing that their *Invest* message would coerce the receiver into choosing *Not Invest*. If the sender believes that there is a sufficiently large probability that their message will induce a *Not Invest* decision from the receiver, then the senders' best response will be to play *Invest*. Figure 5.1 provides a more formal explanation of this decision process. It follows that p denotes the sender's perceived probability that an *Invest* message will induce the receiver to choose *Not Invest*. Moreover, $(1 - p)$ denotes the probability that this message will induce an *Invest* response from the receiver. If the sender believes that their *Invest* message has resulted in $p > \frac{5}{9}$, then it will be a best response for the sender to follow through and play the move *Invest*. One of the implications of this argument is that a consistent message-decision profile from a player need not necessarily reflect a tendency for honesty among players as suggested by EÖ (2010). Instead, following an *Invest* message with an *Invest* decision may merely reflect strategic play given a sender's updated beliefs.

The suggestion that strategic thinking influenced senders to honour *Invest* decisions has relevance to a claim made by Farrell (1988) in his response to Aumann's conjecture. Farrell (1988) acknowledged Aumann's rationale for why a cheap talk message that did not meet the self-signalling condition ought to be uninformative, yet he held that the informativeness of such a message depended on the temporal precedence associated with players' decisions and messages. If a player decides on their move prior to their message, then Farrell (1988) held that Aumann's argument is compelling. However, Farrell (1988) also argued that matters become ambiguous if the player decided upon their message prior to their move. The argument for why senders tended to honour *Invest* messages in the one-way condition is most consistent with the later interpretation.

[32] It is harder to explain why senders in the one-way condition sent *Not Invest* messages, particularly if they intend to play *Invest*. It may have been the case that players who sent *Not Invest* messages and subsequently made *Invest* decisions were engaging in some form of strategic reverse-psychology. An alternative explanation is that these players may not have been thinking strategically at all.

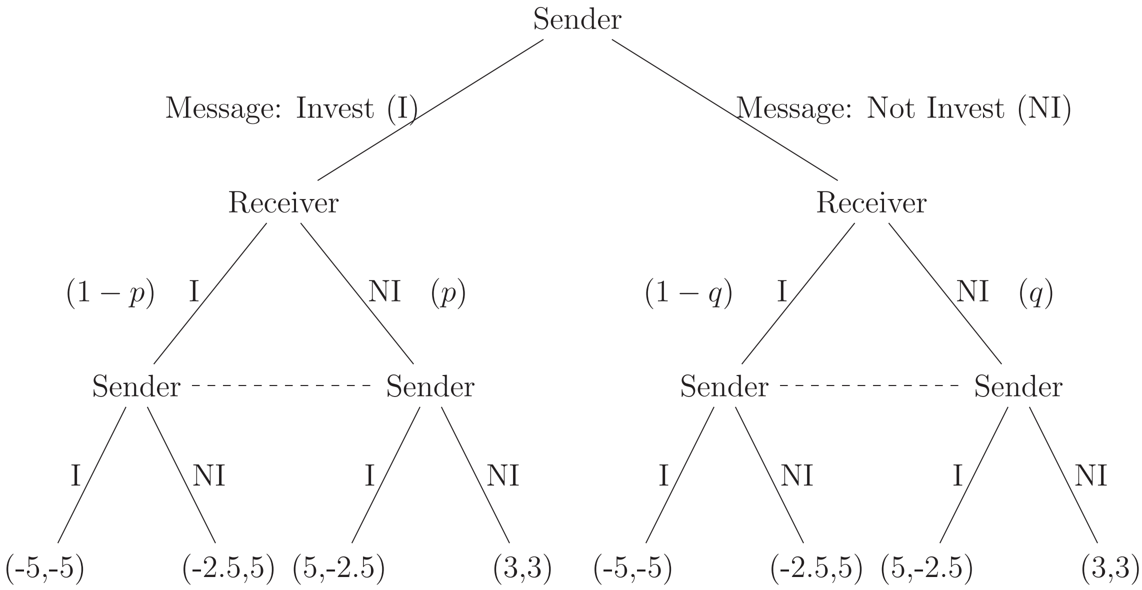

Figure 5.1: Extensive form of Chicken used in this experiment

That is, the claim that senders honoured *Invest* messages for strategic reasons seems most plausible if players decided upon their messages prior to making their decisions in this game. Although, more cognitively demanding, it is still possible that strategic thinking may have induced players to honour *Invest* messages even if they made their decision prior to selecting their message. For example, it is conceivable that senders used a variant of backward induction after choosing their decision in this game. Using such a method, a player could make a decision and then work backwards to choose the message they believe would give them the best outcome given their decision. In this experiment, a player who decided to *Invest* may have reasoned that the best way to get their opponent to play *Not Invest* was through sending an *Invest* message. If receivers perceived this to be the case, however, they would be justified in disregarding the sender's message. This is because the message would be irrelevant to the sender's decision since their decision had already been selected.

While the actions of players who sent *Invest* messages in the one-way condition casts doubt on the validity of Aumann's conjecture, looking at the actions of receivers provides further insight into this issue. Assuming that a credulous receiver (i.e. a receiver who believes a sender's message is prescient) will best respond to a message, one can gain an insight into how informative messages were from receivers' standpoints.

In the one-way condition, *Invest* messages elicited *Not Invest* decisions from 68% of receivers. While this proportion of *Not Invest* decisions was greater than chance would predict, it was very similar to the proportion that occurred in the NC condition. As a result, this casts doubt on whether receivers in the one-way condition genuinely believed senders' messages.[33] The most obvious reason for why this might have been the case relates to Aumann's conjecture. Simply, receivers may have reasoned that senders would communicate *Invest* messages regardless of the decision that they intended to play. If this were the case, then such messages should rightly be disregarded since a sender's messages would be viewed solely as an attempt at influencing the receiver's decision. However, an alternative explanation is that receivers, for the most part, did believe senders' *Invest* messages, yet some receivers opted not to best respond to the message by instead playing *Invest*. Although participants were instructed to play this game with the intention of gaining the highest possible payoff, some participants may have overlooked this instruction. It may have been the case that some receivers felt a sense of injustice as a result of the sender trying to take advantage of the situation by sending an *Invest* message.[34] Following the research that has found that people care greatly about fairness, (i.e. Fehr & Gächter, 2000), it could be that some receivers deliberately tried to punish senders at their expense. This argument suggests that some participants made deliberate "kamikaze" *Invest* decisions in response to the senders' *Invest* messages. The implication of both of these explanations is that senders' confidence associated with any perceived first-mover advantage would have been misplaced. The lack of credulity or unwillingness to concede on the part of receivers would explain why one-way communication did not greatly increase the proportion of Nash equilibria outcomes.

Unlike in the one-way condition whereby many participants sent and honoured *Invest* messages, two-way communication elicited markedly different message-decision combinations from participants. In the two-way condition, it was entirely unexpected to find that participants not only sent, but also honoured *Not Invest* messages with such a high frequency. This behaviour whereby 67% of participants sent *Not Invest* messages, of which 88% were honoured, lowered the proportion of equilibria outcomes

[33]The similar proportion of equilibria outcomes in both the one-way and NC conditions appears to be largely the result of receivers disregarding senders' *Invest* messages despite them being honoured 72% of the time by senders.

[34]The data from the one-way condition shows that 87.5% of collisions occurred after players sent *Invest* messages. However, this result should be interpreted with caution due to the low number of *Not Invest* messages that were sent.

relative to the NC condition, but increased the proportion of cooperative outcomes by 13%. This finding raises some interesting questions. Firstly, why did participants send *Not Invest* messages so often, despite Aumann's (1990) and Rasmusen's (2001) claims that it is a dominant strategy for players to send the message *Invest*? One explanation is that players sent the message *Not Invest* with the expectation that receivers would reciprocate this act of cooperation by also playing *Not Invest.* Players may have perceived this to be the best strategy to employ in the two-way condition since they did not have the advantage of an individual sender as in the one-way condition. The suggestion that reciprocity may have influenced players to send *Not Invest* messages follows the large body of evidence indicating that reciprocity is a powerful determinant of human behaviour (i.e. Kahneman et al., 1986; Fehr & Gächter, 2000; Falk & Fischbacher, 2006).[35] It is plausible that reciprocity played a role in the two-way condition since a *Not Invest* message, if believed and best responded to, would create a lower payoff for the sender. As such it is difficult to justify this behaviour by solely looking at monetary payoffs.

The large body of honoured *Not Invest* messages in the two-way condition relative to the other conditions provides strong evidence that two-way communication had the effect of inducing a greater sense of cooperation amongst players. Players' actions indicated that they placed a greater emphasis on reassuring their opponent that they wished to coordinate on the cooperative outcome when two-way communication was permitted. The finding that messages in the two-way communication served a reassurance role in Chicken is consistent with previous research that has found two-way communication to play a reassurance role in the SH (Cooper et al., 1992). However, there are some fundamental differences between Chicken and the SH that make this finding somewhat unexpected in Chicken. That is, in the SH, two-way communication allows players to coordinate effectively on the risky Pareto dominant Nash equilibria because both players have a mutual interest in attaining this outcome. This finding was consistent with Farrell's (1987) claims since neither player could attain a better outcome relative to the Pareto dominant Nash equilibria. However, the same does not hold true for the cooperative outcome in Chicken. Regardless of a player's message in Chicken, if they believe that their opponent will play *Not Invest*, then the player's best response is to play the move *Invest.* However, in the two-way condition of this experiment, it was observed that a message pairing of (*Not Invest, Not Invest*) was

[35]Reciprocity means a behaviour that cannot be justified in terms of selfish and pure outcome oriented preferences.

honoured 73.6% of the time by both players. The interesting aspect of this finding is that the cooperative outcome is not a Nash equilibria, therefore, isn't considered a likely outcome for salience in Chicken (Hargreaves-Heap & Varoufakis, 2002). This point was made readily apparent by Giordano et al. (2013), when they overlooked the cooperative outcome in Chicken, suggesting that it is unstable.

The findings in the two-way condition may warrant an extension to Farrell's (1987) claims regarding messages and focal points. That is, if two players communicate intended actions that constitute a non-equilibria outcome, then player's messages can still help to make this outcome focal. This finding is consistent with previous research that has found non-binding talk about fairness leads to non-equilibrium, equal division payoffs (McGinn, Milkman, & Nöth, 2012). Since this finding is novel in Chicken, however, it necessitates a further enquiry into why this might have been the case. Namely, why was it that players were so inclined to honour their *Not Invest* messages, particularly when their opponent also indicated that they were going to choose *Not Invest*? The high proportion of honoured (*Not Invest, Not Invest*) message pairings opposes fundamental game theoretical concepts such as the principle of best response. A simple analysis of Chicken shows that it is irrational in a monetary sense to respond to an opponent's *Not Invest* message with a *Not Invest* decision if this message is perceived as honest. Players would be $2 better off in this experiment if they were to achieve their preferred equilibrium relative to the cooperative outcome. One explanation for why players honoured *Not Invest* messages in the two-way condition is that factors extraneous to the mathematical description of Chicken, such as moral norms, may have influenced participants' behaviour. While design measures were implemented to reduce the impact of social preferences in this experiment, it possible that the presence of two-way communication exacerbated any social preferences that lingered in this experiment. For instance, while the messages communicated by players were not strictly binding in a legal sense, it could have been the case that players perceived the messages to be socially binding. Players may have possessed strong moral norms that induced them to honour non-binding *Not Invest* agreements. Coupled with psychological factors such as guilt aversion, this may help to explain why two-way communication promoted more cooperation. This follows the research of Charness & Dufwenberg (2006) who found that promises (or statements of intent) sent from agents to principals enhanced trust, cooperation, and efficiency, due to decision makers experiencing guilt if they believed they let others down.

Guilt aversion provides an avenue through which two-way communication may have influenced participants' behaviour in the two-way condition even though, the messages sent were not strictly binding. Although guilt could have a variety of sources in this game, one prominent way to create feelings of guilt in this experiment is to let others down. Guilt could arise as a result of playing the move *Invest* after both players have sent *Not Invest* messages. If both players indicated that they intended to play the move *Not Invest*, the expectation of players both playing *Not Invest* would certainly increase. A heightened prospect of reaching the second highest payoff in the game amongst players may cause players to feel a higher degree of guilt about reneging from their message. This is because if one of the players chose the move *Invest*, then the resulting outcome for the opponent would be reduced. Conversely, if one of the players were to send an *Invest* message, the other player would not have the same expectation of a cooperative outcome. Therefore, a lower degree of guilt would be created as a result of reneging from this *Invest* message. If guilt aversion was a prominent factor that guided the decisions of players in the two-way condition, it is interesting what this might reveal about the monetary costs associated with players' guilt. Indeed, if a player reneged from their *Not Invest* message this would potentially gain them an additional $2 at the expense of their opponent losing $5.50. Since very few players did renege, it seems that the $2 enticement was not sufficient to offset the guilt most players would have assumed if they dishonoured their *Not Invest* message. The interesting aspect of this finding is that guilt aversion appears to have only entered participants' decision frames in the two-way condition. One-way communication saw senders "take charge" by regularly sending and playing *Invest*, suggesting that guilt aversion was not a prominent feature that influenced participants' messages and decisions in this condition.

5.3 Messages, Decisions, and Gender

The findings relating to participants' decision and message choices across gender raise some interesting issues with regards to potential differences in risk tolerance between males and females.[36] Given the nature of the Chicken game used in this experiment, participants' level of risk tolerance is certainly one factor that may have influenced their behaviour. That is, the option to *Invest* is most readily associated with the risky decision in Chicken since this has the potential to earn players the biggest gain while at

[36] Conrath (See 1972, for early research that looked to examine gender differences in Chicken.)

the same time the greatest loss. Conversely, selecting *Not Invest* is a more conservative option since it has the potential to generate more moderate gains and losses. When the decisions of male and female participants were compared using the Z-test, the only difference that was significant at less than the 10% level occurred in the one-way condition. That is, males made invest decisions with greater regularity when acting as the sender in the one-way condition (Z=-1.6514, p-val.= 0.0989). In addition, probit model 4 indicated that that male participants were significantly more likely to make *Invest* decisions relative to females in the two-way condition. Although there is still some contention, the general consensus of most of the past research on risk tolerance and gender is that females tend to be more risk averse than males (see Eckel & Grossman, 2008, for a review). It could be argued that the greater proportion of *Invest* decisions from male participants in the one-way and two-way conditions provides some support for this claim. However, an alternative explanation might be that females innately possess a larger preference for cooperation relative to males. This would be consistent with the research of (Cabon-Dhersin & Etchart-Vincent, 2013) who found that females tended to cooperate significantly more often than males when playing Chicken.[37]

While an analysis of only the decisions of participants provides support for gender differences, more intriguing findings can be seen when assessing the messages and decisions of participants in conjunction with one another. When assessing participants' messages, an immediate observation is that females sent a higher proportion of *Invest* messages in both the one-way and two-way conditions relative to males. That is, 93% of females sent *Invest* messages in the one-way condition, compared to the 73% of *Invest* messages sent by males. Moreover, in the two-way condition, 47% of females sent *Invest* messages while only 20% of males sent *Invest* messages. The difference in the one-way condition wasn't significant at the 10% level; however, the message differences across gender in the two-way condition were significant at less than the 5% level (Z=2.1909, p-val.=0.02852). Although these findings are interesting, more revealing findings become evident when looking at the decision patterns that accompanied these messages. Namely, females made a much lower proportion of *Invest* decisions in

[37]When looking at the probit model for one-way communication, it was also discovered that the gender of the receiver had a significant impact on a sender's decision in the one-way condition. The APE for this variable, the sender was on average 35.64% more likely to make an *Invest* decision against a male in the one-way condition relative to when they were playing against a female opponent. An alternative interpretation is that senders in the one-way condition had a tendency to communicate *Not Invest* messages to female participants. This finding may have been due to a form of social desirability bias, whereby participants had a tendency to be lenient towards female opponents. See the conclusions section for a further discussion.

both the one-way and two-way conditions relative to the proportion of *Invest* messages they actually sent. Conversely, the opposite finding occurred for males. That is, male participants' messages understated the proportion of *Invest* decisions that they would subsequently make in the game.

Two interesting questions present themselves as a result of these findings. Firstly, why were females more inclined to send *Invest* messages in both the one and two-way conditions, yet have a lower propensity to *Invest* come decision time? Secondly, why did the opposite result hold true for males? One explanation expands on potential differences in risk tolerance between males and females. That is, although the decision to *Invest* can be perceived as being the risky option, this is not necessarily the case for sending an *Invest* message. A message indicating the intention to *Invest* does not in itself make the sender susceptible to loss. Furthermore, Aumann (1990) claims that messages do not contain pertinent information about what a sender intends to do, but rather, only information about the action the sender wants the receiver to undertake. As a result, the message to *Invest* can be interpreted as an attempt to induce the receiver to play the move *Not Invest.* Conversely, a *Not Invest* message offers the receiver the opportunity to reciprocate with a *Not invest* decision, yet still leaves an enticement for the receiver to play *Invest.* If messages are interpreted in this manner, it could be argued that sending an *Invest* message is less risky since the sender's outcomes are strictly better when the receiver plays *Not Invest.* Consequently, the finding that females follow up a high proportion of *Invest* messages with a lower proportion of *Invest* decisions may merely reflect the fact that this message-decision profile contains the smallest amount of risk. On the other hand, the finding that males played a higher proportion of *Invest* decisions relative to the proportion stated in their messages could be interpreted as a riskier strategy. Although this finding has been discussed when aggregating participants results by gender, evidence showing that females played a higher proportion of *Invest, Not Invest* message-decision profiles can also be seen at the individual level in the one-way condition. In the one-way condition, 40% of females followed this message-decision combination. This proportion was significantly greater than the 6.7% of males who played this strategy (Z=2.1583, p-val. 0.03078).[38] As such, the behaviour of participants at both the aggregate and individual level has parallels with past research that has found females to exhibit greater risk aversion compared to males.

[38] In the two-way condition, there was no evidence of gender difference for this message-decision combination. This may have been because far fewer participants, in general, followed *Invest* messages with *Not Invest* decisions in the two-way condition.

5.4 Level-k model Analysis

The results of this study provide some insight into whether behavioural models such as the level-k model provide an avenue for predicting behaviour in Chicken with communication and without communication. Although this study wasn't specifically intended to identify the different thinker types of the level-k model, the results of this study can be compared at face-value with the predictions of EÖ. Generally, it is assumed that L_0 thinkers do not exist, but only in the minds of L_1 thinkers. This assumption follows an ample amount of research which has found that the majority of people transition between 1-3 thinking steps (see Camerer, 2003 for a review). When researchers try to classify participants econometrically into different thinking types, model specifications typically restrict players to thinkers of types 1 to 3. (i.e. Ellingsen et al., 2011). Moreover, the predictions made in the action profile in Table 2.1 suggest that when thinkers of only L_1 or higher are in the one-way condition, perfect coordination will occur regardless of the match-up. As a result, the assumption that no L_0 thinkers exist in the sample is sufficient to broadly assess the claims of EÖ since any further classification of participants would not impact EÖ's prediction of perfect coordination on Nash equilibria occurring.[39]

In general, the results of this experiment do not provide support for the claims of EÖ. Assuming this sample did not contain any L_0 thinkers and also that EÖ's model was prescient, one would have expected one-way communication to have greatly increased the proportion of equilibria outcomes. Instead, there was only 50% coordination on equilibria outcomes in the one-way condition, considerably less than the 100% that EÖ predicted. In addition, two-way communication did not result in a proportion of equilibria outcomes greater than that achieved in the NC condition and less than that of the one-way condition. In this experiment, two-way communication marginally lowered the proportion of equilibria outcomes, which was the opposite of what EÖ predicted. These results do not definitively suggest that the level-k model has no place for predicting the impact of communication in games like Chicken. However, the extent to which EÖ's predictions differed from the results of this experiment do create cause

[39] This implies that I am using EÖ's versions of the level-k model as a statistical model rather than a cognitive process model. That is, the results of this model are being compared with those suggested by EÖ. No consideration is being given to the underlying cognitive processes that help to form participant's decisions.

for concern. Since EÖ's model does rest heavily on a few key assumptions, it could be that faulty assumptions have led to the apparent discrepancy between predictions and results in this experiment.[40]

EÖ are very forthright when stating that their model is heavily reliant of the assumption that people contain a lexicographic preference for honesty. This assumption may have validity in certain games, yet this assumption is at odds with the claim that it is a dominant strategy for players to send an *Invest* message in this Chicken game regardless of what the player intends to do (Aumann, 1990; Rasmusen, 2001). For example, if a player intended to *Not Invest* and wanted to send an honest *Not Invest* message, then this would mean overlooking the dominant *Invest* message. As a result, the assumption set out by EÖ implies that players' preference for honesty is stronger than the principle of dominance. Although the notion of dominance is one of the fundamental principles of game theory, the results of this experiment provided mixed support for EÖ's honesty assumption. In the one-way condition, the message *Invest* was communicated 83.3% of the time while all messages in this condition were honoured only 63% of the time. The dominant *Invest* messages were sent very regularly and participants' honoured messages in this condition only slightly more often than if players were uniformly randomising over honest and dishonest messages. As such, it seems that the principle of dominance overpowers the lexicographic preference for honesty assumed by EÖ in this instance.[41] This finding may help to explain why one-way communication was relatively ineffective in helping to ensure coordination on the equilibria in the Chicken game played in this experiment. However, the opposite appears to hold true concerning this assumption in the two-way condition. That is, with only 33% of participants sending *Invest* messages; it does not appear that participants' message selection was governed according to the principle of dominance. In addition, players honoured their messages 80% of the time, suggesting that the preference for honesty was much more plausible in the two-way condition.

Despite EÖ's assumption surrounding honesty appearing to be better met in the two-way condition of this experiment, this does not help to reconcile why such a low

[40] It could also be that my assumption of no L_0 thinkers existing in this sample was faulty. However, there would need to be a very large portion of L_0 thinkers to reconcile the results of this experiment with EÖ's predictions.

[41] As previously discussed, the fact that players honoured their messages does not necessarily imply that players were honest. This is particularly true if players sent messages prior to making a decision since the players' decision may have been a function of updated beliefs.

proportion of equilibria outcomes prevailed. One factor that may help to explain this finding relates to the message content that was predominant in the two-way condition. That is, players typically sent *Not Invest* messages to one another and these were almost always honoured. Even more intriguing, a pairing of *Not Invest* messages resulted in a cooperative outcome 73.6% of the time. The situation whereby both players have sent *Not Invest* messages demonstrates the inherent conflict that two-way communication creates. This conflict arises because following a pair of *Not Invest* messages, each player is in the predicament of deciding between whether to honour their message or renege by best responding to their opponent's message. As such, EÖ's assumption surrounding honesty and credulity are in conflict with one another. Instead of players choosing to best respond to an opponent's *Not Invest* message, it seems that the lexicographic preference for honesty has dominated. This behaviour has resulted in players reaching a higher proportion of cooperative outcomes rather than Nash equilibria. As a result, this assumption appears to have greater merit in the two-way condition, just not as EÖ intended due to the large number of *Not Invest* messages that players sent. Whilst suggestions have been put forth for why players regularly sent *Not Invest* messages in the two-way condition, a proponent of the level-k model may suggest that this could be due to the sample of participants containing a very high portion of L_1 thinkers. To assess this claim, further experimental research of the Chicken game that facilitated an econometric classification of participants would be required.

5.5 Practical Applications

With the game of Chicken permeating throughout human life, this research has numerous practical applications. Given that Chicken is most readily used to model situations of conflict, the findings from this research could have important implications for disciplines such as conflict resolution and mediation. Specifically, one of the most important findings from this experiment relates to how communication structure impacts the participants' willingness to cooperate. With only one player communicating in Chicken, the sender tries to take advantage of their position in order to help them win the game by arriving at their preferred Nash equilibria. While one-way communication has the benefit of increasing the average payoffs for senders ($6.63) relative to the NC condition ($6.12), this comes at the expense of the receivers' average payoff that decreased to ($3.37). It is apparent that the small gains accrued by the sender are more than offset by the losses of the receiver when looking at this outcome from a total welfare perspective. Indeed, the average payoff for both senders and receivers in the one-way condition was \$4.99, 18% lower than in the NC condition. These findings suggest that one-way communication results in an undesirable outcome from a total welfare perspective. Consequently, if there are third parties who are acting to mediate conflicts with characteristics similar to Chicken, then this finding warns about the potential costs of having a one-way communication channel between the parties involved. Conversely, unlike one-way communication that lowered total average payoffs, two-way communication acted to increase the average payoffs of players to \$6.35 each while it also had the lowest number of collision outcomes. This finding highlights the importance of mediators ensuring two-way communication channels are present between parties engaged in a conflict similar to Chicken. These results do not necessarily suggest that multi-round communication (i.e. whereby players can send more than one message each) will lead to a similar outcome. Future research should explore the impact of multi-round communication on behaviour and outcomes in Chicken.

Although the results of this experiment suggest that two-way communication can make players better off, the results are not nearly as strong as have been the case in other types of games. Most notably, in the SH game, two-way communication has been shown to almost always guarantee that players will coordinate on the Pareto dominant Nash equilibria. As such, for real-world situations that can be modelled by the SH, allowing both players to communicate seems like a fairly reliable way to unanimously improve the outcomes for all parties involved. However, the same claim cannot be made with comparable conviction when discussing two-way communication in Chicken. This appears to be because too great a divergence exists in players' preferences in Chicken. Both players have one Nash equilibrium that they prefer while their opponent's preferred Nash equilibrium is only their third best outcome. As a result, while allowing communication between players in Chicken is likely to be a step in the right direction, there are likely to be devices beyond communication that can result in better outcomes for both players. For example, the results of this experiment showed that the average payoffs attained by players in the two-way condition did not even come close to the payoffs that players could attain if they were always to cooperate. In fact, even senders in the one-way condition did not achieve payoffs that were on average as great as the payoffs offered in the cooperative outcome. Both players could be made unilaterally better off if some form of a contract were to be implemented binding players to cooperate. In a real-world context, this implies that mediators would be best advised to try and establish binding agreements between people engaged in Chicken games, rather than solely relying on non-binding communication. However, people engaged in a real-world Chicken game would certainly like their preferred equilibria over the cooperative outcome. As such, the challenge for mediators will be to get both people to foresee the lesser outcome that will prevail if they are not willing to commit to such an agreement.

5.5.1 Case Study: The Greek-Eurozone Chicken game

An example of a situation where this research may have relevance are the bailout negotiations between Greece and the Troika that occurred between February and June of 2015.[42] Following Greece's financial troubles that began in 2009, Greece had received over €240bn in bailout packages as at May 2015. In return for the bailout packages, Greece promised to implement meaningful economic, structural, and fiscal reforms to reignite its ailing economy. However, in early 2015, it became apparent that the bailout packages had been relatively ineffective in stimulating Greece's economy. Greece announced that they would be unable to make certain interest repayments owed to the International Monetary Fund (IMF) in May and June of 2015 unless they received further bailout money. The Troika were unsatisfied with the reforms undertaken by Greece and, as a result, were unwilling to give Greece further bailout money unless they implemented stronger reforms. Conversely, Greece's Prime Minister, Alex Tsipras, who was elected to power in January 2015, had been vocally against implementing stronger reforms in Greece, thus creating a stalemate between Greece and the Troika. Over four months of negotiations transgressed between Greece and the Troika without a solution. With neither side willing to compromise, the negotiations between Greece and the Troika have been described as a game of Chicken (Schumacher & Espie, 2015).[43]

The Chicken game between Greece and the Troika is presented in figure 5.2. Both parties essentially have had two options going into the bailout negotiations. The first option has been to *concede* by way of making compromises as desired by the other party. For Greece, this would mean making binding promises to implement some meaningful reforms to their economy. For the Troika, this would involve extending further bailout money to Greece without any binding promise that Greece would implement extensive reforms. The second option available to both Greece and the Troika has been to *hold firm* in the negotiations and make no concessions. This option involves Greece refusing

[42]The Troika is a three-party commission consisting of the European Central Bank (ECB), the European Commission, and the IMF.

[43]At the time of writing, Greece and the Troika were still locked in negotiations.

to make any economic reforms and the Troika freezing further bailout funds to Greece unless Greece agreed to the extensive reforms proposed by the Troika. Although the numbers in figure 5.2 are notional, they do capture the nature of the Chicken game played by Greece and the Troika. The best outcome for either party is to hold firm in negotiations while the other party made concessions. For the Greeks, this would mean receiving further bailout money without having further reforms imposed on them. For the Troika, this would mean setting a strong precedent and attaining a dominant bargaining position for future negotiations. In this game, the collision outcome would occur if both parties held firm in negotiations and no agreement could be reached. In this instance, Greece would go into arrears on it's IMF repayments leading to a Greek default. A Greek default would be the worst outcome for both parties since it would entail large costs for Greece while the Troika would have to contend with further economic fallout throughout Europe. Arguably, the best outcome for both Greece and the Troika is the cooperative outcome. The cooperative outcome would entail Greece making some reforms to their economy and in return the Troika would give Greece further bailout money, despite the reforms not being as extensive as the Troika had wanted. The cooperative outcome would mean that neither party has won the Chicken game, but the consequences associated with a Greek default would be avoided.

		Troika	
		Concede	Hold Firm
Greece	Concede	3 3	5 -2.5
	Hold Firm	-2.5 5	Fallout Default

Figure 5.2: Chicken game between Greece and the Troika

The negotiations between the Greece and the Troika raise some interesting questions relevant to this research since communication is an implicit component of this Chicken game. Namely, it would be interesting to understand the role that communication has played in the negotiations to date. In the initial stages of the Chicken game, the Greek finance minister, Yanis Varoufakis was leading the negotiations on Greece's behalf. It had been reported that Varoufakis had created tensions with the Troika as a result of his unwillingness to consider concessions. Moreover, Varoufakis further alienated himself by quoting one of Franklin D Roosevelt's most memorable lines on Twitter: "FDR, 1936: 'they are unanimous in their hate for me; and I welcome their hatred'. A quotation close to my heart (and reality) these days..." (Varoufakis, 2015). With Varoufakis at the helm of Greece's negotiating team, the economist Nouriel Roubini noted that "...the Troika was saying 'we are not going to blink', Varoufakis was saying 'we are not going to blink' " (Roubini, 2015). As at mid-May 2015, the negotiations between Greece and the Troika are still ongoing with no agreement having been reached between the parties.

A key question relevant to the Greek-Troika Chicken game relates to why communication has been ineffective in helping both parties reach an agreement? One explanation might be that tough negotiating coupled with personal animosity between Varoufakis and the Troika appears to have nullified the benefits of communication in the Greek-Eurozone Chicken game. Specifically, refusals to consider the other party's position may, in effect, have transformed the multi-stage communication between Greece and the Troika into two streams of one-way communication. If this were the case, it would help to explain why the cooperative outcome has not been reached at present. However, another explanation for the failed communication may be that the Chicken game played between Greece and the Troika was not a one-shot game but rather a repeated game. As noted by Chuah et al. (2011), many real-world Chicken games consist of brinkmanship and escalation. The characteristic of brinkmanship is evident in the Chicken game between Greece and the Troika since Greece's repayment date to the IMF places a deadline on the negotiations. As a result, the longer Greece and the Troika negotiate, the greater the risk they take to get the other to concede. The failed negotiations to date may be because the risk of a Greek default has not reached the critical threshold necessary to get both of the parties to offer concessions. A final suggestion for why communication has been ineffective in the Greece-Troika Chicken game may simply be because communication is a poor way of resolving this situation. This would be a challenge to the generalisability of the findings from this research.[44]

[44]Since the Chicken game between Greece and the Troika is still ongoing, future research will need to enquire into the role that communication played once this Chicken game is over.

5.6 Limitations

There are several limitations associated with this research, the majority of which are related to the experimental design that was employed in this study. Firstly, students at Massey University's Albany campus served as the participants for this experiment. These students may have had characteristics that differentiated them from the wider population of New Zealanders. As such, caution should be exercised when generalising these results to different groups of people. Secondly, participants were not strictly anonymous in this experiment raising the potential for extraneous factors to have entered into participants' decision frames. Although measures were implemented to mitigate the impact of social preferences on participants' decisions, these measures may not have been effective as intended. For example, probit model 3 showed that participants were more likely to make an *Invest* decision when their opponent was male compared to female. This result could have been due to some form of social desirability bias influencing participants to be overly lenient towards female participants. Furthermore, although participants were randomly assigned to the no communication and one-way conditions in this experiment, this was not the case for the two-way condition. Trials in the two-way condition were completed subsequently because the two-way condition was only going to be undertaken conditional on getting enough participants in the first two conditions. Although the trials for the two-way condition were all completed on the same day as the no communication and one-way conditions, it is possible that participants in the two-way condition may have differed in an important way. Another limitation relates to the size of the monetary payoffs offered to participants in the Chicken game played. Due to financial and ethical reasons, only modest payoffs could be offered. Undoubtedly, if much larger amounts of money were at stake, participants may act in a different manner than was observed in this experiment (see Smith & Walker, 1993). Furthermore, following Camerer's (2003) criticism of the binary lottery procedure, the payoffs available to participants in this game were directly enumerated in New Zealand dollars. This design feature meant that participants were playing a *game form* rather than a true *game* involving von Neumann-Morgenstern utilities. In order for the dollar payoffs used in this experiment to reflect utilities, it was necessary to assume that all participants were risk-neutral. However, many of the participants may have been risk-averse or even risk-seeking and that would mean that utilities for these participants would not have been a linear function of their monetary payoffs. If this were the case, participants' decisions would be sensitive to their risk attitudes (Chuah, Hoffmann, & Larner, 2011; De Heus, Hoogervorst, & Van Dijk, 2010; Engelmann & Steiner, 2007) and participants would not necessarily be playing a true game of Chicken. Moreover, another limitation was that the probit models estimated were relatively simple and did not control for other variables that may have impacted participants' decisions. For example, participants' level of risk tolerance would likely have affected their messages and decisions. If other relevant explanatory variables were controlled for, this might have altered the results provided by the probit models. It is also important to note that all of the explanatory variables were categorical. Although probit models can be run using all categorical data, they tend to run more smoothly when a continuous variable is included in the model. Lastly, much of the discussion focused on offering potential explanations for why participants behaved in the way they did during this experiment. Since this research was not specifically intended to measure the cognitive processes directing participants' behaviour, the explanations offered, albeit supported by previous research, are certainly contestable.

5.7 Future Research

The findings of this research provide several avenues through which future research may be able to make further contributions. Firstly, it is important to establish whether the results of this research hold when using a different group of participants. This research will help to address whether the results of this experiment are specific to the students of Massey University or generalisable to a wider group of people. If a larger scale attempt at conducting this research were to be undertaken, it would be interesting to see if the results vary when this experiment is conducted using participants from different countries. Secondly, this experiment restricted participants to either one-way or two-way communication whereby the form of communication was structured. Additional research needs to ascertain how participants behave if multiple-round communication was permitted and also if unstructured communication was allowed. People in real-world Chicken games will likely engage in dialogue on multiple occasions while they often have the liberty to communicate as they please. As a result, this research would offer insights that are more generalisable to real-world contexts. Another way future research can provide insights is by trying to better understand the decision processes that underpin participants' actions in this game. Surveys could be completed by participants after undertaking this experiment; however, there would be no guarantee that participants' responses accurately reveal how their decisions were formed. With recent advances in brain scanning technology, a neuroeconomics approach involving scanning technology such as functional magnetic resonance imaging (fMRI) could be used while people engage in a cheap talk game of Chicken.[45] This would potentially provide an insight into how cheap talk messages activate specific regions of participants' brains, which would give researchers the ability to better understand the mechanism through which cheap talk impacted participants' decisions. Finally, an analysis of how communication impacts real world Chicken games needs to be undertaken. For example, this could involve the analysis of meeting transcripts between Greece and the Troika once their Chicken game has ended. This would help to provide insights into the role that communication plays in real-world Chicken games.

6 Conclusion

In this thesis, an experimental test was conducted to better understand the impact of cheap talk in Chicken. Participants (n=180) played an endowment version of Chicken, with either no communication, one-way communication or two-way communication. The findings of this research do not support the prediction made by Giordano et al. (2013) that one-way communication would help a sender achieve their preferred Nash equilibria following an *Invest* message. Instead, the findings provide some novel insights into Camerer's (2003) claim that one-way communication allows players to "take charge" while two-way communication creates an argument in mixed motive games. Indeed, senders did take charge by frequently proposing and playing the lucrative but potentially rewarding *Invest* option in the one-way condition. Regularly playing *Invest* allowed senders to attain higher payoffs on average relative to players in the NC condition. However, one-way communication did not significantly increase the proportion of equilibria outcomes as predicted by Giordano et al. (2013), largely because receivers did not always best respond to the senders' messages. When two-way communication was permitted, however, it was unexpected to observe such a large portion of players not only propose, but also play *Not Invest*. In addition, agreements to play the cooperative outcomes were regularly upheld by players. These findings suggest that in the two-way condition, players used their messages to reassure their opponent that they wanted to cooperate. As such, instead of two-way communication creating an argument between players in Chicken, as was suggested by Camerer (2003), it seems that two-way communication has predominantly resulted in agreements between players. This finding supports the idea that two messages can create a focal point even when a pair of messages does not constitute a Nash equilibrium. Guilt aversion and

[45] See Kable (2011) and Camerer, Loewenstein, & Prelec (2004) for reviews of how neuroeconomics is being used to further develop economic theory.

moral norms were offered as potential explanations to help account for this finding. Finally, although this research was not specifically intended to classify participants into different thinker types, the merits of the EÖ's level-k predictions involving cheap talk in Chicken were broadly assessed. At face value, the results of this study do not support the claims put forth by EÖ; however, their model's assumptions such as participants' lexicographic preference for honesty seem to be well-met in the two-way condition. Further attempts, whereby participants are econometrically classified into different level thinker types need to be undertaken to analyse fully the validity of EÖ's model.

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Appendix A: Participant Information Sheet

Decision-making in the Game of Chicken

INFORMATION SHEET

Researcher(s) Introduction

My name is Nigel Espie and I am currently completing a Master's of Business Studies degree in economics at Massey University. An important part of this degree is the research component (120 credit thesis), whereby I must research a particular field of interest with the intention of making a contribution to that field.

I have selected game theory as a field of inquiry with my research specifically looking into how people make decisions in a situation called the Game of Chicken (Chicken). Under the supervision of Professor Christoph Schumacher, an experimental test whereby people play a variation of Chicken will be undertaken in order to see how actually people play this game.

Project Description and Invitation

The Game of Chicken is a generic name for situations involving a certain type of conflict. This game involves 2 players whom are both faced with deciding between a risky and a conservative option. There are four outcomes that can eventuate in this game which depend on the decisions of both the players involved.

For the purposes of this project, participants will play an endowment version of Chicken whereby participants are given a small amount of money that they must decide to either invest or not invest. Depending on the decisions of both players, and in turn the outcome of the game, participants have the potential to either increase or decrease the amount of money they are given at the outset of the experiment.

I wish to invite students of Massey University to participate in this research.

Participant Identification and Recruitment

Flyers advertising the project will be posted around Massey University's Albany campus, which will have instructions for how people can enquire about participating in this research (I.e. by sending an indication of interest to an email address: n.espie@massey.ac.nz). After, enquiring about the research, a confirmation email will be sent to participants in order to confirm the time and location of the experiment.

Since I am a student at Massey University many students that wish to participate in this research may know me personally. Students that do know me can participate in this research, but must only do so on their own volition. Participation in this research will in no way impact my relationship with these students.

Key Information

- The names of participants will be obtained upon signing up for the project and will be kept strictly confidential.
- Participants must be 18 years or older to partake in this research.

  Experiment will occur in a spare room on Massey University's Albany campus. The specific room will be advised to participants upon signing up for the experiment.
- 120 participants are needed for this research. This number has been determined on statistical grounds in order to allow for the use of certain statistical tests of the data.

Appendix A (cont.): Participant Information Sheet

- Participants will be given $5 at the outset of the experiment which can either be increased, held constant, or decreased based on the outcome of the game. That is, participants can either leave the experiment with ($10, $8, $2.50, or $0).

- Participants do not face any risk of physical harm as a result of this experiment. The only risk that participants do face is the loss of the money they are given at the outset of the experiment.

Project Procedures

Upon entering the experiment, located in the archives room on level 1 of the Massey University Library (Albany), 2 participants will be explained the rules of the endowment game that they will play. Participants will be given the opportunity to ask questions about the game to the researcher. The researcher will then ask participants a few questions about the game to ensure that they understand it. Participants will subsequently complete an informed consent form if they wish to participate. The researcher will then direct both of the participants to parallel desks separated by a partition and then the game will begin. The researcher will then tell both participants to make their decision in the game (to either invest or not invest the money) by way of holding up a card with their decision inscribed on it. After the decisions have been made, the researcher will record the decisions of both participants and then give them their respective payoffs in sealed envelopes. Participants will be then thanked for their involvement in the study and will then be free to go. Participation in this experiment is expected to take approximately 5-10 minutes.

Data Management

During the experiment, the researcher will record the decisions of both participants on a results sheet after the game is completed. After all of the trials have been completed, the result from multiple trials will then all be collated and digitally recorded and stored on a password protected USB drive. Participant's names will not be associated with the digital version of the data.

The data attained from this experiment will be used in order to complete a Master's thesis which may also be submitted to a peer reviewed journal.

The data collected from this experiment will be stored in a secured filing cabinet in the office of Professor Christoph Schumacher. Informed consent forms will be stored in a secured filing cabinet in the office of Sharon Henderson, P.A. for the School of Economics and Finance. Professor Christoph Schumacher will take responsibility for the disposal of the data. The data will be stored for at least 5 years.

Upon completing the informed consent form, participants will have the ability to opt-in in order to receive the results of the research. Participants will simply record their email address on the informed consent form if they wish to receive the research summary resulting from the experiment. This information will be torn-off from the informed consent and stored separately from them in the office of Professor Christoph Schumacher.

Participant's Rights

You are under no obligation to accept this invitation.

If you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study prior to the commencement of the experimental game of chicken
- Ask any questions about the study at any time during participation;
- Provide information on the understanding that your name will not be used unless you give permission to the researcher;
- Be given access to a summary of the project findings when it is concluded.

Appendix A (cont.): Participant Information Sheet

Project Contacts

Please feel free to contact myself or Professor Christoph Schumacher if you have any questions about this project.

Master's Student: Nigel Espie. Email: n.espie@massey.ac.nz
Supervisor: Professor Christoph Schumacher. Email: c.schumacher@massey.ac.nz

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application 14/044 / MUHECN. If you have any concerns about the conduct of this research, please contact Dr Andrew Chrystall, Acting Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x 43317, email humanethicsnorth@massey.ac.nz.

Appendix B: Experimental Instructions

Chicken Experiment- Researcher Instructions to Participants

Seat participants.

Please read the following information sheets regarding this experiment and sign the informed consent form if you are happy to proceed in the experiment. If you would like to receive a summary of the research findings, please indicate this and also your email address.

Once you have read through the information sheet, I will explain the rules of the game that will be played during this experiment which will be followed by a few brief questions to ensure that you both understand it.

Once participants read through the information sheet.

You and your fellow participant are about to play a simple decision making game for real money. You both begin this game with $5 which is now your personal money to use in this game. (*Put money on table)*

In this game both participants have two options: either you can invest your $5 or you can choose to not invest your $5. Based on the decisions of both participants in this game, there is the potential to either increase or decrease your $5.

The following Matrix depicts the payoffs available and how they depend on the decisions of both players in the game. This matrix will also be visible when you play the game.

Separate players into player 1 and player 2.

If both players choose to not invest, then both players will earn and additional $3.

If player 1 chooses to invest whilst player 2 chooses to not invest, then player 1 earns an additional $5 and player 2 loses $2.50.

If player 2 chooses to invest whilst player 1 chooses to not invest, then player 2 earns an additional $5 and player 1 loses $2.50.

Lastly, if both players choose to invest, then both players lose $5.

I will now ask a few questions to ensure that you both understand the rules of the game.

1. What are the payoffs for both players if both players choose to not invest?
2. What are the payoffs for both players if player 1 invests and player 2 chooses to not invest?
3. What are the payoffs for both players if both players choose to invest?
4. What are the payoffs for both players if player 1 chooses to not invest and player 2 chooses to invest?

Check if answers correct following each question. If incorrect, re-explain outcomes. If correct proceed.

When you play this game, you might ask yourself how we want you to act. For the scientific value of the experiment it is important that all participants set out to maximize their own individual payoffs. Therefore, we ask you to simply focus on getting as high payoffs as possible for yourself.

On your desk, you will see two cards. One with the word “invest” on it, and the other with the word “not invest” on it. When we begin this game in a few moments, you will indicate your

Appendix B (cont.): Experimental Instructions

decision to me by revealing the card with the action you wish to take. Only I will be aware of the decision you make in this game. Once the experiment is compete, you will receive your payoffs and leave the experiment individually.

Read for one way condition only

An additional feature of the game that you will play is that one participant will be chosen to send a message to the other participant before you make your decision. In the message, you will indicate which action you intend to choose in the game. This will be done by passing the relevant card to me which I will show to the other participant. Please note that the sender does not have to choose according to the message. The participant that receives the message is not allowed to respond to this message. Please select your message now.

Read for two way condition only

An additional feature of the game that you will play is that both participants will have the opportunity to send a message to the other participant before you make your decision. In the message, you will indicate which action you intend to choose in the game. This will be done by passing the relevant card to me (at the same time as each other) which I will show to the other participant. Please note that you do not have to choose an action in the game according to the message you send. Please select your message now.

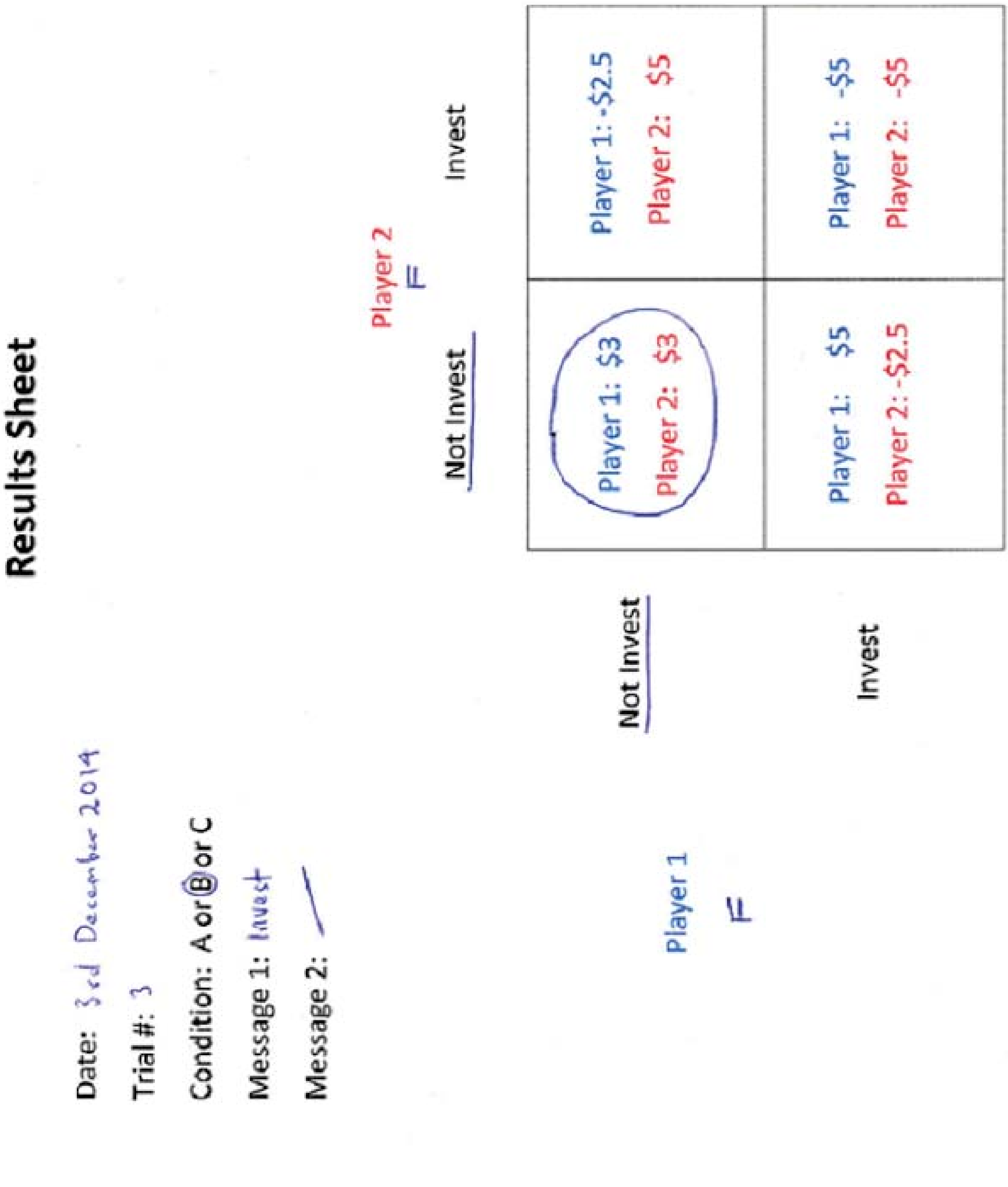
Read for all conditions

Let's begin the game. Please indicate your decision by revealing one of the cards in front of you. I will go to the corner of the room and give you thirty seconds to make this decision.

Debriefing.

Give envelopes.

Appendix C: Results Sheet Example



Results Sheet

Date: 3rd December 2014

Trial #: 3

Condition: A or B or C

Message 1: Invest

Message 2: —

		Player 2 F	
		Not Invest	Invest
Player 1 F	Not Invest	Player 1: \$3 Player 2: \$3	Player 1: -\$2.5 Player 2: \$5
	Invest	Player 1: \$5 Player 2: -\$2.5	Player 1: -\$5 Player 2: -\$5

Appendix D: MUHEC Ethical Approval

MASSEY UNIVERSITY
ALBANY

20 November 2014

Nigel Espie
c/- Professor C Schumacher
School of Economics and Finance
Massey University
Albany

Dear Nigel

HUMAN ETHICS APPROVAL APPLICATION – MUHECN 14/044
Communication in the Game of Chicken: An Experimental Test

Thank you for your application. It has been fully considered, and approved by the Massey University Human Ethics Committee: Northern.

Approval is for three years. If this project has not been completed within three years from the date of this letter, a reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Andrew Chrystall
Acting Chair
Human Ethics Committee: Northern

cc Professor C Schumacher

Te Kunenga ki Pūrehuroa

Research Ethics Office
Private Bag 102 904, Auckland, 0745, New Zealand Telephone +64 9 414 0800 ex 43279 humanethicsnorth@massey.ac.nz

Appendix E: Logit Model Output

Table A.1: Logit model 1: Impact of communication on participants' decisions

Variable	Estimate	Std. Error	z-value	P-val.
Intercept	-0.8867	0.3593	-2.468	0.01359*
One-way	1.5898	.4969	3.199	0.0014**
Two-way	-0.3058	0.3921	-0.780	0.4354
Genopp	0.2220	0.3681	0.603	0.5464
Gendec	0.4379	0.3685	1.188	0.2348

n = 150, Pseudo R^2 = 0.0924, PCP= 68%, Log-likelihood=-92.31, df=4
X^2=18.80, P-val=.001

Table A.2: Logit model 2: One-way vs. Two-way com. on participants' decisions

Variable	Estimate	Std. Error	z-value	P-val.
Intercept	0.4643	0.4943	0.939	0.348
Twoway	-1.9794	0.5219	-3.793	0.0001***
Genopp	0.7240	0.4951	1.462	0.1436
Gendec	0.5092	0.4899	1.039	0.2987

n = 90, Pseudo R^2 = 0.16, PCP= 71.11%, Log-likelihood=-51.97, df=3
X^2=19.71, P-val=.0002

Table A.3: Logit model 3: Messages in the one-way condition

Variable	Estimate	Std. Error	z value	P-val.
Intercept	-0.0212	1.3953	-0.015	0.9879
Mesdec	-0.6655	1.3939	-0.477	0.6330
Genopp	2.6818	1.2439	2.156	0.0311*
Gendec	1.6750	1.0628	1.576	0.1150

n = 30, Pseudo R^2 = 0.27, PCP= 80%, Log-likelihood=-12.73, df=3
X^2=9.33, P-val=.0252

Table A.4: Logit model 4: Messages in the two-way condition

Variable	Estimate	Std. Error	z value	P-val.
Intercept	-4.2094	1.2801	-3.288	0.001^{**}
Mesdec	4.0537	1.1654	3.478	0.0005^{***}
Mesopp	1.0511	0.8438	1.246	0.2129
Genopp	0.2477	0.7692	0.322	0.7475
Gendec	2.1290	1.1327	1.880	$0.0602^{\cdot}$

$n = 60$, Pseudo $R^2 = 0.34$, PCP= 80%, Log-likelihood=-24.28

X^2=24.75, df=4, P-val=.00005