

DISCLOSURE UNDER UNAWARENESS: AN EXPERIMENT

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Abstract

We consider a persuasion game between a seller and a buyer. The seller has a good whose quality is known to him but not to the buyer. Before the buyer decides on how many units to buy, the seller can disclose some verifiable information to the buyer. The “better” the information, the more the buyer will buy. The information is two-dimensional. There are two treatments. In the unawareness treatment, the buyer is unaware of the second dimension. In the control treatment, the buyer is aware of both dimensions. Theory predicts unraveling in the control treatment but not the unawareness treatment. We test this prediction experimentally.

Keywords: Disclosure of information, persuasion games, verifiable information, unawareness, unraveling, rationalizability, experimental games.

JEL-Classifications: D83, C72, C92, D82.

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1 Introduction

Starting with seminal work by Grossman (1981), Milgrom (1981), Grossman and Hart (1980), and Milgrom and Roberts (1986), persuasion games have been used to study disclosure of verifiable information in many economic, political or legal contexts (see Milgrom, 2008, for a review). The striking result in the literature is unraveling of information. This seems to clash with casual empirical observation that informed parties may not fully disclose relevant information or that recipients of disclosures fail to fully deduce the information contained in them.

Various assumptions have been introduced to circumvent the unraveling result. For instance, informed parties may only be informed after they have somehow committed to a disclosure strategy and this may lead to non-full disclosure in equilibrium (Kamenica and Gentzkow, 2011). Here we advance an alternative explanation. Receivers of information may be unaware of some dimension of the information. When the informed party keeps silent on the dimension of information the receiver is unaware, then the receiver cannot deduce anything from the silence. This prevents unraveling especially with regard to unfavorable information along the dimension that the receiver is unaware. See Heifetz, Meier, and Schipper (2011) for a detailed exposition of the argument.

In this chapter, we present an experiment to test this prediction. In particular, we compare unraveling in a persuasion game with full awareness with unraveling in an analogue persuasion game in which the receiver is unaware of a dimension of the information. We show that the relative frequency of unraveling in the game with unawareness is lower than in the game with full awareness as theory predicts but this difference is just marginally significant in our sample. Thus, further work is necessary to settle the issue.

Our experiment is one of the few experiments that test predictions in unraveling games (see Li and Schipper, 2017, Jin, Luca, and Martin, 2016, Hagenbach and Perez-Richet, 2016, Benndorf, Kübler, and Normann, 2015, and Forsythe, Isaac, and Palfrey, 1989). None of the other experiments on persuasion games consider limits to unraveling posed by unawareness. Our experiment is not just the first experiment to consider unawareness in persuasion games but the very first experiment on unawareness in games.

The chapter is organized as follows: In the next section, we outline the models and theoretical predictions. This is followed in Section 3 with an exposition of the experimental design and the hypothesis. The analysis is collection in Section 4. Finally, we conclude in Section 5. The instructions for the experiment including screenshots are relegated to appendices.

2 Models

We consider a two-player persuasion game between a seller and a buyer. The seller has a good. The good can have different attributes. We consider two attributes. Each attribute

may be present or not present independently of the presence of the other attribute. Thus, the good can have one of four different attribute combinations. The seller knows which attribute combination his good satisfies. Initially the buyer doesn't know which attribute combination the good satisfies. Before the buyer takes a decision about how many units to buy, the seller can provide verifiable information about the attributes of the good to the buyer. The seller can be vague, in the sense of disclosing a range of attribute combinations, but is not allowed to lie about the true attribute combination of the good. That is, no matter what set of attribute combinations the seller discloses to the buyer, it must contain the true attribute combination of the good.

For the sake of concreteness, we call the first attribute “quality” and the second “feature”. The quality can be either 2 or 3. We denote by q the quality. The feature can be either a or b (i.e., feature present or not present). If nature chooses quality $q \in \{2, 3\}$ and feature $f \in \{a, b\}$, then the seller's set of messages is $\mathcal{M}(q, f) := \{M \mid M \in 2^{\{2,3\}}, q \in M\} \cup \{M \mid M \in 2^{\{2,3\} \times \{a,b\}}, (q, f) \in M\}$.¹

The buyer can purchase either 1, 2, 3, or 4 units of the good. We denote by x the amount purchased. The price of each unit is fixed to \$4. Depending on the true attribute combination of the good and the amount purchased by the buyer, the buyer's payoff is given in Table 1.

Table 1: Payoffs to the Buyer under Full Awareness

		Attribute combination			
		(2, a)	(2, b)	(3, b)	(3, a)
	$x = 1$	14	10	8	7
Units	$x = 2$	8	16	12	11
purchased	$x = 3$	4	10	18	14
	$x = 4$	1	7	12	20

We observe that feature a is useful to the buyer if and only if the quality is 3. Feature b is useful if and only if the quality is 2. Moreover, we also observe that the optimal quantity for the buyer matches the order of attribute combinations in the table. I.e., it is determined by the main diagonal of Table 1.

We neglect cost of production. Thus, the payoff to the seller is simply price times quantity or $\$4 \cdot x$.

We now consider two versions of the game. The first version is defined as above. This is an example of a persuasion game à la Milgrom and Roberts (1986). We call it the persuasion game with full awareness. I

¹To simplify the design of the experiment, we restricted the seller's set of messages in such a way as to not allow her to select messages pertaining only to the feature. I.e., we exclude messages in $\{M \mid M \in 2^{\{a,b\}}, f \in M\}$.

In the second version the buyer is initially unaware of the feature while the seller is aware of both dimensions. Being unaware means intuitively that the buyer doesn't not even conceive of the existence or non-existence of the feature (i.e., a or b); see Heifetz, Meier, and Schipper (2006) for an epistemic characterization of the notion of unawareness used in our setting. It means that the feature is essentially out of the buyer's mind. Consequently if the seller doesn't make him aware of the existence of the feature with her verifiable message before the purchase, the buyer can contemplate only about the quality of the good but not about the presence of the feature. We assume that in this case the buyer views his payoffs given by Table 2. That is, payoffs are such as if the feature is not present (i.e., the second dimension takes on value b). Such a setting is realistic especially if the good is an experience good whose features are only discovered by the buyer once consumed. In any case, whenever the seller discloses information, the information must be truthful in the sense of not ruling out the true state.

Table 2: Payoff to the Buyer with Unawareness of the Feature

		Quality	
		2	3
Units purchased	$x = 1$	10	8
	$x = 2$	16	1
	$x = 3$	10	18
	$x = 4$	7	12

This second setting outlined so far defines an instance of a game with unawareness (see Heifetz, Meier, and Schipper, 2013). Nature moves first and determines the quality of the good and whether or not the feature is present. Each move of nature leads to a singleton information set of the seller. At this information set, the seller can choose a message consistent with the move of nature. I.e., if the move of nature is (q, f) , then the seller sets of message is $\mathcal{M}(q, f)$ defined above. If the seller chooses a message in $\{M \mid M \in 2^{\{2,3\} \times \{a,b\}}, (q, f) \in M\}$, then the buyer becomes aware of the existence of the feature. Consequently, the buyer's state of mind is represented by an information set in the game tree containing histories consistent with the message of the seller. If the seller chooses a message in $\{M \mid M \in 2^{\{2,3\}}, q \in M\}$, i.e., she remains silent on the feature, then the buyer remains unaware of the feature. Consequently, her state of mind is given by an information set in a less expressive game tree, in which nature initially chooses between qualities in $\{2, 3\}$ followed by the seller selecting a message in $\{M \mid M \in 2^{\{2,3\}}, q \in M\}$ (assuming that nature chose quality q in this less expressive tree). That is, the persuasion game with unawareness involves two game trees, one similar to the case of full awareness and one less expressive tree where moves of nature and message of the seller are restricted to mentioning qualities only and anything having to do with the feature is erased. In the more expressive tree, at any history in which the seller is silent on the feature, the information set of the buyer is a subset of histories of the less expressive tree signifying

the fact that the buyer remains unaware of the feature.²

To discuss solution concepts, we need both strategies and beliefs. As usual in extensive-form games, strategies map information sets into actions available at that information sets. Note that in the persuasion game with unawareness both players have information sets in the more and less expressive game trees.

For the seller, the quality and attribute selected by nature represent the information sets. A strategy σ_s of the seller maps his information sets (in both trees, in case of unawareness) to the set of messages consistent with the information set. E.g., if (q, f) is the information set of the seller, then $\sigma_s(q, f) \in \mathcal{M}(q, f)$. In case of unawareness, in the less expressive tree, if q is the information set of the seller, then $\sigma_s(q) \in \{M \mid M \in 2^{\{2,3\}}, q \in M\}$. The information sets of the buyer are identified with the messages sent by the seller. The strategy of the buyer σ_b maps his information sets (in both trees, in case of unawareness) to quantities in X . For each player $i \in \{b, s\}$, we denote by Σ_i player i 's set of strategies. In case of the persuasion game with unawareness, there is also a notion of partial strategy, namely a strategy restricted to the less expressive tree.

A belief system β_s of the seller is a profile of beliefs, one for each of her information sets. Each belief is about strategies of the buyer. In case of unawareness, the belief at an information set in the less expressive game tree, is about partial strategies of the buyer.

Analogously, a belief system β_b of the buyer is a profile of beliefs, one for each of her information sets. Each belief is about strategies of the seller and moves of nature. At each information set, it assigns probability 1 to combinations of moves of nature and strategies of the seller such that the seller's strategy and move of nature reaches this information set.

While standard persuasion games a la Milgrom and Roberts (1986) have been solved using sequential equilibrium, we use prudent rationalizability (Heifetz, Meier, and Schipper, 2011). It is a version of extensive-form rationalizability incorporating an admissibility criterion. It is strategy-equivalent to iterated admissibility applied to the associated normal-form game. The advantage of using prudent rationalizability is two-fold: First, the solution concept applies to both versions of the game. That is, prudent rationalizability can naturally be applied to games with unawareness while the notion of sequential equilibrium is problematic in games with unawareness; see Schipper (2017) for a discussion. Second, since prudent rationalizability is an iterative solution concept it gives us a prediction for any finite level of reasoning about the rationality of the opponent. Thus, similar to the level- k thinking literature, we are able to learn about levels of reasoning of players or more precisely about mutual k -level cautious strong belief in rationality. In the limit, it identifies strategies consistent with common cautious strong belief in rationality. Finally, in persuasion games without unawareness, prudent rationalizability slightly refines pure sequential equilibrium strategies.

We say that strategy σ_i of player i is rational with belief system β_i at her information

²See Heifetz, Meier, and Schipper (2011) for an example of a persuasion game with unawareness.

set if that σ_i maximizes expected payoffs with respect to the belief prescribed by β_i at that information set.

Prudent rationalizability is now defined inductively. For each player $i \in \{b, s\}$, all strategies are level-0 prudent rationalizable, $\Sigma_i^0 = \Sigma_i$. For each $k \geq 1$, the set B_s^k of level k beliefs of the seller are all the belief systems β_s that assigns strict positive probability to each level $k - 1$ strategies of the buyer, Σ_b^{k-1} , and probability zero to any other strategy.

The set of level k prudent rationalizable strategies of the seller Σ_s^k are all level $k - 1$ prudent rationalizable strategies of the seller Σ_s^{k-1} such that for each strategy $\sigma_s \in \Sigma_s^k$ there exists a level k belief system $\beta_s \in B_s^k$ with which the strategy σ_s is rational at every of her information sets.

For each $k \geq 1$, the set B_b^k of level k belief systems of the buyer is the set of belief systems β_b such that for each of his information sets, if there exists a move of nature and a level $k - 1$ prudent rationalizable strategy of the seller such that this strategy reaches this information sets, then the support of the belief at this information is the set of level $k - 1$ prudent rationalizable strategies of the seller and moves of nature that reach this information set.

The set of level k prudent rationalizable strategies of the buyer Σ_b^k are all level $k - 1$ prudent rationalizable strategies of the buyer Σ_b^{k-1} such that for each strategy $\sigma_b \in \Sigma_b^k$ there exists a level k belief system $\beta_b \in B_b^k$ with which the strategy σ_b is rational at every of his information sets.

The set of prudent rationalizable strategies of player $i \in \{b, s\}$ is $\Sigma_i^\infty := \bigcap_{k=1}^\infty \Sigma_i^k$.

A strategy survives k levels of the prudent rationalizability procedure, if there exists a full support belief on the k -level prudent rationalizable strategies of the other player and - in the case of the buyer - feasible moves of nature for which the strategy is rational at every information set of the player. The prudence or cautiousness is captured by full support beliefs. It means that at each level, a player does not completely exclude any of the opponents' remaining strategies and feasible moves of nature. This includes the worst possible quality-feature combinations (or, in the case of not raising awareness, the worst possible quality) consistent with the message observed by the buyer. Hence, skepticism about messages comes for free through prudence/cautiousness. Heifetz, Meier, and Schipper (2011) and Meier and Schipper (2012) provide further discussions of the solution concept, including an existence proof for finite extensive-form games and a proof of equivalence to iterated admissibility based on Pearce (1984, Lemma 4).

To see how prudent rationalizability works in persuasion games consider first a persuasion game with two quality levels $Q = \{2, 3\}$. (Such a game is actually played by our participants in the first 15 rounds of the experiment.) At the first level, a buyer receiving a singleton message from the seller knows the true quality (since the seller cannot lie). Thus, he best-responds by choosing the quantity equal to the quality level disclosed. At the second level, the seller forms full-support beliefs about first-level prudent rationalizable strategies of the buyer. If her quality is 2, then she happily tells the buyer

because otherwise she runs the risk of the buyer buying less than 2 (since she entertain full-support beliefs). At the third level, the buyer forms full-support beliefs over second-level prudent rationalizable strategies of the seller. In particular, if he does not hear the message $\{2\}$ from the seller then he knows that the seller does not have quality 2 since any second-level prudent rationalizable seller with quality 2 would have happily disclosed this fact to him. At this point, information unravels with respect to qualities in the sense that the buyer deduces complete information about the quality from the seller's message even though if the message itself may remain vague because a seller with quality 3 may say $\{2, 3\}$.

To define unraveling more formally, let \preceq be a binary relation on moves of nature that reflect the buyer's preferences (see the main diagonals in Tables 1 and 2. I.e., $(2, a) \preceq (2, b) \preceq (3, b) \preceq (3, a)$ as well as $2 \preceq 3$. Given a message M and the awareness of the buyer, we denote by $\min_{\preceq} M$ the minimum quality-feature (in the case of awareness of the buyer) or minimum quality (in the case of unawareness of the buyer) consistent with the message. For instance, if $M = \{2\}$ then $\min_{\preceq} M = \{(2, a)\}$ if the buyer is aware of the feature. Otherwise, if the buyer is unaware of the feature then $\min_{\preceq} M = \{2\}$. We say that a strategy profile is unraveling (in terms of information and awareness) if

- (i) for each move of nature $(q, f) \in \{2, 3\} \times \{a, b\}$, the seller sends message $M \in \mathcal{M}(q, f)$ such that $\min_{\preceq} M = (q, f)$.
- (ii) for each message M of the seller, the buyer purchases quantity $x \in X$ that maximizes the buyer's payoff at $\min_{\preceq} M$.

We say that a player's strategy is unraveling if it is part of the unraveling strategy profile. Note that in the case of the persuasion games with unawareness, unraveling requires making the buyer aware of the attribute dimension. It is important to note that in the game with full awareness, message $\{2\}$ can be unraveling whereas it is not in the game with unawareness.

Proposition 1 *In the persuasion game with full awareness, any prudent rationalizable outcome is an unraveling outcome.*

The proof follows directly from Li and Schipper (2017, Proposition 1) upon noting that the four quality levels 1, 2, 3, and 4 in their game map to $(2, a)$, $(2, b)$, $(3, b)$, and $(3, a)$, respectively.

The unraveling prediction under full awareness contrasts with prudent rationalizable outcomes when initially the buyer is unaware of the feature. If the move of nature selects the quality-feature combination $(2, a)$, then in any prudent rationalizable outcome the seller remains silent about the feature (i.e., chooses a message that is silent on a or b). The buyer remains unaware of the feature and views the game as given by the less expressive tree. In this tree, there are just two quality levels, 2 and 3. Since the buyer is

unaware of the feature, he cannot induce from the fact that the seller remains silent on it that the good has feature a . In fact, he does not consider the feature at all. That is, information unravels with respect to the quality of the good but not with respect to the feature.

Proposition 2 *In the persuasion game in which the buyer is initially unaware of the feature, in any prudent rationalizable outcome the seller does fully reveal the quality-attribute combination if nature selects $(2, a)$.*

The observation is due to Heifetz, Meier, and Schipper (2011, Proposition 2).

3 Experimental Design and Hypothesis

The experiment was programmed in zTree (Fischbacher, 2007) except for a questionnaire on demographics. This questionnaire was paper-based and distributed only after the experimental session involving the computerized persuasion games had been completed. Subjects were recruited on campus using the ORSEE recruitment system by Greiner (2004).

Upon arrival in the lab, participants received written instructions for the experiment (see Appendix A). They were given sufficient time to read the instructions. After the experimenter went over the written instructions in front of the participants, participants were able to ask questions about the instructions and the experiment. These questions were answered by the experimenter in public. The same experimenter conducted all sessions.

Each session ran one of the following two treatments:

Treatment A: Participants played 15 rounds of a persuasion game with two quality levels, $\{2, 3\}$, then in the 16th round *both* the seller and the buyer were notified about the second dimension, $\{a, b\}$, and subjects played the persuasion game of two dimensions. This treatment serves as control treatment.

Treatment U: Participants played 15 rounds of a persuasion game with two quality levels, $\{2, 3\}$, then in the 16th round *only the seller* was notified about the second dimension, $\{a, b\}$, and subjects played the persuasion game with two dimensions with the buyer being unaware of the existence of the second dimension (i.e., the “feature”).

Each participant was allowed to participate only in one session and was assigned to one of two treatments. Thus, we conducted a between-subject experiment. None of the participants of a prior experimental persuasion game reported in Li and Schipper (2017) were allowed to participate in present experiment.

At the beginning of each session, participants were randomly assigned into matching-groups of six participants. Each participant stayed in the same matching-group throughout the session. Participants were unaware of matching-groups. At the beginning of each round, each participant was randomly matched to another participant from the same matching-group. The resulting pair of participants played the persuasion game together for one round, one participant being randomly assigned to the role of the seller and the other being the buyer. Participants were randomly rematched within their matching-group after each round. The random rematching should prevent to a large extent repeated games effects over the 16 rounds while allowing us to collect a sufficient number of independent observation. Each matching group is an independent observation. Due to randomly assigning the role of the buyer or seller to each participant, a participant may find herself in the role of a seller in one round and in the role of a buyer in another. This change of roles should facilitate interactive reasoning. Participants may find it easier to reason about the other player once they have been in a similar role.

In each round, first the seller received information about the move of nature (i.e, quality in rounds 1 to 15 and the quality-feature combination in round 16). The move of nature was private information to the seller and was not observed by the buyer. Then the seller decided on what message to send to the buyer (see the seller's screenshot in Appendix B). After receiving the message from the seller, the buyer decided on the quantity to buy (see the buyer's screenshot in Appendix B). Finally, both the buyer and seller were informed about their own payoffs (see the screenshots of payoffs in Appendix B).

In the 16th round of treatment with full awareness, both the seller and the buyer were notified of the existence of the second dimension along with the new payoff table for the buyer (see the screenshots for the seller and the buyer in Appendix B), but still only the seller received information about the quality level and feature selected by nature and made a message choice. Different from previous rounds, the choice set of the seller is extended by 8 additional messages involving the second dimension.

In the 16th round of treatment with unawareness, only the seller was notified of the existence of the second dimension along with the new payoff table for the buyer, and upon receiving information on the quality level and the feature selected by nature, the seller then decided on a message. The set of available messages contains also messages that hide the second dimension (see seller's screenshot in Appendix B). If the message received by the buyer did not contain the second dimension, then the buyer simply chooses a quantity to purchase as in the first 15 rounds. If the message received by the buyer did contain the second dimension, then before making the decision the buyer was notified about the second dimension along with the new payoff table.

After playing the 16th round, participants completed a 30-question Raven's progressive matrices test (Raven et al., 2000) at the computer. Each question consists of a graphic pattern in which one piece is missing. Participants need to select the missing piece out of 8 options in order complete the pattern. After the Raven's progressive matrices test, participants received a paper-based questionnaire about demographics from

the experimenter.

At the end of the session, participants were paid a show-up fee plus earnings from the persuasion games. For each participant, one persuasion game was randomly and independently selected for payment. The payoffs in the persuasion games are already denominated in US dollars. The Raven’s progressive matrices test and the questionnaire were not incentivized. This was known to the participants upfront.

We are not interested here in the first 15 rounds. They serve just to allow participants to gain familiarity with a simpler version of the task. We are solely concerned about decisions in round 16. In particular we focus on whether outcomes in treatment A differ significantly from outcomes in treatment U. It allows us to compare the unraveling prediction for persuasion games with full awareness with predicted failure to unravel in persuasion games with unawareness. In line with the theoretical predictions, we hypothesize the following:

Hypothesis 1 *The relative frequency of unraveling outcomes when nature selects (2, a) in treatment A is significantly higher than in treatment U.*

4 Results

The experiment was conducted in a computer lab of the University of California, Davis, in May 2016 and February-March 2017. There were 18 sessions; 9 for each treatment. A total of 378 participants joined the experiment; 192 participants in treatment A and 186 participants in treatment U. Table 3 summarizes demographic information of our sample. The average payment including the show-up fee was \$17.96 with a maximum of \$25, a minimum of \$9, and standard deviation 3.86. Each experimental session lasted for about 1 hour and 15 minutes.

Table 3: Demographics of Our Sample

Variable	Number	Mean	Std. Dev.
Participants	378		
Female	235	0.62	
Age	378	20.71	2.50
White	100	0.26	
Asian	198	0.52	
Black or African	6	0.02	
Mixed or Others	73	0.19	
GPA	373	3.22	0.47
Economics	85	0.23	

Figure 1 visualizes the relative frequencies of unraveling in both treatments. Table 4 shows absolute and relative frequencies for both treatments. In line with theoretical

predictions, the relative frequency of unraveling in the treatment in which the buyer is unaware of the second dimension is lower than in the treatment in which both players are fully aware of the second dimension. However, using the one-side Fisher Exact Test for 2×2 tables with two independent samples (Siegel and Castellan, 1988) we find a p-value of 0.0836. Thus, the difference is just marginally significant.

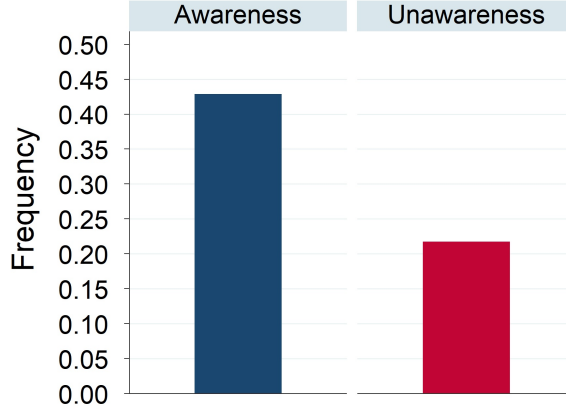


Figure 1: Relative Frequency of Unraveling upon Nature Selecting (2, a)

Table 4: Frequency of Unraveling upon Nature Selecting (2, a)

	Treatment A		Treatment U	
	Abs. Freq.	Rel. Freq.	Abs. Freq.	Rel. Freq.
Unraveling	15	42.86	5	21.74
Non-unraveling	20	57.14	18	78.26

5 Discussion

When buyers are aware of what good be potentially bad about a good, then they may become suspicious if the seller does not disclose relevant information. In contrast, if buyers are unaware of some aspects of the good that could negatively affect their value for it, then they won't become suspicious if the seller is silent on these aspects. This context has been modeled in persuasion game without and with unawareness on part of buyers. The theoretical predictions match the above intuition. In this note we experimentally test these predictions. Although we observe more unraveling of information in the treatment with full awareness as compared to the treatment with unawareness, the difference is just marginally significant. This may be due to a number of reasons. First, we may lack of statistical power due to a relatively low number of observations. We only make use of

observations in which nature chooses $(2, a)$ as this is where theory predicts a difference. A remedy would be to collect more data, especially with nature choosing $(2, a)$. Second, in persuasion games with full awareness, we observe a low frequency of unraveling when nature chooses $(2, a)$ although theory predicts all outcomes to be unraveling. This may be lack of higher order reasoning. Our solution concepts allows us to partially identify levels of reasoning. We plan to follow up on this with an post-hoc study. Third, if levels of reasoning play a role then the difference in predictions may depend on crucially on cognitive ability. It might be the case that the difference is more pronounced when focusing on participants who score relatively high on the Raven progressive matrix test, a common test of cognitive ability that we run after the games were played. Yet, focusing on a subgroup of our data makes sense only if we have more data to begin with. Again, we would need to collect additional data in order to follow up on the association with cognitive ability.

A Experimental Instructions

U

Instructions for the Market Game

Welcome to the experiment!

Please now turn off your cell phones. These must remain turned off for the duration of the experiment. The amount of money you will earn in this experiment will depend on your choices. Thus, it is in your best interest to follow these instructions carefully. You will be paid in cash at the end of the experiment. During the experiment, we ask that you please do not talk to each other. If you have any question, please raise your hand and an experimenter will assist you.

The experiment is made up of 3 phases. The first phase consists of a repeated market game. In the second phase you will complete a simple test. The third phase consists of a questionnaire.

Phase 1

The market game is repeated for 16 rounds. In each round you will be randomly selected as a seller or buyer and then paired up with another participant in the other role. Your role assignment is shown to you on the computer screen as the experiment proceeds. The market works as follows:

Each market consists of one seller and one buyer. The seller can sell an imaginary object with a fixed price of \$4 to the buyer. The object's quality may differ. The quality is randomly chosen from 2 and 3 with equal probability by the computer. 3 represents the higher quality while 2 is the lower quality. At the beginning of each round, the seller is notified of the objects's quality (q), which is displayed on the computer screen. The seller is able to supply as many objects of that quality as demanded by the buyer. The buyer does not know the object's quality unless the seller chooses to provide some information about the quality to the buyer. The seller can communicate through the computer any set of qualities to the buyer provided that (s)he does not exclude the true quality.

For instance, if the true quality is 2, then the seller can send one of the the following two messages shown in the right-hand side column of the following table to the buyer. The images in the column on the left are the associated messages displayed on the computer screen. The shaded number(s) is(are) contained in the message. So if the true quality is 2, any possible message sent by the seller must include the true quality 2.

2	"The quality is 2."
3	
2 3	"The quality is either 2 or 3."

After receiving the information, the buyer selects the quantity of the good (x) to purchase. The quantity to purchase is restricted to 1, 2, 3, and 4 and only one of these four integers is acceptable as the buyer's purchasing quantity.

The seller's payoff in each round is the price of the object (\$4) multiplied by the number of units (x) sold to the buyer:

$$4 \cdot x.$$

The buyer's payoff in each round is determined by both the quantity purchased (x) and the true quality (q) of the object, which is net off the price paid to the seller. It can be easily calculated by the following table. The entries in the table show the buyer's payoff for each true quality level (in columns) and units purchased (in rows). For instance, if the true quality is $q = 3$ and you purchase 1 unit (that is $x = 1$), then as the buyer your payoff in this round is \$8.

		Quality	
		$q = 2$	$q = 3$
Units Purchased	$x = 1$	10	8
	$x = 2$	16	12
	$x = 3$	10	18
	$x = 4$	7	12

After the buyer informs the seller about the quantity purchased via the computer, the computer will show the seller and the buyer the quantity purchased, the true quality and their own payoffs for the round just played. For an instance, if the true quality is 2 and the buyer chooses to purchase 4 units, then the seller's payoff is \$16 and the buyer's payoff is \$7.

The experiment proceeds to the next round after both the seller and the buyer acknowledge this information by clicking the button on the computer screen. In the next round, each participant again is randomly selected to be a buyer or a seller and randomly matched with some participant of the experiment to play the market game. The true

quality of the seller in this market game is also randomly selected and may differ from the true quality of the prior round. Phase 1 ends after 16 rounds of the market game have been played.

Phase 2

Phase 2 consists of a simple test. The test is made up of 30 questions. For every question, there is a pattern with a piece missing and a number of pieces below the pattern. You have to choose which of the pieces below is the missing one to complete the pattern. For each question, one and only one of these pieces is the missing one to complete the pattern. You will score 1 point for every correct answer. After completing the test, you will be informed of your own test score. The test score will not affect your payment that you receive from the experiment.

After completing both phases 1 and 2, your cash payment will be displayed on your computer screen. Your cash payment will be your payoff from one round randomly drawn from the 16 rounds of the market game plus a \$5 show-up fee.

Phase 3

While waiting to be called upon for payment, please complete the questionnaire that the experimenter will hand you. The questionnaire contains questions about demographics. Please carefully complete this questionnaire as this information is very important to us. After completing the questionnaire, please remain in your seat until you have been called upon for payment.

Thank you very much for your participation.

B Screenshots

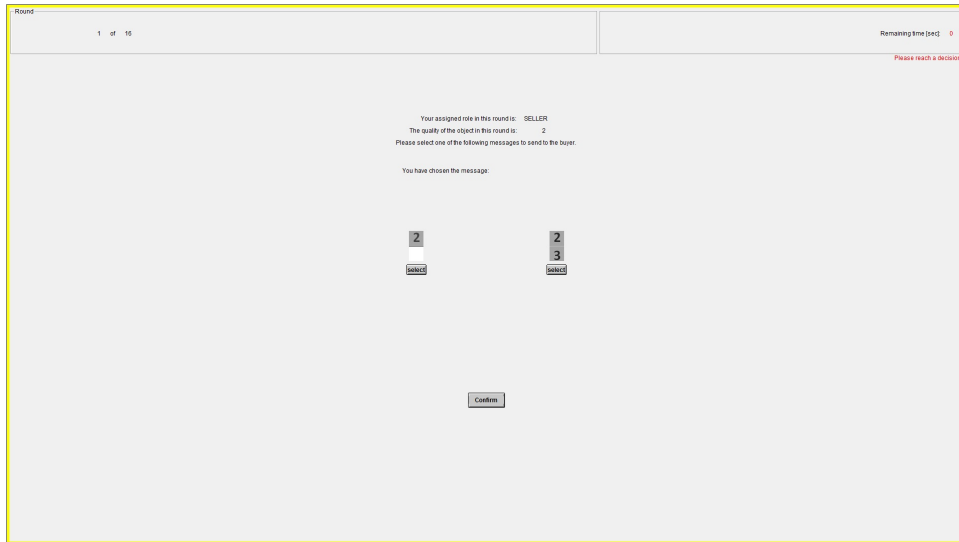


Figure 2: Seller's Message Options Rounds 1 to 15

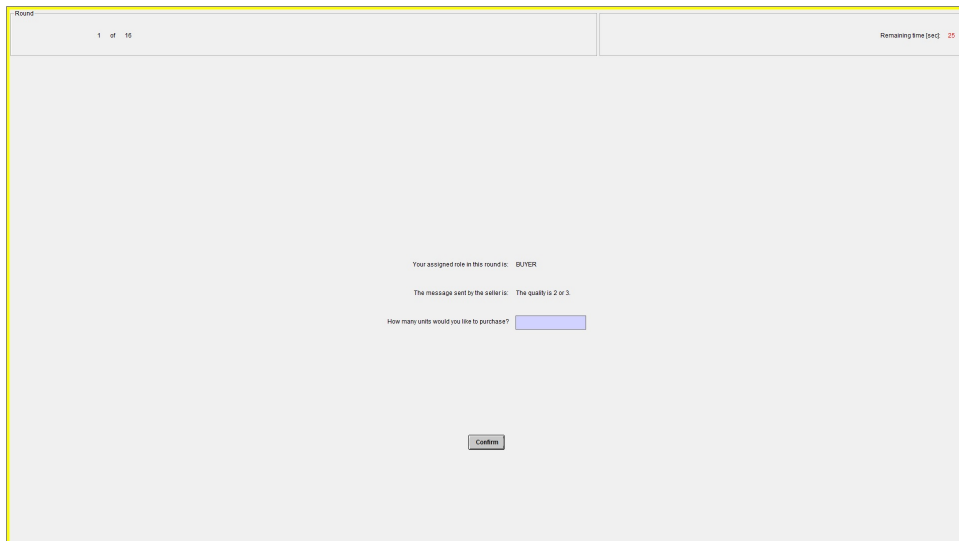


Figure 3: Buyer's Purchase Decision Rounds 1 to 15

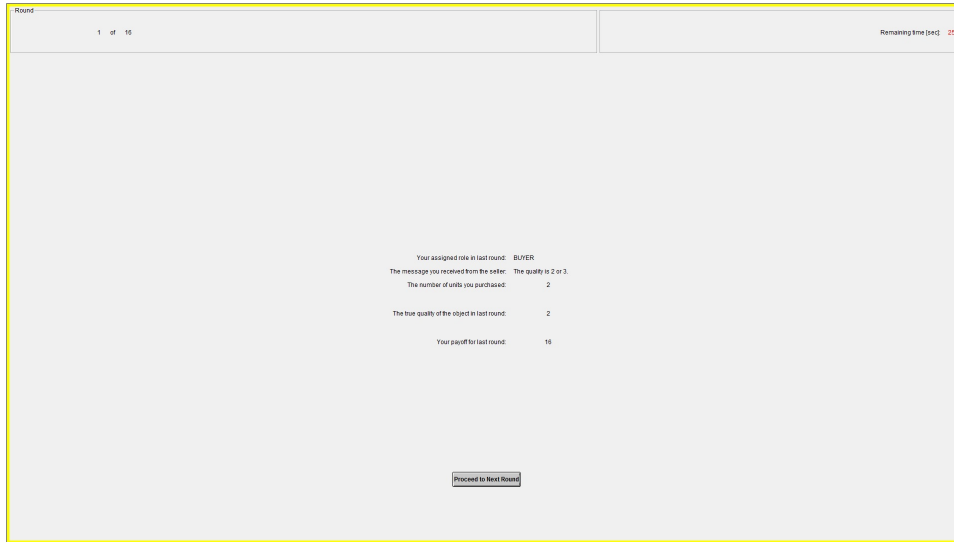


Figure 4: Buyer's Payoff Information at the End of Rounds 1 to 15

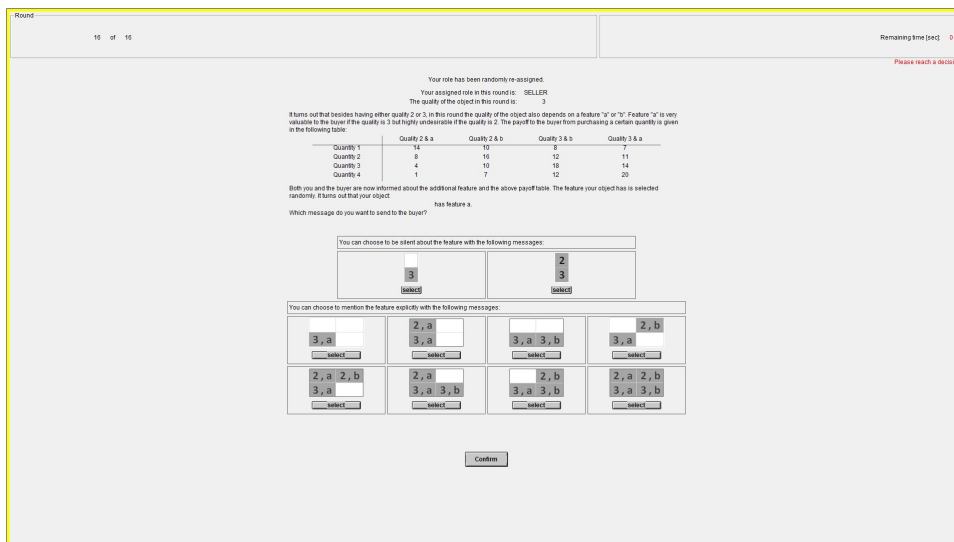


Figure 5: Seller's Message Options Round 16 in Treatment A

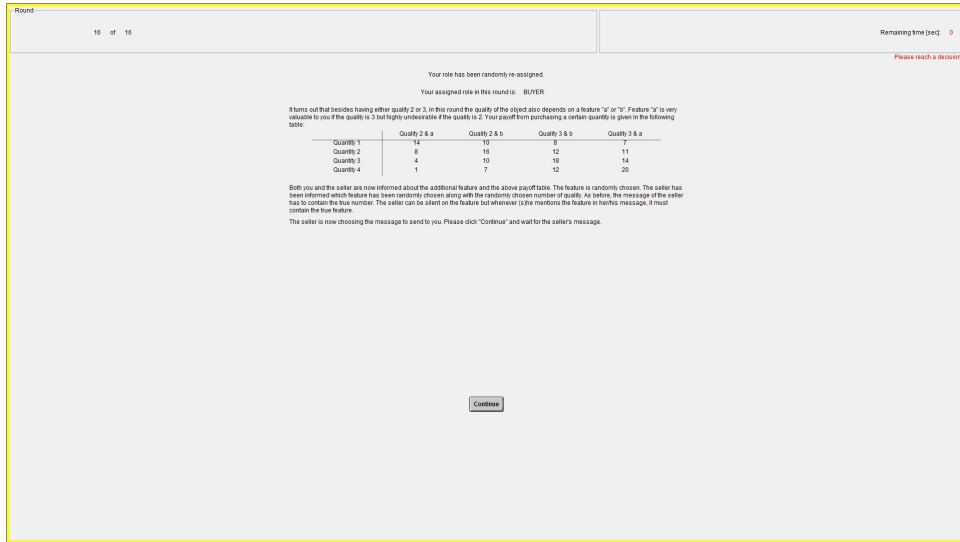


Figure 6: Buyer's Information Round 16 in Treatment A

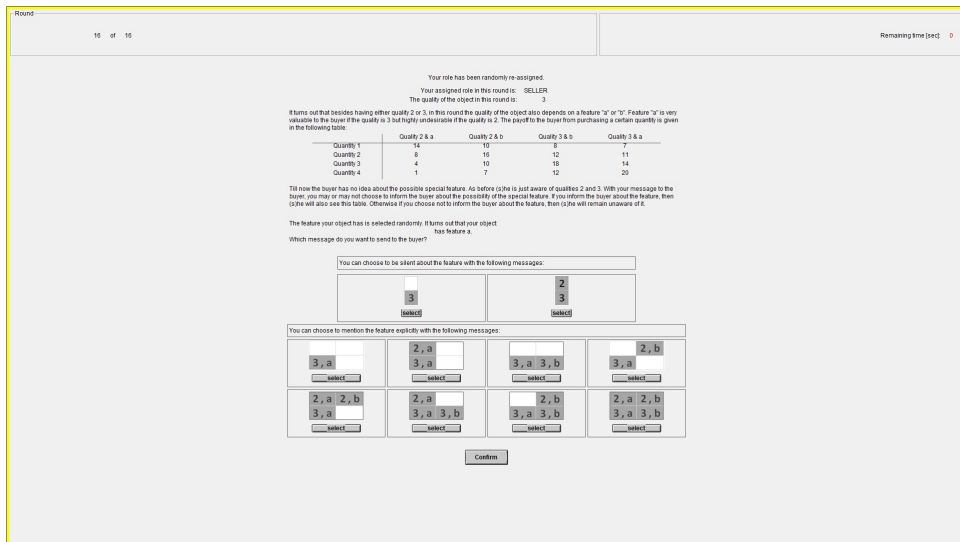


Figure 7: Seller's Message Options Round 16 in Treatment U

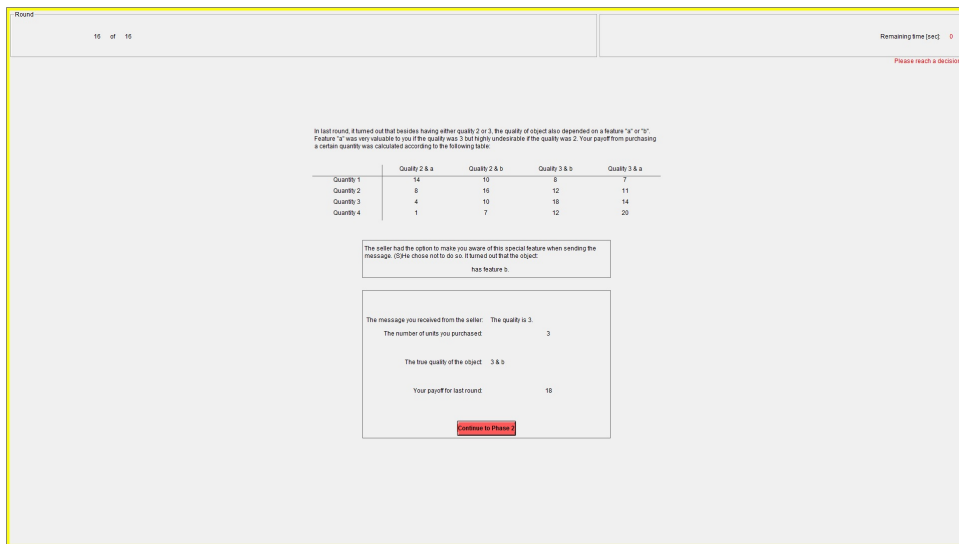


Figure 8: Buyer's Payoff Information Round 16 in Treatment U

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