ソシオネットワーク戦略ディスカッションペーパーシリーズ ISSN 1884-9946
第 63 号　2018 年 6 月
RISS Discussion Paper Series
No.63　June, 2018

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The effect of cognitive ability and ageing on sender behavior in dictator and ultimatum game experiments *

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Abstract

We investigate whether cognitive ability and ageing affect experimental sender behavior in dictator games (DG) and ultimatum games (UG), and if so, how they affect the behavior. The experimental results indicate that the higher is the cognitive ability of a sender, the smaller (larger) is the offer amount in the DG (UG). In the DG, this trend holds for the sender with high cognitive ability, but he or she sends a larger amount than do those with median cognitive ability. This result suggests that the effect of cognitive ability on sender behavior is different between strategically uncertain and certain situations, and provides further evidence that cognitive ability matters for investigating economic behavior. Second, the results show that the ageing effect is different in both games. In the DG, the effect is positive while in the UG, it is not significant. This result suggests that the ageing effect vanishes in a strategically uncertain situation, such as the UG.

Keywords: Sender behavior, dictator game, ultimatum game, cognitive ability

JEL codes: C91, D91

1 Introduction

Factors influencing altruism, inequality aversion, and reciprocity have been clarified by many experimental studies so far. Dictator game (DG) experiments are used to measure altruism. Engel (2011) surveys this experiment and summarizes what affects dictator behavior[1]

*This study was supported by the MEXT-Supported Program for the Strategic Research Foundation at Private Universities, 2014-2018.

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[1]For instance, below factors are known to affect dictator behavior; the double-anonymous method (Hoffman et al. (1994), Hoffman et al. (1996), Eckel and Grossman (1996)); the

Ultimatum game (UG) experiments (Güth et al. (1982)) are utilized to investigate the reciprocity and inequality aversion (Fehr and Schmidt (1999)) of a player. Most experimental results show that the prediction of the subgame perfect equilibrium—the first mover sends the minimum amount and the second mover accepts any proposal—is not observed. Instead, frequently observed experimental results show that the first mover proposes 40–50% of the endowment to the second mover (Camerer (2003)). This result may be caused by inequality aversion.

This study focuses on the first mover (sender) behavior in DG and UG experiments as Forsythe et al. (1994). We analyze how his or her decision is influenced by cognitive ability;[2] we examine whether there is an influence, and if so, whether the influence is in the same direction or not between two games.

Kawamura et al. (2018) conduct a series of experiments and investigate whether cognitive ability affects altruistic behavior. Brandstätter and Güth (2002) and Kawamura and Ogawa (2018) investigate whether cognitive ability affects sender behavior in UG experiments. Brandstätter and Güth (2002) focus on the effect of cognitive ability in UGs, finding that intelligence has no significant effect on bargaining behavior. Kawamura and Ogawa (2018) find that the higher cognitive ability is, the larger is the offer amount.

The type of cognitive ability on which we focus is a non-verbal estimate of fluid intelligence, which is "the capacity to think logically, analyze and solve novel problems, independent of background knowledge" (Mullainathan and Shafir (2013), p. 48).

Because our participants are non-students, we can also investigate the effect of age on sender behavior. Roalf et al. (2011), Beadle et al. (2013), Rieger and Mata (2013), and Kettner and Waichman (2016) report the effect of age on sender behavior in DG experiments. The first three studies report that the older a sender is, the more he or she sends, while Rieger and Mata (2013) reports no relationship between age and sender behavior.

Two studies that use UG experiments find increased fairness by older relative compared to younger adults in samples from the United States (Roalf et al. (2011)) and Australia (Bailey et al. (2012)). By contrast, Beadle et al. (2013) finds no age difference in the offer amount.

Our experimental results indicate that the higher cognitive ability is, the larger is the offer amount in the UG and the smaller is the offer amount in

personal traits of a dictator (Brandstätter and Güth (2002); Ben-Ner et al. (2004)); the property rights of endowments (Hoffman et al. (1994); Cherry (2001); Cherry et al. (2002); Oxoby and Spraggon (2008); Ogawa et al. (2012)); and the difference between group and individual decisions (Cason and Mui. (1997); Luhan et al. (2009); Franzen and Pointner (2014); Ito et al. (2016).

[2]Many studies in recent years have indicated that cognitive ability influences economic decision-making. Some studies have reported that cognitive ability is related to rational thinking, reasoning, and risk aversion. For instance, researchers have examined the relationship between cognitive ability and economic behavior (e.g., risk attitude and/or time preference), such as Shamosh and Gray (2008), Burks et al. (2009), Dohmen et al. (2010), Benjamin et al. (2013), and Beauchamp et al. (2017). Benito-Ostolaza et al. (2016) and Hanaki et al. (2016) also investigate how participants with high cognitive ability deal with strategic uncertainty.

the DG. The behavioral difference between the two games stems from strategic uncertainty that a sender faces. In addition, in the DG, while senders with high cognitive ability also have the abovementioned trend, their offer amounts are higher than those of senders with median cognitive ability.

This study makes the following two major contributions. First, we present a new factor that affects players' decisions (i.e., cognitive ability), even in a very simple game. Second, we show that the effect of cognitive ability is influenced by the level of strategic uncertainty.

The remainder of the paper is structured as follows. In Section 2, we explain the hypotheses. In Section 3, we explain the experimental procedure. In Section, 4, we show the experimental results and examine the hypotheses. In Section 5, we discuss the experimental results. Section 6 concludes.

2 Hypotheses

We first describe the behavioral predictions based on the subgame perfect equilibrium. First, in the DG game experiment, a sender does not send any amount of money in the equilibrium, because his or her utility decreases. In the UG, a sender does not send any amount of money in the equilibrium, either. Subgame perfect equilibrium is rarely observed in either experimental game, but we also check to observe if the subgame perfect equilibrium is realized.

Next, we examine whether cognitive ability affects sender behavior. If cognitive ability and behavior are unrelated, there is no behavioral change even if the cognitive ability changes. Therefore, we propose the first hypothesis as follows.

- Hypothesis 1 Cognitive ability does not affect sender behavior.

However, as mentioned in Section 1, we know that cognitive ability affects sender behavior in DG and UG experiments. Thus, we propose the second hypothesis.

- Hypothesis 2: Cognitive ability significantly affects sender behavior.

Assume that cognitive ability significantly affects sender behavior. There are two possibilities. One is that the direction is the same between the two games. The other is that the direction is different between the two games. The first possibility leads to hypothesis $2'$ below. This outcome is because high cognitive ability allows a sender to think more deeply and to choose an offer amount close to the subgame perfect equilibrium.

On the other hand, the second possibility leads to hypothesis $2''$.

- Hypothesis 2': The higher cognitive ability is, the lower is the offer amount in both games.

- Hypothesis 2": The higher cognitive ability is, the lower is the offer amount in the DG and the larger is the offer amount in the UG.

We next hypothesize about the relationship between ageing and the offer. Roalf et al. (2011), Beadle et al. (2013), and Rieger and Mata (2013) investigate the ageing effect on donating behavior. Roalf et al. (2011) find that the percentage of half-split offers is significantly larger among old participants (65-85 years) than among young participants (21-45 years), while the average donation rate is not significantly different between old and young participants. Rieger and Mata (2013) finds no significant effects of age in the DG. Beadle et al. (2013) finds that older dictators give more money than younger dictators do when empathy is easily loaded, but the positive relationship between offer amount and participant's age is not significant in the standard situation.

On the other hand, Yamagishi et al. (2014) and Matsumoto et al. (2016) find a positive correlation between prosociality, which is measured by the results of various experiments, such as the prisoner's dilemma, and age in a suburban area of Tokyo, Japan. Kettner and Waichman (2016) find that dictators aged over 60 years donate more than do university student dictators who have participated in an economic experiment before, while the difference in the donation amount is not significant between the elderly and inexperienced student dictators.

Two studies using UG experiments find increased fairness on the part of older relatives compared to younger adults in samples from the United States (Roalf et al. (2011)) and Australia (Bailey et al. (2012)). By contrast, Beadle et al. (2013) and Kawamura and Ogawa (2018) find no age difference in the offer amount. Hence, we hypothesize as follows.

- Hypothesis 3: The older a sender is, the higher is his or her offer amount in both games.

3 Experimental Design and Procedure

We conducted single-blind DG experiments (18 sessions, 416 participants) and UG experiments (11 sessions, 234 participants) at the Center for Experimental Economics, Kansai University, located in Osaka, Japan, from October 2015 to August 2017 [3]. Participants were non-students aged above 18 years. Table 1 shows the profile of sender participants.

We asked a leaflet distribution company to distribute flyers to recruit participants from residential areas within a radius of 20 km from the Center for Experimental Economics, which is in the northern part of Osaka prefecture. Those who wanted to participate in the experiment applied in advance by online application, telephone, e-mail, or letter. In addition, we sent an e-mail and/or direct mail to those who had already participated in another type of experiment to seek their participation.

Because we utilized their age to investigate their behavior in each game, we also collected their academic information for use in the analysis. In addition, we

[3] The result of the DG comprises data from Osaka in Kawamura et al. (2018). The result of the UG comprises "hot treatment" data in Kawamura and Ogawa (2018).

Table 1: Profile of each treatment

Treatment	DG	UG
No. of participants	208	117
No. of males	99	51
Average age (standard dev.)	56.23 (14.56)	54.32(14.64)
Average Raven's score (standard dev.)	7.88(3.23)	8.03 (3.48)
Education[4]: High school (the number)	39	18
Education: Junior college	31	24
Education: University	108	60
Education: Graduate school	8	7

collected information on gender, but we did not confirm that gender difference affects sender behavior. Therefore, gender data are not used for the analysis.

Our experiment has the following structure: (1) a dictator is given a certain endowment (2,000 JPY) by the experimenters; (2) he or she donates some money from the endowment to his or her anonymous recipient; and (3) the recipient accepts the offer. If a dictator is selfish and rational, he or she donates nothing in the equilibrium.

On the other hand, a UG consists of two stages with a sender and a responder. In the first stage, the sender receives a certain amount of money from an experimenter, and decides the offer amount to be sent to the responder. In the second stage, the responder observes the offer, and chooses whether to accept it. The subgame perfect equilibrium is "a sender offers the smallest offer and a responder accepts it." However, the average offer is 40-50% of the endowment and the unfair offer is likely to be rejected (Camerer (2003)).

All the experiments were programmed by Z-tree (Fischbacher (2007)). We conducted the DG or the UG experiment first. Thereafter, we conducted Raven's test Raven (1936), which measures the cognitive ability of participants. They were asked to answer 16 questions in 10 minutes, after which they were paid a reward and returned home. The experiment took about 100 minutes in total.

The monetary reward was calculated as follows. We converted the total points that a participant earned in the experiment to JPY at a conversion rate of 1 point = 1 JPY. We paid participants the sum of their earnings and participation fee (1,000 JPY). The average reward was 2,395 JPY in the DG and 2,020 JPY in the UG.

Table 2: Descriptive statistics between the DG and UG

	No. of participants	Average offer (JPY)	Std. Dev.	Min.	Max.
DG	208	604.81	426.39	0	2,000
UG	117	825.64	268.51	0	1,200

4 Experimental Results

We compare the difference in the offer amounts in the UG and DG by a test with unequal variance [5] and we find that the offer amount is different between the UG and DG ($p < 0.001$). The median offer is different between the two games (Kruskal–Wallis equality-of-populations rank test, $p < 0.001$). Thus, the offer amount is larger in the UG than in the DG and the amount is apparently higher than zero in both games.

Table 3: Variable list

variable	Explanation
Age	Age of participant
Raven	Raven's score of participant
UG	Ultimatum game dummy
UG×Raven	The cross-term between the UG and Raven
raven_high dummy	1 if the participant's cognitive score is higher than 11, otherwise, 0.
raven_high dummy × UG	The cross-term between UG and Raven.
junior college_dummy	1 if a participant is a junior college graduate, otherwise, 0.
university_dummy	1 if a participant is a university graduate, otherwise, 0.
graduate_dummy	1 if a participant is a graduate school graduate, otherwise, 0.
UG × Age	The cross-term between UG and Age.

Table 3 presents the explanations of the independent variables. Let us explain Raven_high dummy. This dummy takes 1 if Raven's score is larger than the average score +1 SD, otherwise 0.

Table 4 indicates the results of the regressions. This table shows the coefficients of Raven, UG × Raven, Age, and Raven High are significant. The coefficient of Raven is significant at the 10% level in Models (1), (2), and (3). Raven + Raven× UG$\neq 0$ is significant ($p < 0.09$) in Models (1), (2), and (3). Thus, the higher cognitive ability is, the smaller is the offer amount in the DG and the larger is the offer amount in the UG.

The coefficient of Raven high is positive and significant, which means that a sender with high cognitive ability sends more money to a recipient in the DG than other senders do.

[4] 20 and 5 respondents did not provide answers about their academic background in the DG and UG, respectively.

[5] We perform statistical tests on the equality of standard deviations (*sdtest* and find that the standard deviations in the offer amount in the UG and DG are statistically different ($p < 0.01$).

Table 4: Regression results

	(1)	(2)	(3)	(4)
	offer	offer	offer	offer
UG	-72.429	186.943	-62.041	293.288
	(97.451)	(215.149)	(101.996)	(223.269)
raven	-21.853*	-18.912*	-21.197*	-17.085
	(10.755)	(10.963)	(12.234)	(12.740)
ugr	41.200***	32.487*	40.282***	28.406
	(13.910)	(16.445)	(14.447)	(17.402)
age	3.524**	4.693***	4.293***	6.004***
	(1.322)	(1.517)	(1.391)	(1.759)
raven_high	232.672**	224.022**	244.723**	233.584*
	(95.321)	(96.904)	(110.602)	(114.086)
raven_high_UG	-209.070*	-194.792	-215.391	-195.943
	(114.051)	(118.240)	(136.041)	(141.719)
ug_age		-3.493		-4.756*
		(2.632)		(2.561)
junior college_dummy			170.499**	179.007**
			(65.638)	(65.564)
university_dummy			50.262	53.457
			(54.317)	(53.681)
graduate_school_dummy			88.274	87.020
			(75.954)	(77.289)
Constant	547.523***	459.808***	435.342***	304.147*
	(116.160)	(127.051)	(131.890)	(158.935)
Observations	325	325	300	300
R^2	0.119	0.122	0.140	0.145

Robust standard errors are clustered by session in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Because the coefficient of Raven High $\times$ UG is negative and significant, we check whether the coefficient of "Raven High + Raven High $\times$ UG" is significantly different from zero in order to investigate the effect of Raven High in the UG. We find this effect is not significant; a sender with high cognitive ability in the UG does not send more money to a recipient than do other senders in the UG.

Hypothesis 1 is not supported. Thus, sender behavior is affected by cognitive ability in both games.

Hypothesis 2 is supported. In particular, hypothesis $2''$ is supported. In other words, we find that the effect of cognitive ability on sender behavior is different between the UG and DG. Moreover, while senders with high cognitive ability in the DG have the same trend as do other senders in the DG and UG, the former type of sender sends more money to a receiver. For example, a sender who has a cognitive score of 12 sends almost the same amount as a sender whose score is 1.

Hypothesis 3 is supported in the DG. The older a sender is, the larger is the offer amount in the DG. In models (2) and (4), the coefficient of UG$\times$Age+Age is not significant.

We also find that if the final academic background is junior college, the distribution amount is significantly larger in both games. However, some caution is required for this result; because most of the participants whose academic background is junior college are female (55 out of 49 participants are female), they may be more generous than those of other educational backgrounds are.

5 Discussion

We obtain two main results. The first is on the relationship between cognitive ability and sender behavior. In the UG, the higher is cognitive ability, the larger is the offer amount. In the DG, the higher is cognitive ability, the smaller is the offer amount. Although this trend is also true for senders with high cognitive ability, their default offer amounts are higher than those of senders with median cognitive ability.

The second result concerns the effect of age on the offer amount. The amount increases as a sender's age increases in the DG, while this effect is not significant in the UG.

In this section, we first discuss why the influence of cognitive ability on a sender differs for each game. Then, we discuss the effect of age on sender behavior.

We discuss the relationship between cognitive ability and distribution behavior. The problem that distributors face is different in the two games. In the UG, a distributor faces the strategic uncertainty that the responder accepts or rejects the offer. On the other hand, since the responder always accepts the proposal from the distributor in the DG, there is no strategic uncertainty about the responder's decision.

When strategic uncertainty exists, participants are known to choose risk-averse behavior. Hanaki et al. (2016) find that in strategically uncertain situations, those with high cognitive ability change their behavior depending on the opponent type (human or robot), whereas those with low cognitive ability do not.

A sender in the DG corresponds to a participant in the robot treatment in Hanaki et al. (2016), while a sender in the UG corresponds to the human treatment in Hanaki et al. (2016). These correspondences clarify why the behavior of a sender differs between the DG and UG.

Because there is no strategic uncertainty in the DG, as subjects' cognitive abilities increase, they will choose actions close to equilibrium. However, because the high-score group has higher reasoning power, some senders take not only actions close to the equilibrium but also altruistic actions. As a result, the distribution amount of the high-score group increases.

Since there is strategic uncertainty in the UG, as cognitive ability increases, senders will offer amounts that their responders are less likely to reject. This outcome reduces strategic uncertainty. As a result, the offer amount will be close to half split. This trend holds for senders with high cognitive ability. From this discussion, strategic uncertainty changes sender behavior.

Let us discuss the effect of ageing. We confirm the finding by Kawamura and Ogawa (2018) that the effect of ageing is not significant in the UG. The difference of the ageing effect in the DG and UG seems to stem from the strategic situations. Because there is no strategic uncertainty in the DG, the ageing effect becomes significant. On the other hand, because there is strategic uncertainty in the UG, senders offer nearly half of the endowment to decrease this uncertainty regardless of their age, even if younger senders increase the offer (Table 5). According to Graham and Weiner (1991), as senders age, they experience many good and bad events and see these events from the standpoint of others. Thus, their life history can increase their emotional empathy. However, this argument seems to be appropriate in a situation of strategic certainty.

Table 5: The average offer amount by generation. Standard deviations are in parentheses.

generation	20–29	30–39	40–49	50–59	60–69	70–79	80+
DG	327.27	362.5	590	693.33	637.74	611.11	828.57
	(371.73)	(320.16)	(417.44)	(389.87)	(435.11)	(468.30)	(438.61)
UG	825	836.36	850	834.78	866.67	680	800
	(128.17)	(307.48)	(197.81)	(274.04)	(243.24)	(368.78)	(529.15)

6 Conclusion

We conduct a DG experiment and a UG experiment employing adult participants. In particular, we focus on sender behavior and examine whether cognitive ability and ageing affect the behavior. As a result, we find that in the DG, the higher cognitive ability is, the smaller is the offer amount. A sender with high cognitive ability also has this trend while his or her offer tends to be high. In UG experiments, the higher cognitive ability is, the larger is the offer amount.

This research contributes to the literature by showing that cognitive ability has different influences on sender behavior in the UG and DG. While Kawamura and Ogawa (2018) and Kawamura et al. (2018) separately investigate sender behavior in the DG and UG, this study incorporates sender behavior in the DG and UG. As a result, we find that the effect of cognitive ability is different between the DG and UG. Furthermore, we point out that the source of the different influences of cognitive ability is the strategic uncertainty of the second mover. Our study adds new findings to research on cognitive ability as an explanation for economic decision-making.

We also find that the ageing effect is different in both games. The difference in strategic uncertainty seems to explain this difference.

However, we do not sufficiently confirm whether cognitive ability has a robust effect on economic decision-making. For example, we do not know whether this result is maintained even if we control other variables, such as personality traits and income Hoffman (2011) in the real life of a sender. Recruiting participants from other sections and/or areas of society would be necessary for a robustness check. These topics remain for our future study.

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Appendix: Experimental Instructions: UG

Thank you very much for participating in this experiment. Please read the instructions below. If you have any questions, we will answer them later.

Please raise your hand if you find it difficult to understand the experiment. In this economic experiment, to collect data for the investigation of the results, it is necessary for all participants to understand the decisions they are making. Feel free to ask any questions.

NOTICE

The experimental decision depends on the individual's decision. Please follow these instructions during the experiment.

- Do not speak to another participant. If you have a question, please ask an experimenter.

- Turn off your mobile/smartphone.
- Do not talk with the other participants during the experiment.
- Do not use a mobile phone.

Today's experiment is an ongoing project. Therefore, it is very problematic if other people know the information of today's contents. Please follow the instructions below.

- After the experiment is over, leave the experimental materials on the desk.
- Do not explain what you did in this experiment to other people.

Calculation of monetary reward The monetary reward consists of two components. The first is the participation fee (1,000 JPY), which is paid to all participants regardless of performance in the experiment. The second part is the performance payment. This depends on your and your partner's performances. After the experiment is over, you will receive the sum of both parts. The performance payment ranges from 0 to 2,000 JPY.

The experiment You have already been randomly assigned one of two roles (A or B). If your number is 1 to 14, your role is A; otherwise, your role is B. In the experiment, you are paired with another role participant and make decisions on economic behavior. The decision-making is done through the computer console. Thus, you cannot know who your partner is. In the experiment, you make decisions with experimental "POINTS." A "POINT" is equal to 1 JPY and we exchange your POINTS into JPY as your performance payment. The more "POINTS" you earn, the more you are paid at the end of the experiment.

Decision-making of role A.

- In the first stage, a participant with role A makes a decision.
- At the beginning of the first stage, he/she receives 2,000 "POINTS".
- He/she chooses how many "POINTS" to send to his/her partner with role B. This offer is noticed by the paired role B.
- The amount of "POINTS" he/she chooses is called "X."

Decision-making of role B.

- Role B chooses to "accept" or "reject" the offer from the paired role A.

How to attain "POINTS" If the Role B participant accepts the offer, the Roles A and B participants attain 2000-X "POINTS" and X "POINTS," respectively. If the Role B participant rejects the offer, both roles receive 0 "POINTS."

Example 1

- The Role A participant offers 1,000 points to the Role B participant.

- The Role B participant accepts the offer.
- The “POINTS” attained at the end of the experiment are
  - Role A: 2,000-1,000=1,000 “POINTS”
  - Role B: 1,000 “POINTS”

Example 2

- The Role A participant offers 400 points to the Role B participant.
- The Role B participant rejects the offer.
- The “POINTS” attained at the end of the experiment are
  - Role A: 0 “POINTS”
  - Role B: 0 “POINTS”

The experiment is over after the abovementioned decisions have been made. The amount of “POINTS” you have is exchanged into JPY. Your reward is the amount of “POINTS” and the participation fee (1,000 JPY) in total. Please note that the experiment is one shot. While we prepare the monetary reward for all participants, please answer some questions.