# The Effect of Individual Temperament and Character on Bidding Behavior

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## Abstract

*This study investigates individual temperament and character effects on bidding behavior in a first-price sealed-bid auction with independent private value frameworks. Preceding studies on experimental first-price auctions reported that selection biases, such as risk attitude (Cox et al. 1988), gender (Ham and Kagel, 2006), sex hormone cycle (Chen et al. 2013; Pearson and Schipper, 2013), cause positive and negative effects on bidding behavior. The present study applied a psychological personality trait, Temperament Character Inventory (TCI), to analyze whether individual personality affects bidding behavior. The experimental results show that Novelty Seeking (NS) significantly decreases bids and Harm Avoidance (HA) significantly increases bids. Furthermore, cross term of elicited risk preferences and NS have significant effect on bidding behavior.*

Keywords: Bidding, Temperament, Character, Risk Attitude
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## 1. Introduction

This article report the experimental results on the effect of personality differences on bidding behavior. Several studies consider the association between individual personality and economic decision-making. Borghans et al. (2008) show the stability of personality traits over the life cycle by using the Big Five personality traits. The Big Five seem to explain economic outcomes (for instance, earnings) successfully. However, when Becker et al. (2012) investigated correlation between personality traits and economic preferences, time preferences, risk preferences, reciprocity, and social preferences, the correlation between personality traits and economic preferences was weak. Furthermore, Hammond and Morrill (2014) conducted an experiment to investigate the association between bidding behavior and personality traits, and a relationship was only observed in female subjects. These results indicate that personality affect economic outcomes in the life span, but not affect behavior in the instantaneous decision. All three previous studies used the Big Five personality taxonomy. The Big Five seems to be able to explain economic outcomes, but it has a limited ability to predict economic behavior and preferences. To examine the relationship between personality and economic behavior, the present study introduces the Temperament and Character Inventory (henceforth TCI) to experimental economics.

In psychiatry and biological psychology, TCI is widely used instead of the Big Five personality trait. TCI was developed to detect pathological behavior; thus, it might better

predict behavioral pattern (Cloninger et al. 1986; Kelly et al. 2004). However, it is unclear how TCI affects economic behavior. To study this question, the present study conducted an experiment to measure bidding behavior, risk preferences, and TCI simultaneously. Simultaneous measurement of bidding behavior and other measures is increasing in the newer literature: Engel (2011) measures bidding behavior with elicited risk preferences; Delgado et al. (2008), with neural substrates; Pearson and Schipper (2011), with the 2D4D finger ratio; and Chen et al. (2013) and Pearson and Schipper (2013), with menstrual cycles. The present study adds new insights that personality differences affects bidding behavior to these literatures.

The Big Five and TCI are two major personality trait taxonomies. The Big Five trait had developed to capture inclusive human personality for as long as possible[2]. While the Big Five has advantages with capturing human personality traits broadly, it has disadvantages with predicting one's behavior[3]. TCI, on the other hand, has advantages with predicting one's behavior because TCI utilizes a "stimulus-response" questionnaire[4]. Stimulus-response questionnaires were developed to detect one's pathological behavioral pattern; thus, it is suitable for predicting one's behavior. Furthermore, TCI has some neurobiological backgrounds[5]. Novelty Seeking (henceforth NS) behavior is associated with dopamine

[2] It originates from the lexical hypothesis by Allport and Odbert (1936).
[3] De Fruyt et al. (2000) compare the two personality trait taxonomies. According to their study, some of each component has correlation. See De Fruyt et al. (2000) for details.
[4] Both the Big Five and TCI use two scale "yes or no" questionnaires. However, how questions are worded is different between them, e.g., the Big Five Openness question "I have a rich vocabulary," compared to the TCI Cooperativeness question "I can usually accept other people as they are, even when they are very different from me."
[5] Kelly et al. (2004) show that neural substances play an important role in Novelty Seeking (NS) and decision-making.

regulation (Dreberet al. 2009), Harm Avoidance (henceforth HA) behavior is associated with serotonin regulation (), and Reward Dependence (henceforth RD) behavior is associated with norepinephrine regulation (). Molecular biology found that these neural substances are associated with determining individual behavior. Thus, indirect measurement of these behavioral determinants using TCI will better predict behavior.

To the best of my knowledge, Ekelund et al. (2005) is the first study in economic literature to use TCI. They showed that HA negatively affects self-employment status. The current paper presents the first experimental study in economics that uses TCI. Results in this new area of research seems to provide insights for policy-makers and marketers.

The main results of this study can be summarized in three points. First, subjects with high NS scores tend to shade their bids, and subjects with high HA scores tend to make larger bids. Second, an NS score is less predictive than the Holt-Laury Lottery (henceforth HLL), because the cross terms of NS scores and the HLL positively affect bidding, and consequently the fitness of the regression model improves. Third, adding temperament to the bid function improves its predictive power. These results indicate that congenital temperament NS and HA affects bidding behavior, and risk preference is stronger prediction power on the bidding behavior than NS.

The remainder of this paper is organized as follows. Section 2 shows the bidding model, HLL, and TCI in the experimental design and the hypothesis and estimation model in the

experimental hypothesis. The result of the experiment is shown in Section 3. Finally, discussion about the experiment and the conclusion are in Section 4.

## 2. Experimental Design

There are four subsections in this section. Subsection 1 derives the bidding model, the HLL, and the TCI. The experimental hypotheses are in subsection 2. The econometric estimation model for bidding behavior is in subsection 3. The experimental procedure is outlined in subsection 4.

### 2.1. Bidding model, risk preference elicitation, and TCI

This subsection provides a bidding model for a private-value sealed-bid auction with a single-object environment. Assuming $n$ >2 bidders compete in a market for a single commodity, Vickery (1961) showed the existence of a unique Bayesian risk-neutral Nash equilibrium, in which every bidder $i$ has a private valuation $v_i$ for some commodity independently drawn from a uniform distribution $[v^{\min}, v^{max}]$. For any bid $b_i$, the winning probability is Prob($b_i > b_j$), with $i \neq j$. Given the uniform distribution of values and an assumed symmetric bid function for $b_j = \beta v_j$, the probability of bidder $i$ winning is written as

$$\text{Prob}\left(v_j < \frac{b_i}{\beta}\right) = \left(\frac{b_i}{\beta}\right)^{n-1}$$

Therefore, the expected utility of bidder $i$ is

$$\text{EU} = (v_i - b_i)\left(\frac{b_i}{\beta}\right)^{n-1}$$

The first-order condition of the expected-utility maximization problem is then

$$\max\ (v_i - b_i)\ \left(\frac{b_i}{\beta}\right)^{n-1}$$

$$\frac{\partial \mathrm{EU}}{\partial b_i} = (n - 1)b_i^{\,n-2}v_i\left(\frac{1}{\beta}\right)^{n-1} - nb_i\left(\frac{1}{\beta}\right)^{n-1} = 0$$

$$= (n - 1)\, b_i^{\,n-2}v_i - nb_i^{\,n-1} = 0$$

$$= (n - 1)\, v_i - nb_i = 0$$

The optimal bid function $b^*$ is given by

$$b_i^*(v) = \frac{n-1}{n}v_i,\ i = 1 \ldots n \qquad (1)$$

The risk-neutral Nash equilibrium (henceforth RNNE) bid function $b^*$ is a linear function of their valuation $v$; therefore, it can be estimated as linear regression coefficient.

$$b = \beta_1 + \beta_2 v + \varepsilon \qquad (2)$$

**Constant Relative Risk Aversion**

Cox, Robertson, and Smith (1982), to explain variation in bidding, relax the linear bidding function in equation (1). They used bid data from experimental results to construct a parametric measure of risk averseness. Their model, Constant Relative Risk Aversion (henceforth CRRA), can be obtained by rewriting equation (1) as

$$b^{\mathrm{CRRA}}(v) = \frac{n-1}{n-1+r}v_i \qquad (3)$$

The parameter $r$ expresses sensitivity for risk averseness. If $r$ is equal to one, then the bidder is risk-neutral. The bidder is risk-averse as $r$ becomes closer to zero. Conversely, the bidder is risk-loving as $r$ becomes larger than one.

The CRRA parameter $r$ measures the risk attitude on bidding outcomes directly by using

bidding data. Conversely, it cannot predict indirect bidding performance in an auction experiment; thus, this study uses a lottery choice task to predict bidding performance by using a multiple price list: the Holt-Laury lottery (Holt and Laury, 2002). The Holt-Laury lottery assumes that subjects have a constant relative risk-aversion utility function represented by the power function of lottery prize $x$. $\gamma$ is a parameter of risk averseness. Assume a power function form of a utility function

$$U(x) = x^{\gamma}$$

There are two options, A and B. For each option, there are two possible outcomes: ($k$, $l$) and ($m$, $n$). The two outcomes are convex combinations of the probability (p, q) $\in$(0, 1). Thus, the expected utility over each option is written as below:

$$EU\ (A) = p\ (x_k) + (1 - p)\ (x_l) > EU\ (B)\ q\ (x_m) + (1 - q)\ (x_n)$$

The switching point from option A to option B can capture the risk attitude of a person, since it measures risk tolerance. The experimental parameter and expected value of each option is in Table 1. The prizes of lottery are 600JPY or 480JPY in option A, 1150JPY or 30JPY in option B.

Table 1 Holt-Laury lottery

| Option A | | | | Option B | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| p(600JPY) | Outcome | p(480JPY) | Outcome | p(1150JPY) | Outcome | p(30JPY) | Outcome | EV(A) | EV(B) | Difference |
| 0.1 | 600 | 0.9 | 480 | 0.1 | 1150 | 0.9 | 30 | 492 | 142 | 350 |
| 0.2 | 600 | 0.8 | 480 | 0.2 | 1150 | 0.8 | 30 | 504 | 254 | 250 |
| 0.3 | 600 | 0.7 | 480 | 0.3 | 1150 | 0.7 | 30 | 516 | 366 | 150 |
| 0.4 | 600 | 0.6 | 480 | 0.4 | 1150 | 0.6 | 30 | 528 | 478 | 50 |
| 0.5 | 600 | 0.5 | 480 | 0.5 | 1150 | 0.5 | 30 | 540 | 590 | -50 |
| 0.6 | 600 | 0.4 | 480 | 0.6 | 1150 | 0.4 | 30 | 552 | 702 | -150 |
| 0.7 | 600 | 0.3 | 480 | 0.7 | 1150 | 0.3 | 30 | 564 | 814 | -250 |
| 0.8 | 600 | 0.2 | 480 | 0.8 | 1150 | 0.2 | 30 | 576 | 926 | -350 |
| 0.9 | 600 | 0.1 | 480 | 0.9 | 1150 | 0.1 | 30 | 588 | 1038 | -450 |
| 1 | 600 | 0 | 480 | 1 | 1150 | 0 | 30 | 600 | 1150 | -550 |

Overbidding relative to RNNE could not be fully explained by the risk aversion because the payoffs were not sufficiently salient (Harrison, 1989) and individual risk preferences may not be stable across different tasks (Isaac and James, 2000). The behavior of high-value assigned bidders is inconsistent with risk-averse predictions in experimental auctions. Therefore, this study introduces TCI as a possible alternate predictive factor for risk-averse bids. TCI was developed by Cloninger (1986) to measure personality traits and consists of congenital temperament traits and acquired character traits. Temperament traits have four components:

1. Novelty Seeking (NS)

2. Harm Avoidance (HA)

3. Reward Dependence (RD)

4. Persistence (P)

NS captures one's tendency toward exploratory behavior and excitement in seeking novelty. Cloninger et al. (1993) defined NS as a personality trait associated with exploratory activity in response to novel stimulation, impulsive decision-making, extravagance when approaching reward cues, quick loss of temper, and avoiding frustration. It has been found to be highly heritable. High NS has been suggested to be related to high dopaminergic activity (Cloninger, 1986). Kelley et al. (2004) found a relationship between risk-taking behavior and NS scores[6].

HA captures one's eagerness to avoid harmful outcomes. In psychology, harm avoidance (HA) is a personality trait characterized by excessive worrying, pessimism, shyness, and being fearful, doubtful, and easily fatigued. It has been suggested that HA is related to high serotonergic activity, and voluminous researches has investigated the link between HA and components of the serotonin system[7]. In the economic context, Ekelund et al. (2005) showed that HA has negative impacts on self-employment status.

RD captures one's dependency on relationships toward others. RD is characterized as a tendency to respond markedly to reward signals, particularly to verbal signals of social approval, social support, and sentiment, and learning to maintain and pursue behavior previously associated with such rewards. Recent studies show that RD is related to norepinephrine regulation (Ham et al. 2004), and is associated with addictive behavior.

P captures one's continuity and persistence to one activity. Specifically, P refers to

[6] The expression "risk-taking" in the psychological context does not exactly mean financial risk-taking, as in economics, but the tendency of a person to prefer dangerous choices.
[7] See Ebstein et al. (1997).

perseverance in spite of fatigue or frustration. Cloninger et al. (1993) found that persistence, like the other temperament traits, is highly heritable. P was originally a subcategory of RD, but it has been shown that P is an independent factor.

Character traits have three components:

5. Self-Directedness (SD)

6. Cooperativeness (C)

7. Self-Transcendence (ST)

SD captures one's willpower and self-control. Specifically, SD is the ability to regulate and adapt behavior to the demands of a situation in order to achieve personally chosen goals and values (Cloninger et al. 1993).

C captures one's socialness and cooperation. Cloninger et al. (1993) described it as relating to individual differences in how much people identify with and accept others. Cloninger et al.'s (1993) research found that low cooperativeness is associated with all personality disorder categories.

ST captures one's spiritual sense and unification with the universe. High ST has been linked to psychotic tendencies, such as schizotypal personality disorder and mania, particularly in individuals low in both SD and C. The descriptive statistics of each components of TCI are summarized in Table 2.

Table 2 Temperament and Character Inventory

| | Score range | max | average | min | SD |
|---|---|---|---|---|---|
| Temperament | | | | | |
| Novelty Seeking | 20 | 19 | 10.8 | 4 | 3.14 |
| Harm Avoidance | 20 | 19 | 11.6 | 0 | 4.15 |
| Reward Dependence | 15 | 14 | 8.9 | 3 | 2.27 |
| Persistence | 5 | 5 | 2.8 | 0 | 1.47 |
| Character | | | | | |
| Self-Directedness | 25 | 21 | 12.7 | 5 | 3.61 |
| Cooperativeness | 25 | 22 | 15.4 | 6 | 3.38 |
| Self-Transcendence | 15 | 12 | 4.8 | 1 | 2.40 |

### 2.2 Experimental hypothesis

This subsection provides experimental hypotheses that focus on the effect of TCI factors on bidding behavior.

**Hypothesis 1** *High NS scores decrease bids.*

Preceding psychological literature has shown that those with high NS scores tend to behave aggressively and to make risky decisions (Kelley et al. 2004; Wang et al. 2015). A high NS person, therefore, tends to bid lower to gain large profits with low winning probabilities for the sake of excitement. This explanation is different from risk preference.

**Hypothesis 2** *High HA scores increase bids.*

HA is associated with aversive emotional states. Since a high-HA person hates probabilistic payoff, that person bids higher. Higher bid makes that person gain profit securely.

The predictions of previous two hypothesizes are both in the same directed toward the prediction of the risk preferences. Thus, the next two hypotheses focus on testing the interaction

between NS and HLL. Also, if the relationship between risk-averse preferences and HA is weak, the interaction term between HA and HLL will not have negative impact on bidding.

**Hypothesis 3** *If congenital-temperament NS has a stronger impact on bids than acquired risk attitude, then the cross term of NS and risk-averseness has a negative impact on bids*.

Risk-averseness, as measured by HLL, increases bids; on the contrary, NS is expected to decrease bids. If NS and HLL affect bidding independently, then the interaction term is not significant. By testing the sign of the cross term of NS and HLL, the influence of NS and HLL will be tested.

**Hypothesis 4** *If congenital-temperament HA has a stronger impact on bids than the acquired risk attitude, then the cross term of HA and Risk have larger positive impacts on bids*.

If HA and risk-averseness have a positive correlation, then the interaction term between HA and HLL will positively affect bids.

**2.3 Estimation model**

In this experiment, the following parametric model were estimated in order to specify the linear bidding model (1),

$$b_{i,t} = \beta_0 + \beta_1 v_{i,t} + \beta_2 v^2_{i,t} + \beta_3 v^3_{i,t} + \gamma TCI_i + \delta HLL\ Score_i + \xi T_t + \rho D_i + \varepsilon_{i,t}$$

The term $b$ denotes the bid of subject $i$ in auction round $t = 1 \ldots 20$, which is endogenously decided, and $v$ is the exogenously assigned valuation for subject $i$ in auction round $t$. The quadratic and cubic polynomial forms of $v$ are included in order to force bids to be a linear

function of values, as risk neutrality or constant relative risk aversion would require. The TCI and HLL scores are vectors of each variable. The T dummy is a dummy variable for each auction round t. D is a dummy variable for demographic variables, including age, experience, and department. $\varepsilon_{i,t}$ is the unobserved error term.

**2.4 Experimental procedure**

All experiments conducted at the Experimental Laboratory Institute of Social and Economic Research at Osaka University. All participants were male students at Osaka University recruited via an experimental subject pool including both undergraduate and graduate students. The total number of participants was 116. The ages of all subjects were between 18 and 27 (average 21.02). The experiments consisted of six sessions. There were three treatments and one questionnaire in each session. Treatment 1, Treatment 2, and Treatment 3 were run in different orders to eliminate any order effect. The questionnaire consisted of three answer sheets. Answer sheet 1 was a demographic questionnaire, answer sheet 2 was the HLL (Holt and Laury, 2002), and answer sheet 3 was the TCI (Cloninger et al, 1993). The TCI used was a Japanese language translated version (Kijima et al. 1996)[8].

The experimental procedure is as follows. Subjects are seated by drawing a lottery from an isolated box in front of a computer interface. After reading the instructions, the experimental

[8] To the best of my knowledge, the original English version of the TCI translated into Chinese, Dutch, Finnish, French, German, Japanese, Korean, Polish, and Swedish. Translation of psychological personality trait taxonomies needs a back translation test for use in other languages.

session started. At the beginning of each period, a computer program assigned a “value” to each subject. The value is randomly drawn from {6, 12, 18, 24, 30}. The computer program randomly matched subjects with opponents in each period; also, random matching protocol was used in this session. Each auction consisted of two participants. If a subject won, then that subject’s “Profit” was the “Value” minus the “Bid”; otherwise, the subject’s profit was zero. In the case that the highest bids equaled each other, the computer program decided the winner randomly with probability 0.5. The experimental instructions for the auction are in Appendix 1.

## 3. Results

In this section, first, the experimental results show how each subject’s personality traits affected the bid function by using parameter estimates of the linear regression model. Second, the effect of the cross term of risk preferences and personality on bid is presented. Third, the effect of high value assignment is tested by the interaction of value and TCI. Finally, psychological robustness was checked by hierarchical regression analysis.

The average earnings were 4309.5 JPY, including a 10% tax subtraction. The distribution of TCI scores and HLL are in Figure 1. The Pearson’s correlation coefficient between TCI, HLL, and CRRA are in Table 3. The CRRA parameter, as derived from experimental data, has a weak correlation with TCI scores.

Table 3 Correlation between TCI, HLL, and CRRA

| | NS | HA | RD | P | SD | C | ST | HLL | CRRA |
|---|---|---|---|---|---|---|---|---|---|
| Novelty Seeking | 1 | | | | | | | | |
| Harm Avoidance | -0.376 | 1 | | | | | | | |
| Reward Dependence | 0.210 | -0.328 | 1 | | | | | | |
| Persistence | -0.119 | -0.120 | 0.138 | 1 | | | | | |
| Self Directedness | 0.069 | -0.522 | 0.185 | 0.232 | 1 | | | | |
| Cooperativeness | 0.100 | -0.263 | 0.439 | 0.146 | 0.333 | 1 | | | |
| Self Transcendence | 0.187 | -0.215 | 0.498 | 0.075 | 0.171 | 0.327 | 1 | | |
| Holt-Laury Lottery | -0.173 | 0.206 | -0.209 | -0.075 | -0.100 | -0.265 | -0.302 | 1 | |
| CRRA | 0.215 | -0.135 | 0.120 | 0.016 | 0.131 | 0.014 | 0.091 | -0.022 | 1 |

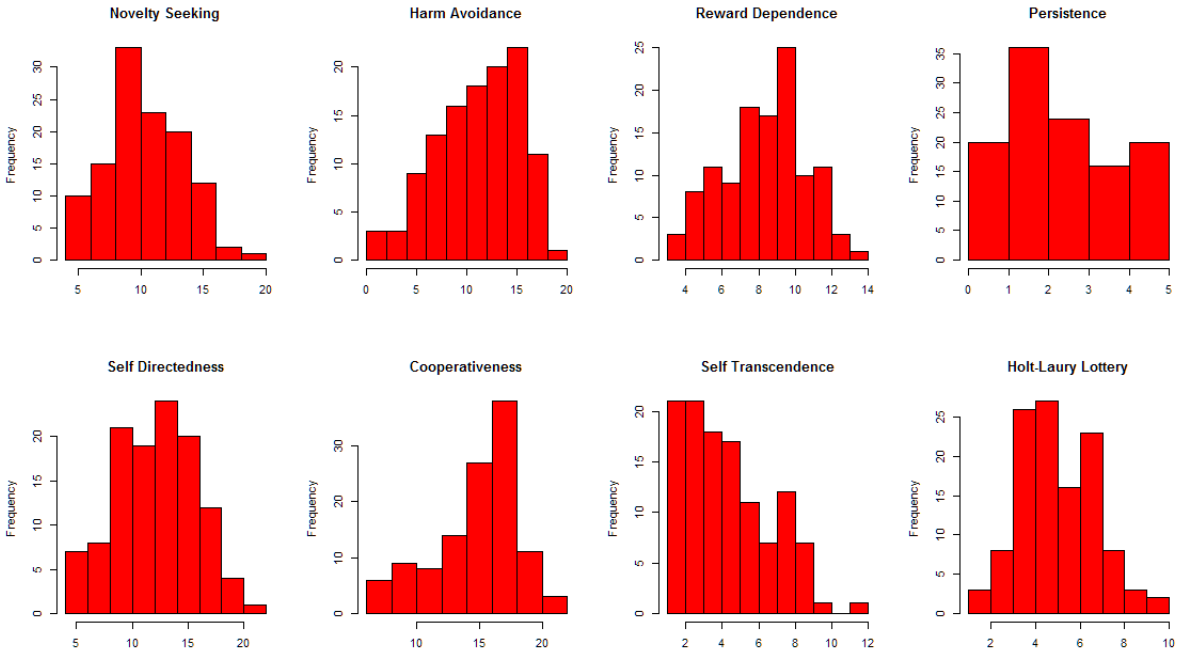


Fig. 1 Histograms of TCI and HLL

The primary result of this study is in Table 4. For analysis, this study fixes three variables: subjects, sessions, and periods. Pooled panel linear regression analysis was carried out, with standard errors clustered at session levels.

**Result 1** *Subjects with high NS score tend to shade their own bid and tend to be more profitable*.

The linear estimation coefficients of Model (1) and Model (2) in Table 4 indicate that NS scores negatively affects bids both with and without controlling for risk attitude. Models (3) and (4) in Table 4 show that high NS subjects earn significantly higher profits. Hypothesis 1 is not rejected by these results.

**Result 2** *HA subjects have significantly positive effects on their own bids and are less profitable*.

The linear estimation coefficients of Model (1) and Model (2) in Table 4 indicate that HA scores positively affect bids both with and without controlling for risk attitude at the 10% significant level. Models (3) and (4) in Table 4 show that high HA subjects earn smaller profits. Hypothesis 2 is not rejected by the results.

Table 4 Regression TCI

| | Model (1) bid | Model (2) bid | Model (3) profit | Model (4) profit |
|---|---|---|---|---|
| Novelty Seeking | -0.068*** | -0.063*** | 0.726*** | 0.806*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Harm Avoidance | 0.037* | 0.032* | -1.112*** | -1.199*** |
| | (0.016) | (0.043) | (0.000) | (0.000) |
| Reward Dependence | 0.030 | 0.027 | 0.362 | 0.316 |
| | (0.275) | (0.325) | (0.213) | (0.275) |
| Persistence | -0.072* | -0.065 | -0.274 | -0.175 |
| | (0.043) | (0.065) | (0.464) | (0.638) |
| Self-Directedness | -0.010 | -0.014 | -0.484** | -0.544** |
| | (0.558) | (0.412) | (0.007) | (0.002) |
| Cooperative | 0.012 | 0.022 | 0.154 | 0.315 |
| | (0.480) | (0.191) | (0.395) | (0.085) |
| Self-Transcendence | -0.032 | -0.013 | 0.098 | 0.378 |
| | (0.182) | (0.574) | (0.701) | (0.146) |
| Risk control | No | 0.111*** | No | 1.684*** |
| (Holt-Laury Lottery) | | (0.000) | | (0.000) |
| *N* | 2320 | 2320 | 2320 | 2320 |
| R-squared | 0.792 | 0.793 | 0.048 | 0.059 |

Note: Standard errors are clustered by subject levels in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

**Other observations**

Persistence negatively affects bids at the 10% significance level without controlling for risk in the regression model. This result seems to appear because a high persistence person tends to bid smaller in order to gain larger profits. Models (3) and (4) shown that SD had a negative effect on profits. These results indicate that a high SD person has high self-control to ensure they win the game, but small profits in each period make them earn smaller profits overall. In order to test this interpretation, the interaction term of SD and HA is included in the Appendix table. In addition, contrasting with the theoretical prediction, the intercept $\beta$ is significantly not

equal to zero. The preceding studies on first-price auction (FPA) experiments shows that bidders who are assigned low values bid irrationally; thus, bidding data with low values dropped from the regression are in the Appendix table.

**Interaction term**

The next analysis is about the test for interaction effects between risk and TCI on bidding. To enter the interaction term into the regression model, all variables were standardized in order to avoid multicollinearity.

**Result 3** *The interaction term between NS and Risk have significantly positive impact on bids.*

Model (3) in Table 5 shows that that the interaction term between NS and HLL has significantly positive effects on bidding. Though HLL has positive effects on bids and NS has negative effects on bids, respectively, the interaction effect between HLL and NS has positive effects on bids at the 10% significance level. This result indicates that individual risk preferences have a stronger impact on bids than NS. Thus, hypothesis 3 is rejected.

**Result 4** *The interaction term between HA and Risk has no significant impact on bidding*.

Model (4) in Table 5 shows that the interaction term between HA and Risk has a negative but insignificant effect on bidding. This result appears to be that the interaction effect between positive effects on bids of HA and positive effect on bids of HLL were disappeared, thus HA and risk preferences are independently affect bids. Then, hypothesis 4 is rejected.

An ANOVA test was carried out between the no-interaction model (1) and each of the

interaction models. The *F* value in Table 5 indicates that there is no significant improvement when an interaction term was put into the model, with the exception of model (3). Model (3) improved its statistical power to a 10% significance level when the interaction term between NS and Risk was included. This result indicates that not only risk preferences, but also the interaction between NS and Risk had significant effects on bidding.

Table 5 Interaction term between NS, HA and risk preferences

| | Model (1) bid | Model (2) bid | Model (3) Bid | Model (4) bid |
|---|---|---|---|---|
| Value | 0.0887*** | 0.887*** | 0.887*** | 0.887*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| NS | -0.037*** | -0.040*** | -0.037*** | -0.037*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| HA | 0.028** | 0.030** | 0.028** | 0.028** |
| | (0.007) | (0.004) | (0.007) | (0.007) |
| RD | 0.014 | 0.008 | 0.014 | 0.014 |
| | (0.165) | (0.386) | (0.146) | (0.146) |
| P | -0.018 | 0.386 | -0.020* | -0.020* |
| | (0.053) | (0.023) | (0.037) | (0.037) |
| Risk | 0.036*** | 0.037*** | 0.037*** | 0.037*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| NS*HA | | 0.024** | | |
| | | (0.009) | | |
| NS*Risk | | | 0.021* | |
| | | | (0.010) | |
| HA*Risk | | | | -0.016 |
| | | | | (0.011) |
| N | 2320 | 2320 | 2320 | 2320 |
| R-squared | 0.793 | 0.792 | 0.793 | 0.793 |
| *F* value | | 0 | 4.427* | 2.149 |

Notes: Standard errors are clustered by subject levels in parentheses. Significance levels: * 10%; ** 5%; *** 1%. *F*-value denotes ANOVA test with Model (1).

Table 6 Interaction analysis between value and TCI scores

| | Model (1) bid | Model (2) bid | Model (3) bid | Model (4) bid | Model (5) Bid | Model (6) bid | Model (7) bid | Model (8) bid |
|---|---|---|---|---|---|---|---|---|
| NS | -0.082*** | -0.000 | | | | | | |
| Value*NS | | -0.004* | | | | | | |
| HA | | | 0.060*** | -0.014 | | | | |
| Value*HA | | | | 0.004** | | | | |
| HLL | | | | | 0.140*** | 0.140*** | | |
| Value*HLL | | | | | | 0.008* | | |
| Value*NS*HLL | | | | | | | 0.000 | |
| Value*HA*HLL | | | | | | | | 0.000 |
| Control variables | yes | yes | yes | yes | yes | yes | yes | yes |
| *N* | 2320 | 2320 | 2320 | 2320 | 2320 | 2320 | 2320 | 2320 |
| R-squared | 0.791 | 0.791 | 0.791 | 0.791 | 0.790 | 0.791 | 0.792 | 0.793 |

Notes: Significance levels: * 10%; ** 5%; *** 1%. The coefficient of value and constant terms were omitted from this table.

Table 7 Hierarchical Regression

| | | Temperament | | Character | |
|---|---|---|---|---|---|
| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) |
| | bid | bid | bid | bid | bid |
| Value | 8.882e-01*** | 8.888e-01*** | 8.877e-01*** | 8.887e-01*** | 8.878e-01*** |
| Temperament | | | | | |
| NS | | -4.138e-02*** | -3.747e-02*** | -4.084e-02*** | -3.764e-02*** |
| HA | | 3.282e-02** | 2.880e-02** | 2.970e-02* | 2.519e-02* |
| RD | | 9.085e-03 | 1.419e-02 | 1.305e-02 | 1.175e-02 |
| P | | -2.081e-02* | -1.883e-02 | -2.009e-02* | -1.826e-02 |
| Character | | | | | |
| SD | | | | -6.895e-03 | -9.659e-03 |
| C | | | | 7.823e-03 | 1.464e-02 |
| ST | | | | -1.479e-02 | -6.350e-03 |
| HLL | No | No | yes | No | yes |
| *N* | 2320 | 2320 | 2320 | 2320 | 2320 |
| R-squared | 0.788 | 0.792 | 0.793 | 0.792 | 0.793 |
| ΔR-squared | | 0.004 | 0.001 | -0.001 | 0.001 |
| *F*-value | | 10.822*** | 13.485*** | 2 | 13.332*** |

Notes: Significance levels: * 10%; ** 5%; *** 1%. All variables were standardized. ΔR-squared denotes subtraction of adjusted R-squared from Model (1). *F*-value denotes ANOVA test between Model (1) and other models.

**Assigned values and TCI scores**

Preceding experimental auctions have shown that bidders assigned low values do not behave according to theoretical predictions (Kagel, 1996); thus, to test the size of assigned value effects on bids, regression models with value interacting with TCI scores were implemented in Table 6. Since NS and HA had significant effects on bids in Table 4, the interaction terms between NS, HA, Risk, and value were put into the regression models.

The interaction between NS and value had a negative effect on bids in model (2) at the 10% significance level. The interaction between HA and value had a positive effect on bids in model (4) at the 5% significance level. The interaction between HLL and value had a positive effect on bidding in model (6) at the 10% significance level. These results indicate that bids were affected by interactions between NS, HA, and HLL when low values were assigned.

**Tests of TCI's predictive power**

To compare the predictive power of TCI and HLL, hierarchical regression analysis was carried out by firstly inserting congenital temperament, then, secondly, adding acquired character and, finally, inserting HLL into the regression model[9]. The ANOVA test for prediction power is carried out in Table 7.

First, the analysis showed that adding temperament improved the R-squared value of model (2) significantly. Second, analysis showed that adding the exogenous risk preference of HLL

[9] Hierarchical regression analysis is often used in psychological contexts. The purpose of hierarchical regression is to compare the predictive power of independent variables by sequential insertion.

improved the R-squared value of model (3) significantly. However, putting character into the regression model instead of HLL worsened the R-squared value of model (4). Adding HLL to model (4) significantly improved the R-squared value. The results of hierarchical regression analysis indicate that adding temperament into the regression model improves the prediction power of bidding. Moreover, adding HLL into that model further increases the prediction power of bidding. In contrast, adding character without HLL worsens the prediction power of bidding.

## 4. Discussion

While psychological personality studies, especially Big Five taxonomy studies, were introduced to economic research (Borghans et al. 2008), there was little evidence of personality effects on economic behavior (Becker et al. 2012). To explain behavior, neuropsychologists employ TCI to measure human personality (Cloninger 1993). TCI was originally developed to detect pathological behavior; thus, TCI might better predict behavior than the Big Five taxonomy.

To examine this question, an experimental auction, risk preference elicitation, and TCI measurements were conducted. Regression analysis was carried out, along with interaction analysis and hierarchical regression analysis, in order to test the effect of temperament and character on bidding.

The results of the experiment show that both temperament (NS and HA) and character (SD) have significant effects on bidding behavior, and NS, HA, and SD all affect profits. Moreover,

the interaction between NA and HLL has significant effects on bidding.

One clear limitation is the gender gap. This research employed only male subjects in order to avoid the effects of unobserved gender heterogeneity (Cassari et al 2008; Chen et al. 2013; Pearson and Schipper 2013).

In conclusion, this study is the first attempt to investigate the relationship between TCI and economic behavior. Remaining topics include the suggestions that other TCI areas, such as RD, seem to be related to altruistic preferences, P and SD seem to be related to time preferences, and C seems to be related to social preferences. Therefore, further experimental research is needed.

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**Appendix 1 Experimental Instruction**

Experiment 2 Instruction

ID_____

Thank you for your participation. We will begin with a series of experiments about bidding behavior, please write down on your sheet number to top of page ID.

Experiment 2 summary

In the each period of experiment 2, participants are matched with pairs randomly by computer, and decide a bidding number that you want to bid Computer assign you a "Value", explain below, each participants decide your "Bid". After every participants decision, winning bid is higher "Bid", and winner gets the "Profit", defined your "Value" – "Bid".

After every treatment finished, we sum up your "profit" and calculate your earning, your monetary earning is your total profit by ten.

If you learn the rule of experiment and decide carefully, you will get amount of money.

Experiment 2 rules

At the begin of period, computer assign you "Value" probability one of fifth, "6", "12", "18", "24", "30". Your matched opponent is also assigned "Value" randomly; opponent's value is secret information for each other.

When you assigned your "Value", you decide your "Bid" between 0 and your "Value". After every participant complete decision, computer collects your Bids. Then, higher "Bid" will be winner, and he gets "Profit" that is his "Value" – "Bid". If the higher "Bid" is even, then computer decides winner with probability 50.

In each period

If you were winner, Your **"Profit" = "Value" – "Bid"**

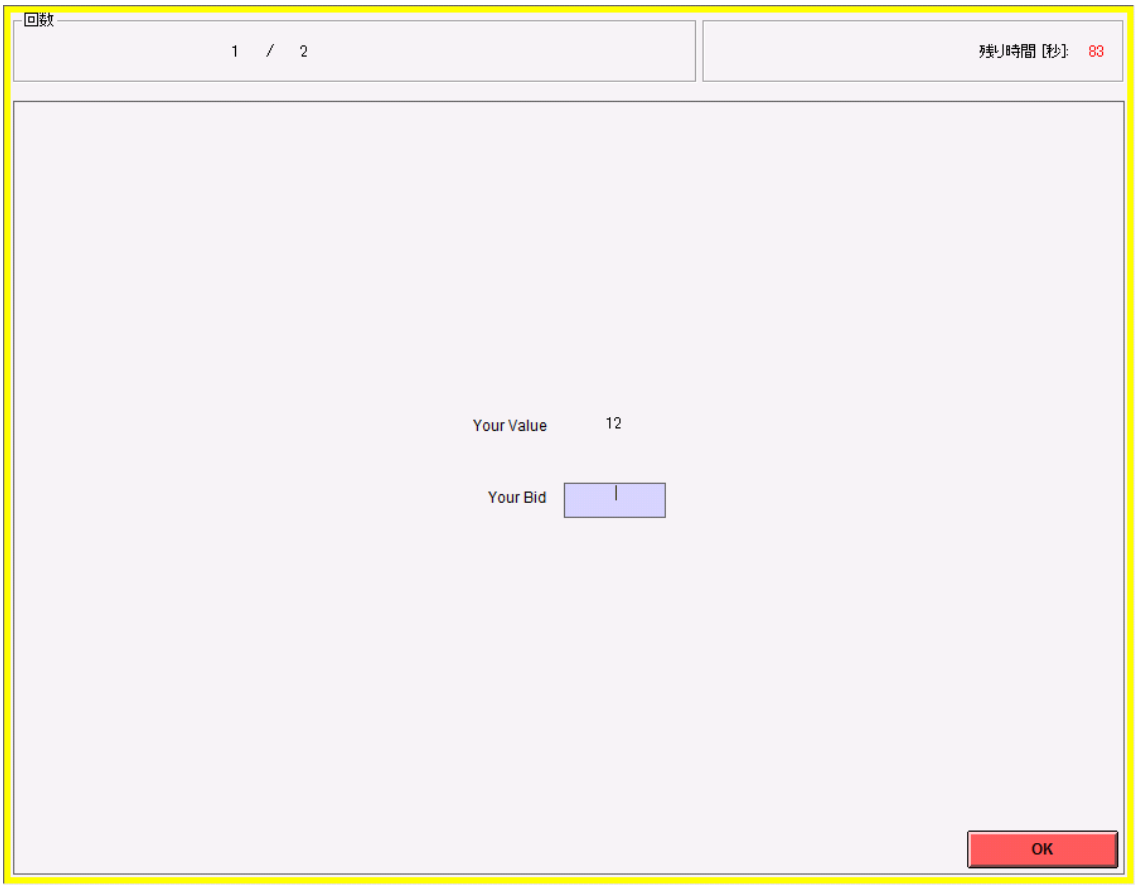
If you were not winner, Your **"Profit" = 0**

Let me explain Computer Screen below

There are two screens **Decision Screen** and **Result Screen**

**Decision Screen**

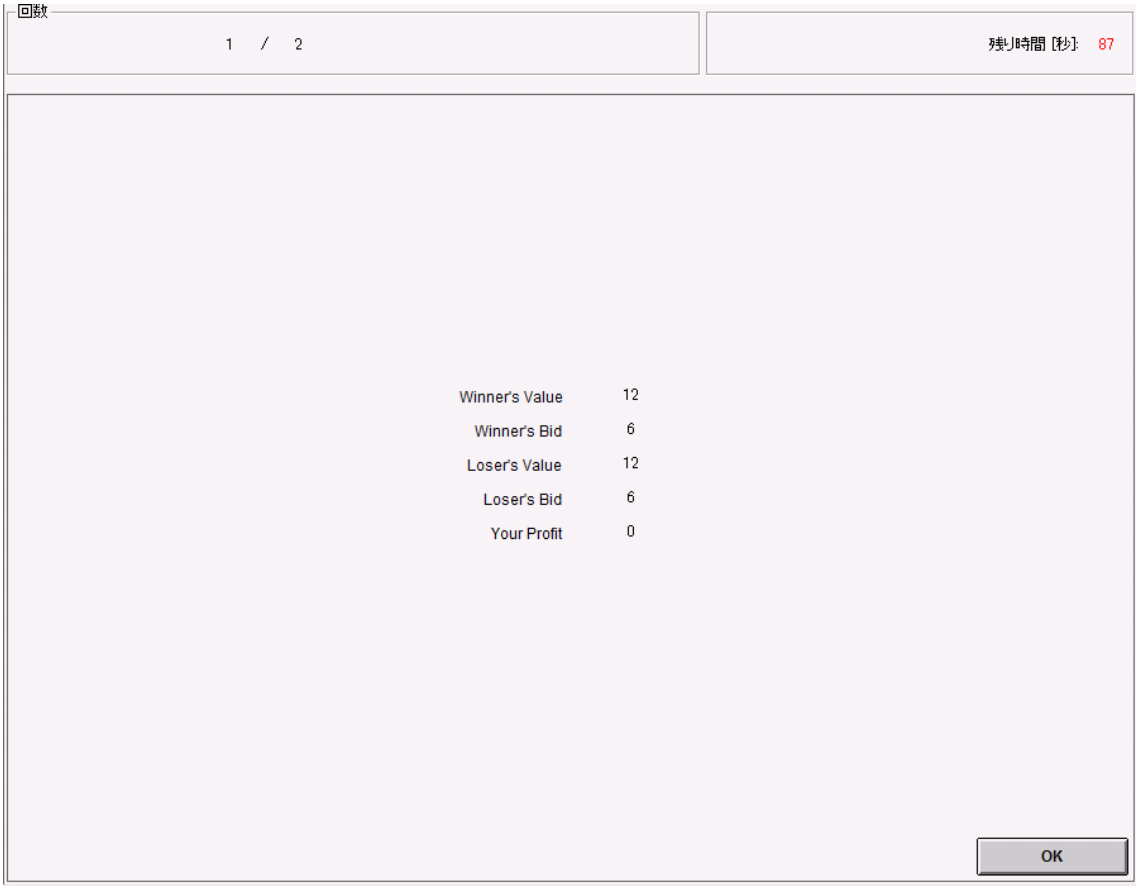
At the decision screen, you can see your "Value", and you decide your "Bid".




In the decision careen, you decide your “Bid” by your “Value”, guessing opponent’s bid, and so on. Then, you enter your “Bid” to box after “Your Bid”, and click red “OK” button to confirm your decision. After your decision, you write down your “Value”, “Bid”, “Guessed opponent’s Value” to record sheet.

**Result Screen**

Result screen shows you, “Winner’s Value”, “Winner’s Bid”, “Loser’s Value”, “Loser’s Bid”, “Loser’s Bid”, and “Your Profit” from top to bottom.




If you were winner, you get “Profit” = “Value” – “Bid”. And, If you were not winner, you get “Profit” = 0.

Please, write down your “Profit” on record sheet.

Experiment 2 continues to period 20.

**Appendix 2 Supplemental Tables**

Regression
Independent variable: Risk

| Independent | Risk | | | |
|---|---|---|---|---|
| | Coefficient | SE | t | p-value |
| NS | -0.047 | 0.055 | -0.85 | 0.396 |
| HA | 0.051 | 0.049 | 1.04 | 0.300 |
| RD | 0.027 | 0.086 | 0.31 | 0.754 |
| P | -0.058 | 0.111 | -0.52 | 0.600 |
| SD | 0.036 | 0.053 | 0.66 | 0.505 |
| C | -0.095 | 0.054 | -1.76 | 0.081 |
| ST | -0.166* | 0.076 | -2.17 | 0.032 |
| Notes: | N=116. R-squared=0.14 | | | |

The Independent variable is Risk averseness. The Coefficients of regression model are not significant effects on Risk attitude except Self-Transcendence. ST negatively effects on Risk averseness.