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Determining the Effect of Personality Types on Human-Agent Interactions

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***Abstract*—Because of the large number of agents and robots beginning to affect everyday life of humans, it is important to understand how humans would treat agents in a mixed human-agent society. In this paper, we are trying to find answers to two questions: whether humans possess different attitudes towards other humans and agents, and whether the personality type of a human influences his/her decisions and how. To investigate these problems, first we use the Keirsey Temperament Sorter-II (KTS-II) to discover the personality types of our human participants. Then each participant plays the "Who Gets More Cake?" game three times, with a simulated human and an agent as opponents. The experimental results are shown in two aspects: the tendency aspect and the consistency aspect. It is shown that humans treat other humans and agents differently and humans with different KTS-II temperaments behave differently on the above two aspects. It is very possible that the Thinking–Feeling dichotomy of Myers-Briggs Type Indicator (MBTI) and the tendency results are not independent. Also, there is a correlation between the Extraversion–Introversion dichotomy and the consistency results.**

***Keywords*-Human-Agent Interactions; Human Behavior; Personality Types; Keirsey Temperament Sorter-II**

I. Introduction

Agents are used nowadays to help with people's everyday life in many ways. For example, an agent could help travelers find the cheapest ticket for a specific flight, or get elders their medications. Thus, it is not surprising that people have feelings about agents. It is reported that humans show empathy towards robots [1], evidenced by measuring their emotional and neurological change when they watch videos of dinosaur robots being abused. However, people's feelings towards agents are not always positive. There's a long-existing controversy about how agents would behave after they have too much intelligence. Some people are afraid that robots, which are a kind of agent, might harm humans if they are intelligent enough and their interests conflict with humans' interests. Along with the technology development of many different kinds of agents, questions have risen: will humans behave preferentially towards other humans or agents? It is known that humans' personality types have an impact on interactions among humans, but how about the human-agent interaction? Will a human's personality type have an impact on his/her decisions regarding other humans and agents? If we discover a relationship between personality types and decisions, how could this be used to help with everyday life? In order to answer these questions, we must determine a human's personality type first.

Table I
MBTI Dichotomies

Extraversion (E) - Introversion (I)
Sensing (S) - iNtuition (N)
Thinking (T) - Feeling (F)
Judging (J) - Perception (P)

A. Personality Types

There are different methods to test personality types. A famous psychometric questionnaire to reveal a person's personality type is the Myers-Briggs Type Indicator (MBTI) assessment [2]. Myers used four dichotomies in MBTI theory, as shown in Table I.

The result of the MBTI questionnaire is a four-letter personality type, with one letter coming from each dichotomy. For example, a person with type INFP is introverted, intuitive, friendly, and more likely to probe the environment.

We chose the Keirsey Temperament Sorter-II (KTS-II) [3], which is associated with MBTI. KTS-II classifies people into four temperament groups according to two basic dimensions of personality: what people say (communication) and what people do (action). The temperaments are Artisan, Guardian, Rational, Idealist. They each have different traits [4]:

- *Idealists* speak mostly of what they hope for and imagine might be possible for people, and they want to act in good conscience, always trying to reach their goals without compromising their personal code of ethics. Examples of the Idealists are Mohandas Gandhi and Princess Diana.
- *Guardians* speak mostly of their duties and responsibilities, of what they can keep an eye on and take good care of, and they're careful to obey the laws, follow the rules, and respect the rights of others. Examples of the Guardians are George Washington and Mother Teresa.
- *Rationals* speak mostly of what new problems intrigue them and what new solutions they envision, and always pragmatic, they act as efficiently as possible to achieve their objectives, ignoring arbitrary rules and conventions if need be. Examples of the Rationals are Hillary Clinton and Stephen Hawking.

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Table II
KTS-II TYPES VS MBTI TYPES

KTS-II temperament	KTS-II character type	MBTI type
Artisan (SP)	Promoter	ESTP
	Crafter	ISTP
	Performer	ESFP
	Composer	ISFP
Guardian (SJ)	Supervisor	ESTJ
	Inspector	ISTJ
	Provider	ESFJ
	Protector	ISFJ
Rational (NT)	Fieldmarshal	ENTJ
	Mastermind	INTJ
	Inventor	ENTP
	Architect	INTP
Idealist (NF)	Teacher	ENFJ
	Counselor	INFJ
	Champion	ENFP
	Healer	INFP

- *Artisans* speak mostly about what they see directly and what they can get their hands on, and will do whatever works or whatever gives them a quick payoff, even if they have to bend the rules. Examples of the Artisans are Michael Jordan and Marilyn Monroe.

Each temperament has four variants, as shown in the first two columns in Table II. The third column in Table II shows the MBTI types corresponding to the KTS-II types. KTS-II describes behaviorial patterns while MBTI describes what people have in mind, which makes KTS-II suitable for our experiments in theory. We use the letters from MBTI to denote the KTS-II personality types herein.

B. The Cake-Cutting Game

After the human subjects find their personality types through the KTS-II test, they play our "Who Gets More Cake?" variant of the classic cake-cutting game.

In the classic cake-cutting game, players want to divide a cake in such a way that all of them believe they have received a fair amount of the cake. There are two basic measurements for a solution of the cake-cutting problem: fairness and envy-freeness. Fairness means anyone gets at least the amount that he believes is fair, while envy-freeness means anyone believes no one gets more than he has and he won't want to exchange his cake with others. If the cake is divided between two players, there is a fair and envy-free solution, which is to have one player cut the cake into two pieces and the other player choose his piece of the cake first. For three players, Selfridge-Conway discrete procedure [5] can be used to provide a fair and envy-free solution. However, our focus here is whether humans of different personality types act differently towards an agent, not dividing the cake perfectly with fairness and envy-freeness. We add a "leftover cake giveaway" part to the cake-cutting game in our "Who Gets More Cake?" game, which is described in section III.

The rest of the paper is organized as follows. In section II, we introduce related work. In section III and IV, the experiments are described in detail and the results are analyzed. In section V, we draw conclusions.

II. RELATED WORK

Reeves and Nass [6] claimed that people were inclined to treat media, usually computers in their studies, as if they were real people or real places. Thus we have the hypothesis that the personality types of humans would influence their behavior towards other humans and agents, just like in the interactions between humans.

Bartneck, Hoek, Mubin, and Mahmud [7] used "iCat" robots of different intelligent levels to test whether humans treat the robots differently. They showed that the robots' intelligence had a significant influence on the humans' decision in the measurement of their hesitation time to switch off a robot. While they investigated the influence of different intelligence levels towards humans' decisions, we try to figure out whether the personality type of a human influences his decisions towards a person or an agent.

Many researchers investigated the influence of personality types on humans' decisions. For example, Schmitt, Shupp, Swope, and Mayer [8] used MBTI test to get personality types and let the human subjects play the ultimatum game. They discovered that the "Thinking (T)" types made lower offers than those characterized as "Feeling (F)" types, and "Extraversion (E)" types indicated a willingness to accept offers less than "Introversion (I)" types. Peever, Johnson and Gardner [9] used the Five Factor Model to test personality types and discovered the games a person preferred was related to his personality type.

Personality traits including those in Five Factor Model and some other traits, such as public self-consciousness and shyness are considered by Von der Putten, Kramer, and Gratch [10]. In their study, subjects recruited through a website interacted with a virtual agent. They found that some personality traits, such as agreeableness, extraversion, approach avoidance, were related to humans' behavior, while some traits, gender, and age didn't affect the results.

Du [11] presented same questions in the mixed human-agent society and some possible experimental methods. Our paper studies the impact of humans' personality types towards their behavior, while it is different from other studies because of three reasons:

- Other than MBTI or Five Factor Model, we used KTS-II test in our study, which broadens the domain of possible explanations of the influences that personality types could bring to human behavior.
- Many researchers considered the interaction between a person and an agent, sometimes just between humans, while we considered a human interacts with both a simulated human and an agent at the same time, showing the different aptitudes the human has towards the simulated human and the agent.

- We explored an experimental setting different from previous studies, which may bring new conclusions since conclusions based on previous studies might only be applied to certain studies. We developed a new game and tried to determine how humans would behave in playing it.

III. Experiment

As mentioned before, our experiment contains two phases:

- Test the subjects' personality types using KTS-II.
- The subjects play the "Who Gets More Cake?" game.

In our "Who Gets More Cake?" game, we have a cake for three players to divide. One player is the human subject/participant, one player is a simulated human, and the third player is an agent/robot (the robot has a way to convert the cake into the energy it needs to move). The participant was told he was playing with another person and a robot, but actually a simulated human and an agent for the reason of experimental control. Players indicate how they would like to cut the cake into three pieces, by drawing two lines/cuts on their own picture of the cake. We follow a protocol proposed by Iyer and Huhns [12], which is proved to be fair for dividing a resource among n agents, to decide how the cake is divided: whoever has drawn the left-most cut will get the left side of the cake from the edge to this cut. Of the remaining two players, whoever has drawn the right-most cut will get the right side of the cake from this cut to the right edge. The third player will get the portion in the middle indicated by that player's two cuts. Note that all players will get one of the pieces that they indicated, as proved in [12].

After the cake is divided, no player would want to trade with others, because they would get a piece that is smaller than the one they drew on the cake. However, there will be one or two portions of the cake left. To make the game more real, the participants were told one player would then be chosen randomly to give the remaining portions of the cake to one of the other players. In fact, the participants were asked to whom they would give the leftover cake in every game. They could only give the leftover cake to either the simulated human or the agent, but not themselves. Each participant was asked to play the game three times, each time with a different cake and with a different simulated human. To play the role of a human realistically, our simulated human has different names in three games and their names are neutral to eliminate the bias of sex. At the beginning of each game, participants were asked to type a greeting sentence to the simulated human and the simulated human will type some greetings too. It takes our simulated human some time to think and draw cuts on the cake, each game with different amount of delay to mimic human thinking.

IV. Results

73 non-computer science students with age around 20 who have little technological background participated in the experiment. They took the KTS-II personality test and played the game after being told the rules of the game. 58 of them played all three rounds of the game. In total, they played 197 games. We measure four criteria:

- The number of games in which the participants give the leftover cake to the simulated human, denoted by N_{human};
- The number of games in which the participants give the leftover cake to the agent, denoted by N_{agent};
- The number of participants who give the leftover cake to the same player (either the simulated human or the agent) in the three games they played, denoted by N_{same};
- The number of participants who give the leftover cake to different players in the three games they played, denoted by N_{diff}.

The first two criteria measure the tendency that a participant would prefer either a person or an agent under some circumstances, which might indicate whether he would like to interact with a person or an agent, and the last two criteria measure the consistency of his choice. For the last two criteria, we only consider the participants who finished all three games.

To deal with the personality type results, we first need to understand how to interpret KTS-II test. KTS-II provides a questionnaire based on seventy questions, each with two options indicating the two aspects of a certain dichotomy. There are ten questions for E-I dichotomy and twenty questions each for the other three dichotomies. A personality type depends on how many options were selected for the two aspects of each dichotomy. If a person chose the same number of options for the two aspects of any dichotomy, an "X" will appear for that dichotomy. For example, if a person chose 5 options for E and 5 options for I, his personality type would have an "X" in the E-I dichotomy, e.g., XSTJ. If this happens, the person is asked to read both ESTJ and ISTJ's descriptions and choose whichever fits better. In our experiments, a few participants had one or more "X"es in their personality types. We handle this by counting them as 1/2 person for one "X" situation for each possible type, 1/4 person for two "X"es situation for each possible type, and so on. For example, the above person with personality type XSTJ is counted as 1/2 person with type ESTJ and 1/2 person with type ISTJ.

In order to investigate how personality types influence the choices the participants make, we introduce several statistical criteria:

- Pearson's chi-squared test (χ^2 test) or Fisher's exact test, which evaluates the degree of independence between two nominal variables.
- $Cramér's\ V$ (V), which is an effect size measure of association between two nominal variables.
- Goodman and Kruskal's lambda, which helps us to

Table III
OBSERVED FREQUENCIES OF FOUR TEMPERAMENTS

O_{freq}	Guardian	Artisan	Idealist	Rational
N_{human}	55.25	23.75	30	24
N_{agent}	26.5	13.5	11.5	12.5

Table IV
PERCENTAGE DEVIATION OF FOUR TEMPERAMENTS

Percentage Deviation	Guardian	Artisan	Idealist	Rational
N_{human}	0.1%	-5.6%	7.1%	-2.6%
N_{agent}	-0.2%	11.6%	-14.7%	5.4%

understand whether knowing a person's personality would help to predict his choice in the game (λ_1) and vice versa (λ_2).

A. Tendency Results

We calculated the first two criteria for all participants, where

$$N_{human} = 133,\ N_{agent} = 64. \tag{1}$$

The data shows the participants give the leftover cake to the simulated human in most games, which is twice as many as those in which it is given to the agent. We grouped the data by sixteen MBTI types. The data, not shown here due to space limits, shows that people of all types give more leftover cake to the humans than to the agents, which reveals their different attitude towards humans and agents. Champions (ENFP), one of the Idealists, give the leftover cake to the simulated human 6 times more than they give to the agent. On the other hand, Crafters (ISTP), one of the Artists, give cake more to the agent. The data is heterogeneous and it's hard to discover a pattern among all the sixteen personality types. Thus, we try to group them in various ways and analyze the results.

Therefore, we calculated the same criteria for the four KTS-II temperaments, as shown in Table III and criteria for each two aspects of the four dichotomies, as shown in Table V. The data, as we observed, are called observed frequencies (O_{freq}) in statistics.

Now we want to see whether the KTS-II temperaments have significant influence on the choices the participants made. Our data fits the conditions of Pearson's χ^2 test. Following the test procedure, we stated the null hypothesis as follows:

H_0: The participants' KTS-II temperaments and the choices they made are independent.

Our hypothesis is that there is no relationship between the participants' temperaments and their choices, which means they give the leftover cake to the simulated human or the agent randomly (i.e., with equal probability). Thus we get the expected frequencies (E_{freq}) proportionally.

We use the following formula to calculate χ^2:

$$\chi^2 = \sum_{0<i<m,\ 0<j<n} \frac{(O_{freq}(i,j) - E_{freq}(i,j))^2}{E_{freq}(i,j)}, \tag{2}$$

where $O_{freq}(i,j)$ and $E_{freq}(i,j)$ denote the observed frequency and expected frequency in the table cell of ith row and jth column. m and n represent the total row number and total column number. Combined with degree of freedom $df = 3$, the statistical results are

$$\chi^2 = 0.72,\ P = 0.8685,\ V = 0.0606. \tag{3}$$

The meaning of the results is that we are $1 - P$ (in the form of percentage) sure to reject the null hypothesis. Normally significant level of 0.05 or 0.1 is used, which means if $P < 0.05$ or $P < 0.1$ we can reject the hypothesis. In our case, $P > 0.05$ and there is 13% probability that we could reject the hypothesis, which is very low. Thus we can't reject the null hypothesis, which means we can't say there is a relationship between the participants' temperaments and their choices. V is an effect size measure which shows the inter-correlation of the variables. In this case, it measures the relationship between the participants' KTS-II temperaments with their choices. According to the convention, $V < 0.1$ means negligible relationship. In our case, $V = 0.0606$ means the association between the KTS-II temperaments and the choices is negligible.

Percentage deviation, which measures the degree to which observed frequencies differs from the expected frequencies, is calculated as follows:

$$PD(i,j) = \frac{O_{freq}(i,j) - E_{freq}(i,j)}{E_{freq}(i,j)}. \tag{4}$$

Table IV shows the percentage deviation of the KTS-II temperaments' tendency results, from which we could see that people with different temperaments behave very differently. Artisans and Idealists are deviated more from the general public than the other two temperaments. The Guardians act just like an average person. By an average person, we refer to an imaginary person who will act as our reference data shows. For example, if this person plays our game for 197 times, he would probably end up with giving the leftover cake 133 times to the simulated human and 64 times to the agent.

At last we use Goodman and Kruskal's lambda to measure the proportional reduction in error. For example, in our case, the estimated probability of correct prediction when predicting a person's choice without knowing his temperament is

$$p_1 = 133/197 = 0.6751, \tag{5}$$

while estimated probability of correct prediction when predicting what choice a person will make knowing his temperament is

$$p_2 = (55.25 + 23.75 + 30 + 24)/197 = 0.6751. \tag{6}$$

Table V
TENDENCY RESULTS AND PERCENTAGE DEVIATION OF FOUR DICHOTOMIES

MBTI	N_{human}	N_{agent}	PD_{human}	PD_{agent}
E (Extraversion)	62	27	3.2%	-6.6%
I (Introversion)	71	37	-2.6%	5.5%
S (Sensing)	79	40	-1.7%	3.5%
N (iNtuition)	54	24	2.5%	-5.3%
T (Thinking)	58.5	35.5	-7.8%	16.2%
F (Feeling)	74.5	28.5	7.1%	-14.8%
J (Judging)	79.5	35.5	2.4%	-5.0%
P (Perception)	53.5	28.5	-3.4%	7.0%

Goodman and Kruskal's lambda of predicting choice on the basis of temperament is

$$\lambda_1 = \frac{(1-p_1)-(1-p_2)}{1-p_1} = 0, \tag{7}$$

which means there is no difference whether or not knowing a person's temperament when predicting his choice. Also we found out lambda of predicting a person's temperament from his choice (λ_2) is 0, which means knowing a person's choice won't do any good to predicting the his temperament.

To give a hint of how the participants' choices of each dichotomy varies, table V shows the tendency results of four dichotomies, where PD_{human} is the percentage deviation of N_{human} and PD_{agent} is the percentage deviation of N_{agent}. We could see that the biggest difference from what is supposed to be with our equal probability assumption happens in the T-F dichotomy.

Then we investigated how MBTI dichotomies influence the choices the participants made. Following the same procedure, first we stated the null hypothesis for each dichotomy as follows:

- For E-I dichotomy: The participants' types in E-I dichotomy and their choices are independent;
- For S-N dichotomy: The participants' types in S-N dichotomy and their choices are independent;
- For T-F dichotomy: The participants' types in T-F dichotomy and their choices are independent;
- For J-P dichotomy: The participants' types in J-P dichotomy and their choices are independent.

Table VI shows the statistic results for each dichotomy. From the table we could see that in T-F dichotomy, there is 87% possibility, which is close to the standard of rejecting the null hypothesis with a significance level of 0.1, to reject the null hypothesis. Still, we can't reject the null hypothesis, but we probably could see it get rejected with more experiments and draw a conclusion that the personality in T-F dimension has something to do with the participants' choices based on statistics. For other dimensions, there is no evidence to lead to the conclusion that we should reject the null hypothesis and say there is a relationship between a certain dichotomy and the choices.

Table VI
STATISTICAL RESULTS OF FOUR DICHOTOMIES FOR TENDENCY

Dichotomy	χ^2	P	V	λ_1	λ_2
E-I	0.34	0.5598	0.0417	0	0
S-N	0.17	0.6801	0.0297	0	0
T-F	2.28	0.1311	0.1077	0	0.07
J-P	0.33	0.5657	0.0409	0	0

Also, we could see from $Cramér's\ V$ there's a weak relationship between T-F dichotomy and the choices, and negligible relationship between any other dichotomy and the choices in the whole population based on our samples. λ_2 for T-F dichotomy is 0.07, which means that we could reduce 7% error when predicting a person's temperament with his choice known compared to that with his choice not known.

B. Consistency Results

Next, we measure the consistency of the participants' choices. First we calculated the consistency criteria:

$$N_{same} = 18,\ N_{diff} = 40. \tag{8}$$

We could see that more than two thirds of participants give the leftover cake to different players in three games, which means they don't always prefer the simulated human or the agent. Similar to the tendency results, we grouped N_{diff} and N_{same} data according to temperaments, shown in the first three columns in Table VII. PD_{same} and PD_{diff} in Table VII denote the percentage deviation of N_{same} and N_{diff}. The data grouped according to dichotomies are not shown here due to space limits, which shows E-I and J-P dichotomies deviate more than the other two dichotomies.

It is not suggested to use Pearson's χ^2 test if there are small expected frequency values, so we use Fisher's exact test here to perform analysis similar to Pearson's χ^2 test for data in Table VII and the result is

$$P = 0.9999. \tag{9}$$

We also perform Pearson's χ^2 test to get an approximate V value. Our null hypothesis is as follows:

H_0: The participants' KTS-II temperaments and the consistency results of their choices are independent.

The statistical results are as follows:

$$\chi^2 = 0.22,\ V = 0.0616,\ \lambda_1 = 0,\ \lambda_2 = 0. \tag{10}$$

It shows that there is no significant dependence between the participants' KTS-II temperaments and the consistency of their choices. A person's temperament has little association with the consistency of his choices. Knowing a person's temperament or the consistency of his choices won't do any help to the prediction of the consistency of his choices or his temperament.

Then we investigated how MBTI dichotomies influence the consistency of the choices that the participants made.

Table VII
CONSISTENCY RESULTS AND PERCENTAGE DEVIATION OF FOUR TEMPERAMENTS

Temperaments	N_{same}	N_{diff}	PD_{same}	PD_{diff}
Guardian	7.75	16.5	3.0%	-1.3%
Artisan	3.25	7.5	-2.6%	1.2%
Idealist	3	8.5	-15.9%	7.2%
Rational	4	7.5	12.1%	-5.4%

Table VIII
STATISTICAL RESULTS OF FOUR DICHOTOMIES FOR CONSISTENCY

Dichotomy	χ^2	P	V	λ_1	λ_2
E-I	0.64	0.4237	0.1054	0	0
S-N	0.01	0.9203	0.0105	0	0
T-F	0.04	0.8415	0.0257	0	0
J-P	0.4	0.5271	0.0833	0	0

Following the same procedure, first we stated the null hypothesis for each dichotomy as follows:

- For E-I dichotomy: The participants' types in E-I dichotomy and the consistency of their choices are independent;
- For S-N dichotomy: The participants' types in S-N dichotomy and the consistency of their choices are independent;
- For T-F dichotomy: The participants' types in T-F dichotomy and the consistency of their choices are independent;
- For J-P dichotomy: The participants' types in J-P dichotomy and the consistency of their choices are independent.

Based on the statistical results shown in Table VIII, we couldn't reject any of the null hypotheses and say any dichotomy and the consistency results are not independent. Besides, knowing a person's dichotomies or the consistency of his choices won't help to predict the consistency of his choices or dichotomies. However, $Cramér's\ V$ shows there is a weak association between E-I dichotomy and the consistency of the choices.

V. CONCLUSION

In this paper, we investigate whether humans' behavior towards other humans and agents is related to their personality types. Seventy-three students participated in the experiments by taking the KTS-II test and then playing the "Who Gets More Cake?" game. We discovered that humans of different personality types behave differently towards other humans and agents. For example, Artisans and Idealists act more deviated from an average person; it's very likely that T-F dichotomy is not independent with the tendency results. This provides a clue in many agent-related applications. For example,if an Idealist has to partner with an agent/robot as his personal assistant for business reasons, he is inclined to interact more with humans than agents, so he should choose a robot with less talking or interactions needed. In the next stage, we may discover agents of which personality type could cooperate well with a certain kind of person, which could be used in many domains, such as elders' personal care, team formation, etc.

Currently our results show little clue of making predictions based on personality. In the future, we will increase the number of participants in an updated experiment to draw more reliable conclusions and explore other possibilities.

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