Decision-making in Abstract Trust Games: A User Interface Perspective

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***Abstract*— To understand the processes involved in trust-based judgments in a computer-mediated multi-agent setting, a user interface (UI) was developed and an experiment was devised based on the Iterated Diner's Dilemma, a variation of the n-player Prisoner's Dilemma. Analysis of the experiment resulted in two major findings: (1) UI composition and information presentation have an impact on human trust and cooperation behavior, and (2) a strong positive correlation between Situation Awareness (SA) and performance is confirmed. There was a significant effect for UI levels on our main performance metric, total participant dining points, at the p=0.041 level. Also, there was a marginal effect for UI levels on participant cooperation at the p=0.084 level. Total participant dining points and SA were strongly correlated, r (92) = 0.62. Similarly, participant cooperation and SA were strongly correlated, r (92) = 0.61.**

***Index Terms*—User interface, composite network, trust, trust-based judgment, Diner's Dilemma, Situation Awareness, human behavior**

I. Introduction

IN TODAY'S highly networked world, an increasing number of decisions are made in online settings. In many cases, these decisions involve collaborative discussion, on-the-fly analysis of shared data, and various other interactions through computer-mediated collaboration platforms. Online users' perception of the available information is by necessity influenced by the tools and user interfaces that provide them access to the data and enable interactive analysis. The impact of user interface (UI) components on online decision-making behavior in terms of trust, cooperation and participants' awareness of the situation surrounding a decision is investigated in detail in this paper.

The contexts of online decisions are diverse and difficult to model in a comprehensive way. In this experiment, a representative abstract decision-making game, known as the Iterative Diner's Dilemma (DD), is employed and theoretical and experimental analysis are applied to explore the complex role of the UI in the involved decision making. DD is an n-player version of the well-known Prisoner's Dilemma that has been extensively studied over the years [2, 14, 20, 21]. The scenario is that several individuals go out to eat with a prior agreement to share the bill equally, with the understanding that the same group of people will repeat these dining dates an unspecified number of times in the future. On each occasion, each diner chooses whether to order an expensive or inexpensive dish, knowing that the bill will be shared equally by all diners.

To measure participants' awareness of the rules and progress of the abstract game, the concept and theory of situation awareness (SA) [8] was used. Endsley defines SA as a person's "perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." In a large variety of contexts SA has been recognized as key to successful decision making and performance at the individual and team levels [9, 27]. Few research papers were found that reported an empirical test of the role of SA and UI support in trust-based judgments in a Prisoner's Dilemma-like setting.

This experiment builds on and significantly extends previously reported work on DD and different UI levels for following game progress [30] (cf. detailed discussion in Section II B). To study the effects of UI components on awareness and decision-making behavior, an online study of 95 users was conducted using Amazon's Mechanical Turk (MTurk). Participants played repeated trials of the DD game, and answered evaluative questionnaires at multiple stages in the game. We were interested in potential correlations of SA and human performance; in the design of UI elements (Fig. 1) to improve SA, interpersonal trust (cooperation), and performance; and finally in the characterization and ultimately modeling of observed human behavior. The experiment highlights two key effects. First, there is a strong correlation between SA and performance in the game, and second, UI composition and information presentation have an impact on

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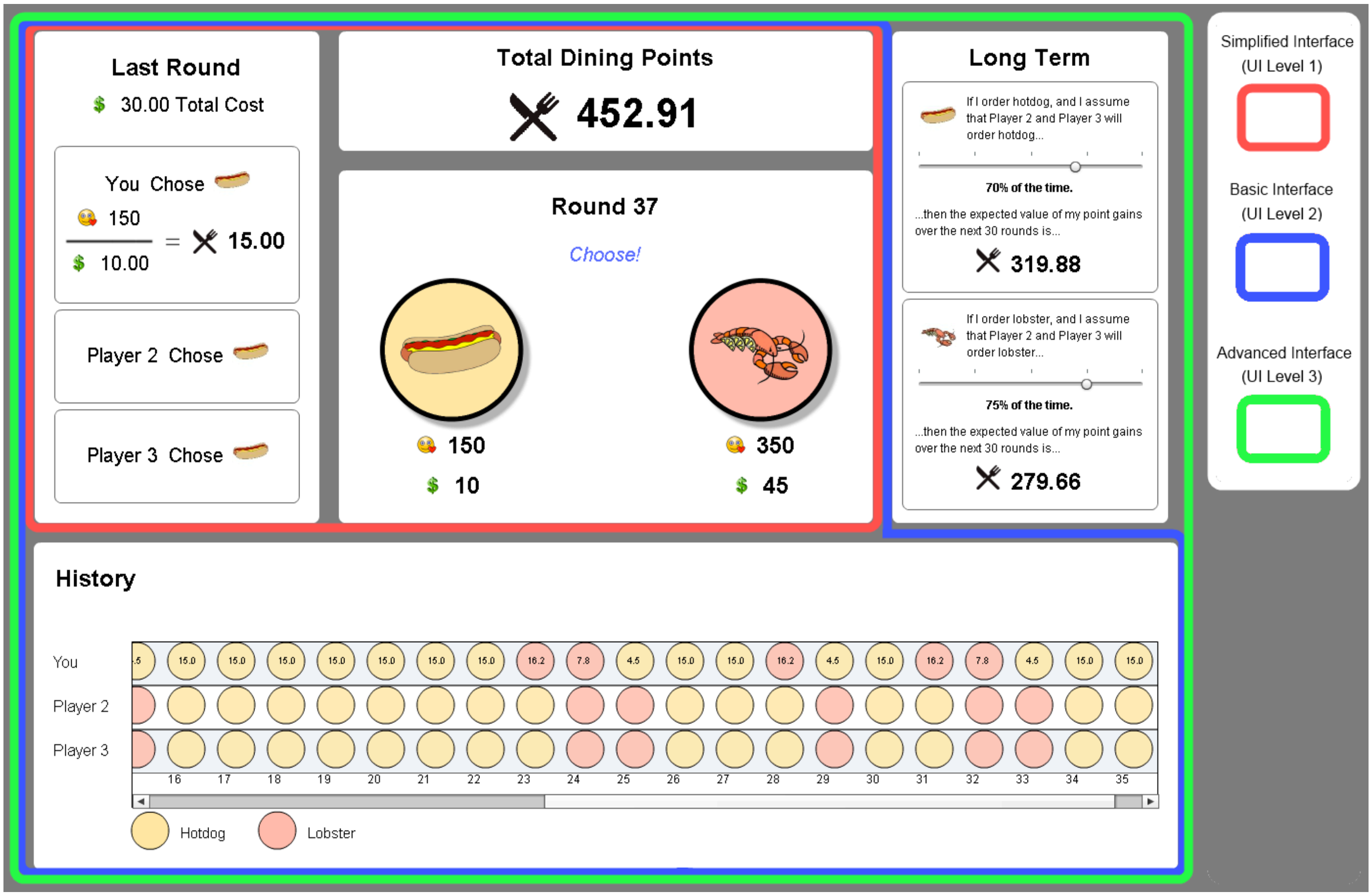

Fig. 1. Three increasingly informative UIs for the Iterative Diner's Dilemma Game. The boxes on the right indicate UI level.

human trust and cooperation behavior. Human trust has many contributing factors, making it difficult to define and model [1], especially across contexts. The term 'trust' can describe the user's trust in a system as a whole or interpersonal trust [25]. In our study, we are interested in interpersonal trust, where the user has to trust other (in this case, simulated) co-diners. We look at cooperation rate as a proxy for this interpersonal trust.

II. Background and Related Work

Related work for this research falls in two main areas: general research on Intelligent Information Displays, including their impact on SA at the cognitive level, and research on Social Dilemmas, including recent research on trust and awareness in the DD problem.

A. Information Displays, Situation Awareness, and Trust

Design of interactive information displays supporting SA is a well-known challenge [9]. As discussed in the introduction, very little is known regarding SA in groups involved in situations of conflict. While higher SA is expected to result in higher cooperation in productive team work [26, 27], intuitively, the less information an "opponent" has, the better it might be for our own good.

Gonzalez et al. [15, 22] studied the effect of varying four different degrees of information on the tendency to cooperate while playing the Prisoner's Dilemma game. The findings were that the amount of interdependence information exposed to the participant was proportional to individual cooperation and mutual cooperation, possibly driven by the awareness and increased response to the partner's cooperation. Joint performance and satisfaction were also generally higher for pairs that had more information. Accordingly, we then expect that higher levels of SA would result in higher levels of cooperation and higher common benefits compared to lower levels of SA.

B. Prisoner's Dilemma and Diner's Dilemma

The Prisoner's Dilemma is a game used in economics and psychology to study cooperation. The iterated form of the Prisoner's Dilemma has been used to study phenomena ranging from military arms races [18] to the red queen hypothesis in evolutionary biology [17, 24].

The Prisoner's Dilemma has been translated to multiple actors in two ways. In the public goods game, the benefits of cooperation are spread amongst all players while the costs of cooperation are borne individually. In DD, the costs of defection are spread amongst all players while the benefits of defection are rewarded individually. Although the public goods game is well researched, DD has received less attention, with the exception of the recent work by Teng et al. [30] that is extended here. That work focused on the relationship between behavior and awareness in DD, wherein a human played repeated rounds of the game with two computer opponents. Based on SA theory and design principles, the authors developed three different UIs that were expected to represent the information needed to support a specific SA Level: perception (level 1 SA), comprehension (level 2 SA), and projection (level 3 SA). Several Trust-related metrics were also assessed, including percentage of cooperation over time and subjective level of self-reported trust toward the opponents. Our paper responds to and goes beyond Teng et al.'s early study in the following ways:

1) Scale and Significance: Teng et al.'s experiment comprised 24 participants resulting in limited significant effects. Our experiment has 95 participants; as a result, our tests had more power to detect significant effects.
2) Variables: In this experiment, the automated opponent strategies are purposefully simplified, mitigating the confounding effect of opponent strategy reported in Teng et al..
3) User Interface: In Teng et al.'s work, the UI for the DD game did not induce the desired level of awareness in the game. We present and evaluate a new interactive UI that addresses some of these game awareness issues (Fig. 1).
4) Measurement of Awareness: In this experiment, SA level is explicitly measured through iterative Situation Awareness Global Assessment Technique (SAGAT) questionnaires [7] during user evaluations.

III. EXPERIMENT

A. Overview

A 5x3 between-subjects experiment was designed to investigate the relationship between trust, SA, and UI complexity. Participants played a web-based implementation of DD against two simulated opponents, which were playing tit-for-tat with five variations of cooperation and defection parameters, described in the next section. To meet the challenge of actively effecting a participant into a particular SA level, three different UIs were designed that exposed varying degrees and complexity of information, described in Section D.

After logging in, participants completed a pre-study questionnaire that collects some basic demographic and expertise information, and required the user to answer three screening questions to test their attention. They were then directed to an interactive training session that explained the game rules in detail over six hypothetical rounds. After the training, if the participants were ready to continue, a 100-round session of DD was started. SAGAT freezes occurred after Round 50 and Round 90 of the game. When all rounds were completed, the users were directed to a post-study questionnaire where they provided feedback on the game and the simulated opponents.

The user's goal was to maximize his or her 'Dining Points', defined as the ratio of the food quality of the chosen meal divided by the diner's share of the bill. In each round, the participant must weigh the pros and cons of selecting either hot dog or lobster by assessing the cost/value tradeoffs involved, the opponent behavior, and the long-term gain of a chosen strategy. We ran a supervised pilot study with 8 participants to verify data collection and experimental procedures before running the main experiment on the web with MTurk participants.

B. Opponent Strategies and Payoff Matrix

The simulated opponents played simple variants of tit-for-tat (TFT): a simple strategy in which the opponent makes the same decision that the participant did on the previous round. Two parameters were varied into five different configurations between participants: the probability that the opponent cooperates (order hot dog) given the player previously cooperated, and the probability that the opponent defects (order lobster) given the player previously defected -- (1) TFT with 33% probability of forgiveness (TFT-1-0.67), (2) TFT with 17% probability of forgiveness (TFT-1-0.83), (3) True TFT (TFT-1-1), (4) TFT with 17% probability of defection (TFT-0.83-1), and (5) TFT with 33% probability of defection (TFT-0.67-1).

The opponent strategies, as well as the DD payoff matrix were designed to be cooperation-encouraging, so that even at high opponent defection rates (up to 56% defection) the outcome-maximizing strategy is to always cooperate. This facilitates investigation of predicted cooperative participant behavior across a wide range of opponent defection rates. Hot dog was \$10 with a food quality of 150, whereas lobster was \$45 with a food quality of 350. Dining Points are taken as the ratio of food quality to each player's share of the bill.

C. Participants

The experimental system was deployed on MTurk and data was collected from 95 participants. MTurk is a web service that provides attractive tools for researchers who require large participant pools and inexpensive overhead for their experiments. Numerous experiments have been conducted, notably Buhrmester et al. [5], assessing the validity of using the service to collect research data, and these studies have generally found that the quality of data collected from MTurk is comparable to what would be collected from supervised laboratory experiments. In the Diner's Dilemma experiment, the MTurk participant age ranged from 19 to 60 with an average of 32 and a median of 30. 61% of participants were male while 39% were female.

D. User Interface

For the purpose of our study, we avoid showing the user information that might be considered a recommendation or expert opinion, potentially biasing them towards cooperation or defection, in line with literature on system transparency and explanatory interfaces [23, 25, 28]. Instead, participants were shown one of three configurations of the UI with varying amounts of information (Fig. 1). The 'simplified' UI only displays the bare minimum amount of information necessary for a participant to perceive the environment, although clever users would still be able to achieve SA levels 2 or 3 by paying close attention or taking extra time to perform a data analysis. The 'basic' interface aids comprehension of opponent behavior by displaying an enumerated game history that participants can examine to get a quick synopsis of opponent behavior from the outset to the current round. The 'advanced' interface included a tool to advise a participant on the long term gains of their choices.

Level 1 UI (simplified): All participants were shown, at a minimum, their current dining points, the food quality and cost of each menu item, the current round, and the results from the previous round in terms of dining points. This view explicitly reports on only the most current and recent game states, leading us to hypothesize that the participants would not be able to keep track of opponent behavior as easily as subjects using the more advanced interfaces.

Level 2 UI (basic): This UI level includes all UI features from Level 1 UI, and adds a 'History' panel to provide historical game information to the participant. In a similar study, Teng et al. [30] presented both the participant and opponent score in a game history panel. Their results showed a drop in participant cooperation when the history panel was presented. Based on their observation that presenting opponent score can promote retaliatory behavior, we omit the score display feature from our user interface design.

Level 3 UI (advanced): This UI level includes all UI features from Level 1 and 2 UIs, and adds a 'Long Term' panel to provide long-term projection information. This is an interactive panel where the participant can enter his or her assumptions about opponent behavior and calculate the expected dining points. By default, nothing is selected, so as to avoid biasing the participant in either direction.

E. SA Measurement

SA measurement provides a proven way to assess system effectiveness and the user's level of awareness of the situation. There are several approaches for the direct measurement of SA. The SAGAT is a widely tested and validated technique [7] for objectively measuring SA across all of its elements (levels 1, 2, and 3) with numerous studies supporting its validity and reliability [6, 12, 16].

Objective SA was measured using the SAGAT, based on questions derived from an analysis of SA requirements of the experiment. There were a total of 15 questions in each of two questionnaires (one after 50 rounds and after 90 rounds), all with multiple-choice answers. Participants were informed about the questionnaires, but not about their timing. The experiment's UI was not visible during the questionnaire phase. The range of possible scores was 0-15 on each questionnaire, with a combined SA score range of 0-30.

IV. ANALYSIS AND RESULTS

In this section, the major findings in the data collected from the 95 participants are presented. The next section is a discussion of these findings. Independent variables in the experiment were opponent strategies and UI levels. Opponent strategies were based on the tit-for-tat strategy with five levels of varying defection and forgiveness behavior. There were three variations of the UI with increasing information density and type. Dependent variables were participant cooperation (an indirect indicator of interpersonal trust), total dining points (an indicator of participant performance), and SA.

The two-factor analysis of variance (ANOVA) showed a significant main effect for the opponent strategy on dining points [$F(4, 80)=69.90$, $p<0.0001$], and cooperation rate [$F(4,80)= 4.87$, $p=0.001$], and SA [$F(4,80)=4.00$, $p=0.005$]. There was no significant interaction effect between opponent strategies and UI levels ($p>0.43$). In all analyses type II sum of squares was used because of unbalanced data. Fig. 2 shows an overview of mean participant cooperation rate over five co-diner strategies for the implemented payoff matrix. Co-diner strategies, from left to right, are TFT-1-0.67, TFT-1-0.83, TFT-1-1, TFT-0.83-1, TFT-0.67-1. The dashed line is score penalty if the participant doesn't use the 'theoretically optimum player strategy'.

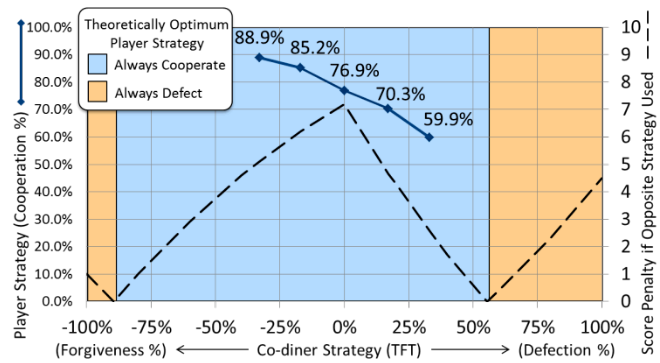

Fig. 2. Mean participant cooperation rate for 5 co-diner strategies. Mean participant cooperation rate decreases with decreasing co-diner forgiveness and then with increasing co-diner defection.

Table I shows mean participant cooperation rates for three UI levels and five opponent strategies. The two-factor ANOVA showed a marginal effect for UI Level on cooperation rate [$F(2,80)=2.56$, $p=0.084$]. Going from UI Level 1 to UI Level 2, participant cooperation rate is higher in all opponent strategies but one. UI Level 3 has the lowest participant cooperation rate in all opponent strategies. Mean participant cooperation for UI Level 1, UI Level 2, and UI Level 3 are 74.9% (n=25), 80.9% (n=30), and 63.3% (n=40), respectively. Participant cooperation is highest for UI Level 2 and lowest for UI Level 3. Post-hoc Tukey HSD analysis indicate that difference is between UI level 2 and UI level 3.

TABLE I. PARTICIPANT COOPERATION RATE BY UI LEVEL AND STRATEGY

Opponent Strategy	UI Level 1	UI Level 2	UI Level 3
TFT-1-0.67	86.4%	97.3%	83.0%
TFT-1-0.83	94.5%	87.9%	73.2%
TFT-1-1	75.0%	87.5%	68.3%
TFT-0.83-1	70.8%	72.1%	68.0%
TFT-0.67-1	61.0%	67.0%	51.8%

Table II shows mean total dining points for three UI levels and five opponent strategies. The two-factor ANOVA showed a significant main effect for UI Level on dining points [$F(2, 80)=3.33$, $p=0.041$]. Going from UI Level 1 to UI Level 2, dining points are higher in all opponent strategies but one. UI Level 3 has the lowest dining points in all opponent strategies but one. Mean total dining points for UI Level 1, UI Level 2, and UI Level 3 are 1167 (n=25), 1249 (n=30), and 1093 (n=40), respectively. Total dining points is highest for UI Level 2 and lowest for UI Level 3. This finding is consistent with participant cooperation; because the conditions tested in this experiment total dining points is a direct function of participant cooperation. Post-hoc Tukey HSD analysis indicates that the difference is between UI level 2 and 3.

TABLE II. MEAN TOTAL DINING POINTS BY UI LEVEL AND STRATEGY

Opponent Strategy	UI Level 1	UI Level 2	UI Level 3
TFT-1-0.67	1421.0	1484.3	1381.5
TFT-1-0.83	1457.3	1413.0	1287.4
TFT-1-1	1282.5	1392.8	1232.5
TFT-0.83-1	1067.5	1087.6	1078.7
TFT-0.67-1	909.0	948.8	906.4

Table III shows mean combined SA score for three UI levels and five opponent strategies. The two-factor ANOVA showed no significant main effect for UI Level on SA [F(2, 80)=45.654, p=0.127].

TABLE III. COMBINED SA SCORE BY UI LEVEL AND OPPONENT STRATEGY

Opponent Strategy	UI Level 1	UI Level 2	UI Level 3
TFT-1-0.67	23.0	26.7	26.5
TFT-1-0.83	24.5	24.9	21.0
TFT-1-1	28.0	26.8	21.6
TFT-0.83-1	19.3	23.9	21.2
TFT-0.67-1	19.4	19.5	19.9

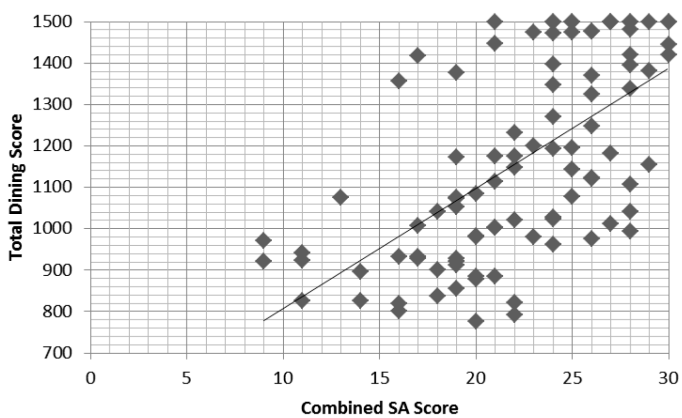

Fig. 3. Scatter plot with regression line of total dining points and combined SA score show strong correlation with r=0.62.

Total dining points and combined SA score were strongly correlated, r = 0.62, p < 0.0001 (Fig. 3). Similarly, participant cooperation and combined SA score were strongly correlated, r = 0.61, p < 0.0001 (Fig. 4).

V. DISCUSSION AND FUTURE WORK

The primary research questions in this experiment are listed below:

1) Is SA positively correlated with human performance (dining points) and cooperation?

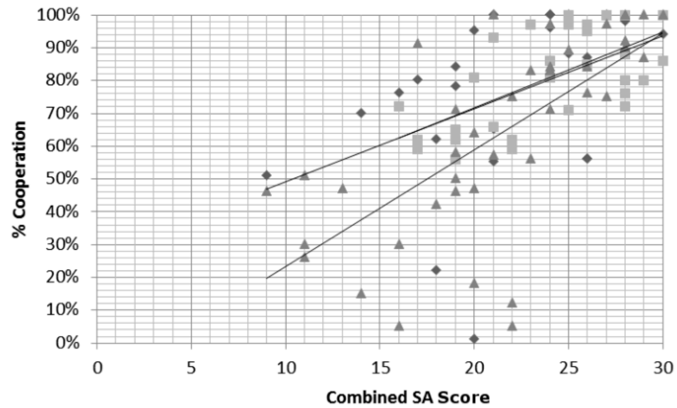

Fig. 4. Scatter plot of participant cooperation rate and combined SA score show strong correlation with r=0.61. (◆= UI L1, ▲=UI L2, ●=UI L3). Least squares regression lines for each UI Level are shown.

2) How can the observed human cooperative behavior be characterized and modeled?
3) How can UIs be designed to improve SA, interpersonal trust (cooperation), and performance? Similarly, what aspects of the UI help improve SA, interpersonal trust, and performance?

For the first question, the correlation between combined SA, and dining score and participant cooperation underscores the relationship between SA and performance (Fig. 3 and Fig. 4). The correlation between combined SA score and participant cooperation was further analyzed to establish a likely cause-and-effect relationship. At first glance, it might seem like the observed correlation (r=0.61) can be attributed to the two parallel facts that lower SA is observed for defecting strategies and participants are expected to cooperate less against those strategies. However, looking at the correlation between combined SA score and participant cooperation within individual co-diner strategies, positive correlations ranging from r=0.37 (against TFT with 33% defection) to r=0.77 (against true TFT) were found. This shows that participants' understanding of the game goes hand-in-hand with their cooperation and dining points. Having good SA helped players emphasize long-term gains (cooperating to encourage opponent cooperation) over short-term gains (defecting to earn higher dining points in a single round), ultimately increasing their total dining points and cooperation rate. It should be noted that in this game configuration participant cooperation was essential for good performance. Future research could benefit from looking at this relationship not just for cooperation-encouraging strategies, but also for cooperation-discouraging strategies.

To answer the second question, actual participant responses to co-diner behavior were compared against theoretical participant responses, computed as if they adhered to one of four strategies: always cooperate (All-C), always defect (All-D), tit-for-tat defecting only if both players defected (TF2T) and tit-for-tat defecting when at least one player defected (TF1T). The percent of times in which actual participant behavior matched hypothetical behavior will be referred to the consistency with a strategy, and is included in Table IV. As these strategies may produce the same response given the same co-diner behavior, it is possible for a participant's responses to be consistent with multiple strategies at the same time. Note that, in this analysis, strategies are applied to evaluate participant behavior; this contrasts with the use of strategies applied to the co-diners to probe participant behavior.

While no one strategy matched the observed human behavior across all co-diner behaviors, participant responses appear to be consistent with either TF2T or All-C. Given the similarity of the two strategies it is difficult to determine which participant behaviors are more consistent. Participant behaviors do not appear to be consistent with All-D, in general. Finally, to the degree that participant responses are consistent with a tit-for-tat strategy, participant responses seem more aligned with TF2T than TF1T, suggesting that a single cooperating co-diner may be sufficient to cause participants to cooperate; both co-diners may need to defect in order for participants to defect.

TABLE IV. CONSISTENCY OF PARTICIPANT BEHAVIOR WITH STRATEGY BY CO-DINER STRATEGIES

Strategy	TF2T	TF1T	All-C	All-D
TFT-1-0.67	85.6%	83.8%	88.0%	12.0%
TFT-1-0.83	80.8%	78.5%	85.4%	14.6%
TFT-1-1	75.0%	75.0%	74.7%	25.3%
TFT-0.83-1	68.8%	56.5%	70.4%	29.6%
TFT-0.67-1	69.9%	57.2%	57.1%	42.9%

Looking across UI levels, participant behavior matches either TF2T or All-C. As before, it appears difficult to determine whether participant behavior overall is more consistent with TF2T or All-C, but both strategies appear to describe participant behavior better than TF1T and All-D (Table V).

TABLE V. CONSISTENCY OF PARTICIPANT BEHAVIOR WITH STRATEGY BY UI LEVEL

Strategy	TF2T	TF1T	All-C	All-D
UI Level 1	76.8%	67.5%	74.9%	25.1%
UI Level 2	74.1%	68.9%	80.9%	19.1%
UI Level 3	73.6%	65.9%	63.3%	36.7%
All	74.6%	67.3%	71.9%	28.1%

For the third question, it was established that the UI does have a significant effect on participant behavior (Table I and Table II). From UI Level 1 to UI Level 2, increased levels of cooperation and dining points were observed. This can partially be explained by the fact that UI Level 2 provides additional historical information in the form of the player 'History' panel. In a similar experiment, Teng et al. [30] reported a decrease in cooperation rate when a game history panel was presented to participants. One significant difference in Teng et al.'s experiment is the inclusion of opponent scores in the game history panel -- something omitted from our experiment. The inclusion of opponent scores might have encouraged the participant to retaliate more in case of a defection. More research is needed to establish this subtle effect.

Interestingly, decreased levels of cooperation and dining points were observed from UI Level 2 to UI Level 3, partly contradicting our hypothesis. The only difference between UI Level 2 and UI Level 3 is the addition of the interactive and what-if scenario exploration encouraging 'Long Term' panel. Previous work by Teng et al. [30] reported reduced cooperation rates with the inclusion of a prediction table that was non-interactive and based on only one round of DD. Our improved 'Long Term' panel was designed to provide level 3 SA (projection) support and emphasize strategic thinking by being exploratory and presenting longer term dining scores [23, 25, 29]. Clearly, the inclusion of the long-term panel affected participants negatively in cooperation and dining points. One possibility for this outcome is the additional visual and cognitive complexity introduced by the long-term panel.

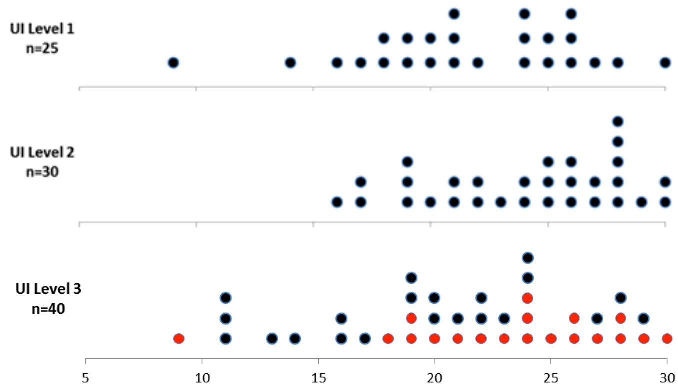

Fig. 5. Combined SA score dot plot. Participants who demonstrated a high level of interaction with the long-term panel (only present in UI Level 3) are shown in red.

The 40 participants who were shown the long-term panel were broken into two groups based on their observed interaction level with the projection widget. The projection widget has a total of two sliders which users control to specify an assumption about the opponent's tendencies (defection or cooperation) by clicking on the slider bar or moving the slider thumb (Fig. 1). The widget responds by reporting the point gains to be expected by making the assumption. The median number of clicks for all participants who were given the most complex UI was 6, therefore users that clicked 7 or more times on either slider are placed into the 'high interaction' group (n=19), while users who clicked 6 or fewer are placed into the 'low interaction' group (n=21). A post-analysis of these groups revealed that users in the low interaction group, on average, only interacted with the cooperation slider for a span of 00:57 while playing the game, and only interacted with the defection slider for a span of 00:32. Meanwhile, the high interaction group spent 04:02 and 03:40 on average, respectively. Mean cooperation rates for the low interaction and high interaction group are 52.6% (n=21) and 75.2% (n=19), respectively. Mean combined SA score for the low interaction and high interaction group are 19.4 (n=21) and 23.05 (n=19), respectively. Figure 5 shows a dot plot of the combined SA scores in the three UI-level conditions, with the low- and high- level interaction groups of UI Level 3 broken out. This analysis supports the possibility that the long-term panel might have confused at least some of the participants, thereby reducing their scores. However, participants who took advantage of the long-term panel exhibited higher SA scores. While UIs should provide integrated information and support higher levels of SA, designing effective UIs without overloading the operator remains a challenge. Future studies in this area could focus on specific aspects of what makes some participants confused instead of effective, as well as how to better provide level 3 SA support.

VI. CONCLUSION

Using the Iterated Diner's Dilemma as an abstract game scenario, we conducted a study on the impact of three different UI designs on achieved SA (measured) and on cooperation rate and game performance (observed). We found a significant effect for UI levels on total participant dining points (our performance metric) at the $p<0.05$ level [$F(2,92)=3.33$, $p=0.041$]. There was a marginal effect for UI levels on participant cooperation at the $p<0.10$ level [$F(2,92)=2.56$, $p=0.084$]. We also observed a strong correlation between SA and performance in the game. We believe that our results, including our difficulty in furthering Level 3 SA through interface design, can inform various other decision-making scenarios and help increase productivity through more efficient decision-making.

Additional experiments and further research are needed to better explain, model, and predict human behavior under different conditions, opponent strategies, and supporting UIs. We believe that this research can help to guide future work on how to visualize information, how to assist users, and constructively influence user behavior towards outcome-maximizing strategies. In ongoing work, we have begun to formulate computational models of the human cooperation behavior we observed, an effort that will contribute to the formulation of human trust models, and will at the same time allow us to scale up the exploration of believable multi-agent interaction beyond two computer-controlled agents. We are also interested in going beyond the confines of abstract trust games, and explore the interdependencies of UI Design, SA, Trust, and Performance in specific real-world scenarios without sacrificing the fully controllable nature of the experimentation and its generalizability.

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