The Impacts of Just-In-Time Social Networks on People's Choices in the Real World. Kwan Hong Lee, Andrew Lippman, Alex Sandy Pentland, Elenna R. Dugundji. The Third IEEE International Conference on Social Computing. October 9-11, 2011.

The Impacts of Just-In-Time Social Networks on People's Choices in the Real World

Kwan Hong Lee, Andrew Lippman, Alex S. Pentland
MIT Media Lab
Cambridge, MA 02139
Email: {kwan,lip,sandy}@media.mit.edu

Elenna R. Dugundji
Universiteit van Amsterdam
Amsterdam, Netherlands
Email: e.r.dugundji@uva.nl

***Abstract*—We address the question of how online social networks affect real world just-in-time decisions. The question is significant due to the pervasiveness of mobile devices in our just-in-time decisions and the way we are connected to our social networks across time and space at various scales, through these mobile communication channels. An empirical inquiry on mobile social influence and how these social networks impact our decisions will provide a framework for utilizing these virtual social influences to build persuasive mobile interfaces and provide timely decision aids that can help with our personal and social goals in the real world. We approach this problem through a real world experiment where we deploy mobile digital menus (Social Menu) in a restaurant and capture people's dish choices in just-in-time manner. The collected data is used to model how discrete choices are affected by the presence of physical and virtual social network information. Results show that virtual social network information though two orders of magnitude weaker than physical influence has influence on people's just-in-time choices and the modality in which social information is presented affects people's decisions in the dimensions of taste, time and price.**

I. Introduction

We constantly face uncertainties in life where we have to make choices with real time and limited information. In situations of uncertainty, human beings are wired to base their decisions on what other people do, what Cialdini denotes as "social proof"[1]. In the context of mobility, we constantly seek out information and short cuts to support our decisions, with mobile devices that assist us in just-in-time information gathering. For example, when we are undecided where to go for dinner, we will use the Yelp mobile application to help select a place. Social navigation provided by ratings and reviews by others help choose a place. The star rating provides a mental short cut and the one with the most number of stars among those particular cuisines of interest will lead our footsteps.

With the wide scale adoption of smart phones world wide, the mobile devices are increasingly becoming essential in location sensitive and time limited activities in the real world. They are becoming indispensable for information gathering during shopping, eating, meeting people, and traveling. During the past holiday season over 60% of mobile phone users used their phones to pre-shop before they went to the stores. In the physical world, unlike online transactions, people face cognitively limited situations where decisions have to be made on-the-go within limited time and space. We try to plan our schedules but many times we are faced with many options and have to make choices on the spot. In the case of grocery shopping, it has been shown that up to 70% of purchases are decided in the store[2] and follow up studies have shown 40∼60% range of unplanned purchases depending on the product category[3]. The main distinction of an offline purchase from an online purchase is the immediate gratification and the travel cost needed to come back if choice is not made at the physical location. Many times one is opportunistically traversing a particular store and if one needs to purchase at that store later, one needs to travel back to the store to make the purchase, while online purchases can be done at anytime and anywhere.

In our digital menu study, we investigated the impacts of social proof and the mental shortcuts due to mobile social information by instrumenting people engaging in real decisions in the real world. Mobile devices not only allow people to connect with other people at varying scales at anytime, from anywhere, but also allow us to capture and share people's economic activities in real time. Systems like the SmartRestaurant made lunch menus of a local restaurant accessible over the phone and allowed people to pre-order their lunch for pick up and make payments through the phone[4]. The resulting transactions are a valid proxy to the economic decisions and by instrumenting the choice architecture, we can understand the impacts of augmented social information propagated through the social network across time and space. Our goal is to understand the impacts of virtually mediated social influences on people's decisions and how it relates to time, taste, price and the physical social environment.

We approached this problem by creating a digital menu mobile application that was used directly during people's economic decisions at a local restaurant. People were informed to participate in the Digital Menu trial to evaluate the user experience of digital menus. They were randomly assigned to different groups that showed different social information when they logged in to the digital menu at the restaurant. The work was evaluated by analyzing the data from different experimental groups. The data we collect through the digital menus is used to model the strength of the influences of online social networks in people's just-in-time choices by employing discrete choice analysis.

Prior research in this area has focused on clever experiments with individuals and trained confederates that influence the research subjects in lab and real world settings. Majority of the experiments involved imagined situations and surveys[5]. Researchers have argued for further real world studies to capture multi-source, multi-target social influences over time and at scale[6]. Our approach allowed us to observe people in different social networks in the real world in a microscopic manner with large groups of people. We captured behavioral traces through the categories and dishes participants browsed, ordered. We captured the social network information they saw and the time they took to making their choices.

The results show:

1) Deviation of choices: about 56% of people made on the spot decisions that did not include any of their favorite dishes from the online pre-survey menu. This implies that people's choices can be changed by the current context and is in agreement with studies on shopping where people make up to 70% of purchase decisions in the store. Therefore, mobile guided just-in-time decision systems could have significant influence on people's choices.
2) Second degree friends have experienced as many common dishes as the first degree friends, indicating that friends of two degrees of separation can provide people with reinforcement in their choices.
3) Scale of influence: empirical data indicated that across time accessibility and scale of virtual social information may affect 2 to 10 times more people when people consider their choices compared to co-present physical social influence which is limited by the party on the table.
4) Time of engagement: friend's names (individuals) on the menu made people spend longer time to decide, showing that visibility of friend's choices encouraged one to spend more time to evaluate choices before making a decision.
5) Price factor: average price comparison between different experimental groups showed that anonymous *group of friends* had strongest influence in pulling people to choosing cheaper items.
6) Summary: Individual friends increased engagement, group of friends affected price choice and popularity served as shortcuts to decision making.

In the following section we discuss related works on social networks and people's choices, social influence and the use of mobile phones as probes to human behavior and layout the theoretical framework for this work. In section 3, we illustrate the approach and research method we devised. The details of the collected data and the results of the data analysis are presented in section 4. We conclude with the discussions on limitations, design guidelines and future research directions.

II. Related Work

Decades of research have been carried out to understand how people make decisions in varying social contexts. However, with the wide adoption of smart phones, social interactions we now engage in introduces a mix of virtual and physical interactions. Lab experiments and field studies of social psychologists have shown how social influence causes people to make irrational decisions and how such forces can be identified, managed and utilized for the benefit of achieving certain goals of persuasion[1]. We are extending these bodies of research by investigating the effects of mobile mediated influences, as mobile phones prevail in our lives. As people in the US are spending over 20 billion hours a year on Facebook, both online and mobile, it is unprecedented how such networks might impact people's choices in the real world. We attempt to further the understanding of the interaction of virtual social networks with the physical world by investigating the impacts of social information in decision making situations that are constrained by space and time.

A. Theories of Social Influence

It is well known that many times our choices are impacted by the social group we belong to. Social norms affect our choices as we pursue diverse goals in efficiency, health, social pleasure or financial savings. We may be influenced by who we know, who we are with, who we are watching or who we are thinking about. We tend to vote similarly to people whom we are close to and regularly meet[7]. More importantly, peer impacts and normative influences that are most situationally similar can affect the outcome of people's decisions[8].

The dish ordering process is an interesting setting for experimentation since one has a limited time to make a decision and many times people seek and ask others when choosing dishes. We all remember a time asking each one of our friends "What are you ordering?" and deciding to order the same dish or choosing a different dish. The situation is also not too risky since it does not penalize a person permanently for having had a bad meal. It also has time, taste, price and social dimensions to the setting. In our study we find that those that ordered more quickly in larger groups were those that followed other people's choices.

When people are seated together at a table and are sequentially choosing their dishes, the sequential order creates social influences that make people choose different dishes from preceding dish choices made by others. Ordering patterns in a Chinese restaurant were investigated to understand group ordering behavior and the results showed that on average people's dish choices diverged from other's choices seated on the same table[9].

Most recently, influence of social networks on social networking sites and cultural markets have revealed the effects of status in purchase behavior and the resulting unpredictability and inequality when social influence was introduced. Analysis of 208 users in the most popular social networking site, Cyworld in Korea, showed that there are three different groups of users with very different purchase behaviors[10]. The low status group of about 48% were not affected by social influence because they were not well connected and showed limited interaction with others in the social network. The

middle status group of about 40% were moderately connected and were influenced to generate 5% higher revenue. Finally the 12% of that were highly connected and represented the high status group were very active on the site but were negatively impacted by their friend's purchases.

Salganik et al.[11] discovered how social influence created inequality and unpredictability of success in an artificial cultural market. In order to study this, they created an artificial music download site to experiment music selection by real people. They separated the world into 9 different worlds with 1 world being the independent condition. The other 8 worlds were independent from each other and the participants in each world created social influences every time they downloaded a song. The socially influenced worlds were shown the number of downloads (popularity) next to the songs. The socially influenced worlds showed consistently higher *inequality*, popular songs became more popular and unpopular songs became less popular. It also created higher *unpredictability* of success of good quality content. Inequality was measured by the average difference in market share between all pair of songs and unpredictability was measured by the Gini coefficient.

We extended these studies by engaging and measuring different types of social influences (peers, peers anonymous and popularity) in a real world setting with real decisions. When there were social influences, people might converge, diverge (to try something different) or be reinforced to maintain their taste preferences. The ubiquity of social network and a mobile application to provide these social signals in real time on the menu provided us with the opportunity to understand and measure the strengths of peer effects (individual and group social effects) and popularity effects relative to each other. In contrast to the people who are co-present, these interventions introduced virtual representations of the social network that were projected across time and space. Although social groups with shared activities engage people more actively towards certain goals, how the different representations of virtual social influences affect real-time choices have not been investigated in detail.

B. Mobile Phones as Sensor Network

As Internet enabled phones proliferate, people have greater range of choices accessible at their finger tips while on the go, enabling last minute changes supported by location based services. Information is increasingly accessed in just-in-time manner as it becomes possible to access the web from anytime, anywhere through these mobile devices. Unlike in the past where meetings with friends were planned, the coordination is becoming more fluid with people joining and leaving at will and meeting locations dynamically changing. Last minute coordination is becoming more common place as people are always connected through mobile phones, resulting in hyper-coordination phenomena[12].

As people are more connected, real-time information is constantly generated by the social connections we have. Until the advent of the Internet, explicit connections such as calling over the phone or physical visits in close physical proximity were required for people to influence each other. However, the recent proliferation of social networking and mobile communications (Twitter on the mobile, status changes on Facebook) show that people are willing to publish openly and consume continuously in real time. With the mobile Internet, this is only amplified due to its hyper-connected nature. This "always on" behavior allows people to ask questions and get answers from others in brief time intervals, to coordinate on the fly and to influence each other in collective decision making.

Recent research with mobile phones have allowed us to capture in detail and understand our communication patterns, mobility patterns and to deduce how people behave in aggregate in the real world. Researcher have been using mobile probes[13] to capture and understand people's shopping behaviors. Bluetooth scanning and location based information from mobile phones have been used to capture people's social relationships in the real world, their patterns of activity and their habits[14]. AT&T study showed that people in New York City travel larger distances on average compared to people in LA despite their commuting distances being shorter[15]. In contrast, Barabasi's work showed how people in a city in Europe regularly do not leave the 3 mile radius during their daily life. The communication patterns based on frequency of incoming and outgoing calls also allow the tie strengths of customers to be estimated[16]. Instead of focusing on mobility patterns and tie strengths, we capture the choices people make through the mobile phones and inject social information to understand how just-in-time choices are affected when certain social signals are published from the social network.

Fogg iterates how mobile phones can be used for opportune interventions at the right time to improve individual and social behaviors[17]. In our modern world, people are wedded to these devices where many people spend more time with their mobile devices than any other human being. The nature of mobile phones being always available and responsive, allows them to be a continual channel of influence. Experiments performed with mobile applications in encouraging better eating habits, recycling behaviors and healthy activities have shown positive outcomes in encouraging behavioral changes. They also document that connecting with people who are enacting on similar behavioral changes strengthens the effectiveness of the application due to the power of social comparison. We investigate these social influences more in detail in the context of just-in-time setting to see how different manifestations of social information affect people's choices.

III. METHOD

In this section, we describe the procedures we took in carrying out the study, the design choices we made and the challenges we faced. We used the mobile phone as a probe to instrument people's choices and provide subtle interventions to observe the effect of online social networks and their propagated choices during just-in-time choices in the real world.

A local sea food restaurant was chosen due to their willingness to support our experiment. However, there were other

benefits from running the experiment at this restaurant. The restaurant is a fairly high-priced restaurant where local people do not go to regularly. As a result, this reduces the impact in our study of habitual preferences towards certain menu items which people might have if they would regularly frequent the restaurant. Since it is a sea food restaurant, lobster and fish are usually people's favorite choices, but it also has a lot of menu items that make it difficult to decide (on the order of 50 entrées). This also creates a situation where participants would not readily know what menu items are available at the restaurant. Although all our participants were from the local Cambridge-Boston area, usually a majority of the customers served by the restaurant are tourists and business people. The average dish price is about $25, making the decision a little bit risky even though we subsidized $10 for each participant. Such a restaurant setting provides an adequate environment for experimenting with just-in-time social influences by introducing several factors of uncertainty in people's choices.

A. Pre-Survey

Over 1000 people participated in the pre-survey, but only a subset of the people came to the restaurant. Over the seven months of the trial, 270 participants dined and 693 dish choices were recorded through the Social Menu. People used Facebook Connect to participate in the survey and opted in to sharing their friends list. People were recruited throughout the MIT area and local apartments around Cambridge by distributing flyers and e-mails. Advertisements were also posted on Craigslist. Naturally, people notified their friends to join the study, creating potential homophily bias. However, it also allowed the social network of participants to be composed of more real local friends than just Facebook friends. People who signed up were those inclined to eat seafood, creating a selection bias towards a population that finds seafood desirable. Many of the participants were affiliated with MIT and were in their 20's and 30's. This also created bias towards people selecting cheaper menu items when they actually dined at the restaurant.

B. Social Menu as Mobile Probe

An iPhone digital menu was used to capture people's ordering behavior (menu browsing and selections) at the restaurant. The Social Menu was an iPhone application that was approved and distributed through the iTunes App Store. However, since less than 25% of people who signed up for the study had iPhones, we placed 5 iPhones at the restaurant to be used as the menu. After checking in, the patrons were led to the table and given the iPhones instead of the paper menu.

The menu was designed for small screened smart phones such as the iPhone and the Android and we achieve this by creating a hierarchical menu. The hierarchical menu first displays a list of categories (i.e. Appetizers, Sides, Fish, Surf and Turf). Special categories like Chef's Choice and Friends' Choice are added to capture how many people are interested in these categories. Once a user clicks a category, the menu items are displayed. In order to track the order, one clicks on a menu item and taps the "Add to Order" button (Figure 1) to add an item to their final order.

Fig. 1. Adding an item to the order

C. System Architecture

Clicking behavior on the Social Menu was communicated to the server in real time through the 3G network to track what users clicked and how long they used the digital menu. Since the system was not integrated with the restaurant, the waiter still took the final order from the patrons.

Patrons have to login to the menu with their e-mail and PIN which they created during their pre-survey. They also have to enter the table code that is given at check-in to identify whether people were sitting at the same table and to verify that they have logged in from the restaurant. The pre-survey had to be completed before coming to the restaurant in order to record in advance people's tastes and their favorite dishes without social bias. The pre-survey results were then also presented on the Social Menu as items that people wanted to eat, in addition to the on-going recorded informationo about what people have actually ordered.

When people signed up, people opted-in to the consent form to share their Facebook friend network. Facebook Connect was used for authentication and the Facebook API is used to poll the list of friends to check if any other Social Menu users were Facebook friends of the user (Figure 2). The backend server used this social network to incorporate social elements to the mobile digital menu.

D. Experimental Groups

People were assigned to random experimental groups when they logged-in to the Social Menu at the restaurant. People who signed-in with the same table code were assigned to the same experimental group. The 4 groups were:

- Group 1: Control group that sees the plain menu
- Group 2: Friends group that sees the *names* of their friends that actually ordered the dishes underneath each dish name as well as the names of the friends that desired those dishes during pre-survey (Personal influence, individual effect)

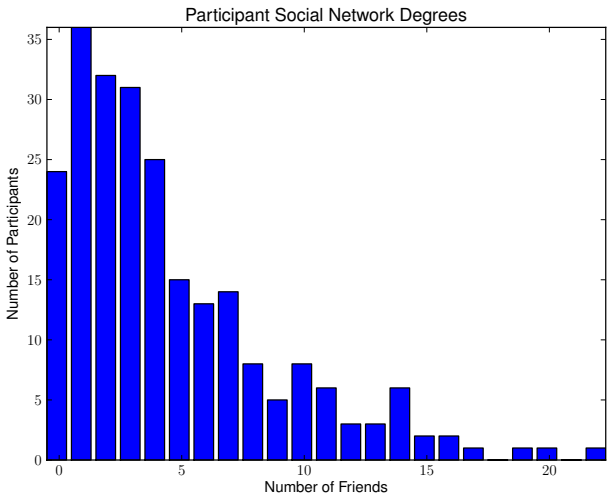

Fig. 2. Number of friends that participated. Friend relationship was determined by Facebook friendship. 80% of participant had less than 5 friends that participated in the study ($N = 270$).

- Group 3: Anonymous popularity group that sees the *number of other participants* that have ordered the dishes as well as the number of other participants that desired those dishes during pre-survey (Informational influence, popularity effect)
- Group 4: Anonymous friends group that sees the *number of friends* without their names that ordered the dishes as well as the number of friends that desired those dishes during pre-survey (Normative influence, group effect)

The social cues were inserted below each menu item in the experimental groups (groups 2∼4) as in Figure 3. Each type of label was designed to trigger different type of social influence.

IV. Analysis and Results

We employ statistical methods to assess the effects of social information on people's ordering behavior. First by comparing people's choices from the pre-survey to the actual orders, we assess how much they diverted in their actual choices at the restaurant from their stated favorite dishes in the pre-survey. Next, discrete choice analysis is used to assess the what factors influence the categorical choices. Price effect is also investigated to understand how different social information affects people's choices regards to price. Finally, we analyze the distribution of time to order and find that different experimental groups have variation in time to order.

A. Social Effect: Co-present and Virtual Influence

We compare the potential social influence in people's choices by identifying whether a person's order at the restaurant was same or different from their preselected dishes during the pre-survey. People chose 5 favorite dishes during pre-survey which are used as pre-selections to compare against what was actually ordered at the restaurant. The metric we use for quantifying social influence in menu choice is given by counting the common dishes between people's orders.

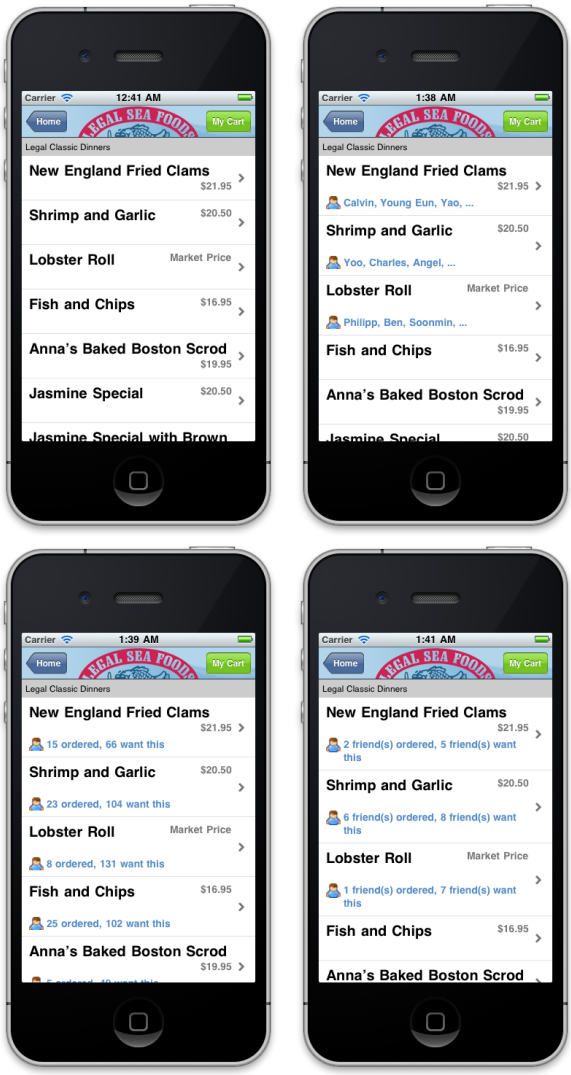

Fig. 3. Different menu arrangements by experimental groups. Top left: control group, top right: individual friends (personal influence), bottom left: popularity group (informational influence), bottom right: group of friends (normative influence)

Co-present and virtual influences across time are compared. Co-present influence occurs when people are seated at the same dining table. We can track whether they were seated together by the common table code that they entered when they signed-in to the menu. Across-time influence occurs when people are able to see the past choices of others through the menu and click on that menu item to consider the dish.

In order to quantify the contextual social influence we define scale and strength. The *scale* of influence is the number of people that may affect one's choice. The scale of virtual influence is 2 to 10 times larger than local influence as that many more people have ordered the same dish and are virtually present on the Social Menu through the iPhone than are physically present seated at the table. The *strength* of influence is the magnitude of the likelihood that can change people's choices when someone is co-present or virtually

present through the menu. We can measure these parameters by finding out what percentage of the people in each group followed someone present virtually versus followed someone present physically.

In our study, we find that over 56% of all orders had deviation from their pre-selections (changed taste) indicating that more than half the time, people's choices could be changed from their favorites. In order to analyze the deviations we define the following:

- Maintain Virtual: Patron ordered from one of their favorite dishes and others also ordered the same dish in the past
- Deviate Virtual: Patron did not order a favorite dish, but the dish was also chosen by others in the past
- Maintain Local: Patron ordered from one of their favorite dishes and someone on the table ordered the same dish
- Deviate Local: Patron did not order a favorite dish, but the dish was also chosen by someone on the table

TABLE I
RELATIVE STRENGTH OF VIRTUAL AND LOCAL SOCIAL INFLUENCE THAT AFFECTED PEOPLE'S MAINTAINING AND DEVIATING FROM THEIR PRE-SELECTIONS

Group	Maintain Virtual	Deviate Virtual	Maintain Local	Deviate Local
Control Group 1	**40%**[a]	**33%**[a]	11%	7%
Group 2	24%	29%	11%	5%
Group 3	30%	19%	7%	10%
Group 4	10%	36%	5%	4%

[a] Control group results serve as baseline

If we investigate further what caused these deviations in the different experimental groups, we see that virtually mediated social information reduced deviation compared to the 33% baseline deviation that occurred by chance in control group (Deviate Virtual, column 2, row 1 in Table I). Similarly, people also chose less of their favorites in social groups (Maintain Virtual, column 1 in Table I). This seems to indicate that the virtual information actually pushed people to choose something away from their original preferences in the pre-survey.

It is also noteworthy that in the friends' groups (experiment 2, 4) there are more diverts through virtual information (comparison of columns Maintain Virtual and Deviate Virtual) indicating that friends choices make one divert from one's pre-selections and try something different. This is similar to friends serving as guides when discovering new online content[18]. In the case of experimental group 3, the popularity information actually influences people to stick with their favorites more than diverting them.

B. Model of Just-In-Time Choices

In this section we analyze how people's categorical choices were affected when ordering at the restaurant using the Social Menu. Since there are 10 categories versus 88 items, using the categories allows us to create a simpler model to assess the effects of social influences. Discrete choice models are created to measure the effects of social influence on just-in-time choices. Biogeme software was used to calculate the coefficients (β's) that express the dependence of social factors on the alternative categorical choices[19].

U_{in} represents the utility function for the categorical choice made for a category i for participant n. There were total of 693 orders ($N = 693$ records) that we used for the regression. We are modeling the dependence of a particular respondent's choice for each of the 10 categories in the menu dependent on the social factors (Table II), which serve as independent variables in our model. We model the utility function for each category i for participant n by Equation 1. In the case of control group $C_{oin} = 0$ and $C_{win} = 0$ since there were no virtual social information present on the menu.

$$U_{in} = \alpha_i + \beta_o C_{oin} + \beta_w C_{win} + \beta_t C_{tin} + \beta_f C_{fin} \quad (1)$$

TABLE II
VARIABLES FOR THE DISCRETE CHOICE MODEL

Variable	Description
i	index for category
n	index for participant
α_i	Alternative specific constant for category i (bias)
C_{oin}	Fraction of virtual people who actually ordered from the category i
C_{win}	Fraction of virtual people who desired/wanted from the category i in the pre-survey, presented to participant n on the social menu
C_{tin}	Fraction of other people in participant n's party sitting at the table who ordered from the category i
C_{fin}	Fraction of times participant n indicated a dish from the category i as a favorite choice in the pre-survey

Alternative specific constants (expressed as α) captures the bias for each category and play the same role as an intercept in linear regression. We have 693 records (Table III) of dishes by individuals that participated in the restaurant and the data is used to calculate the β's through multinomial logit regression. Since a single participant often makes choices for multiple items, there is an inherent complex correlation between choices made by a single individual which we have not addressed yet in our modeling. For example, if a participant chooses a main dish, it is less likely the participant will choose another main dish as part of the same order, but instead rather more likely that the participant would choose a side dish or a starter, to complement the main dish. We leave this aspect of modeling for future research.

TABLE III
SUMMARY OF DISHES AND ORDERS PER EXPERIMENT

Experiment	N_d[a]	N_o[b]
1	170	114
2	219	118
3	184	119
4	120	80
Total	693	431

[a] N_d is the total number of dishes per experiment
[b] N_o is the total number of orders per experiment

From the analysis we find that $\beta_t = 0.409$ is 15% stronger than $\beta_f = 0.353$ (p <0.01). This indicates the stronger magnitude of physical social influence relative to the strength of individual taste in the selection of the dishes. The virtual social influence effects measured by β_o and β_w did not result in statistically significant coefficients. Though in the case of experiment 2 where individual friends information was present, what the friends desired (β_w) showed weak statistical significance that resulted in people diverting to different categories. More specifically when your individual named friends want something (experiment 2), in the case of Legals Lobster and Chef's choice categories, your friends lead you to more likely choosing these dishes compared to other experimental groups.

TABLE IV
NUMBER OF DISHES ORDERED PER EXPERIMENT AND PER CATEGORY

Exp	Category ID									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	41	20	13	4	18	7	32	11	18	6
2	54	32	16	9	23	4	33	18	24	6
3	36	22	9	8	20	7	39	14	23	6
4	26	15	8	4	17	5	18	10	14	3
N_c[a]	157	89	46	25	78	23	122	53	79	21

[a] N_c is the number of dishes per category

In the popularity group (experiment 3), C_o and C_w is of greater scale due to the social information being polled from the whole population. The β_t came out to be weaker than the other experimental groups (including the control group) indicating that people who are co-present had weaker effect while β_f resulted stronger. This can be explained by individual's favorites being reinforced by the popularity information and making the physical friends influence a little bit weaker than the other experimental groups (including the control group).

We also hypothesized that female participants may be more highly influenced by the virtual social information. We found that in the control group females had preference for Soups and Salads (C=2), Legal Classic Dinners (C=5), Completely Legal (C=9). In the experimental group 2 with individual friend's names, virtual social information on what other people had ordered had moderate effect (p <0.16) and the categorical interaction coefficients were strongest with Soups and Salads (C=2), Surf and Turf (C=3) and Sides (C=1). This alludes to the virtual social influence being influential in guiding towards different category of entrées.

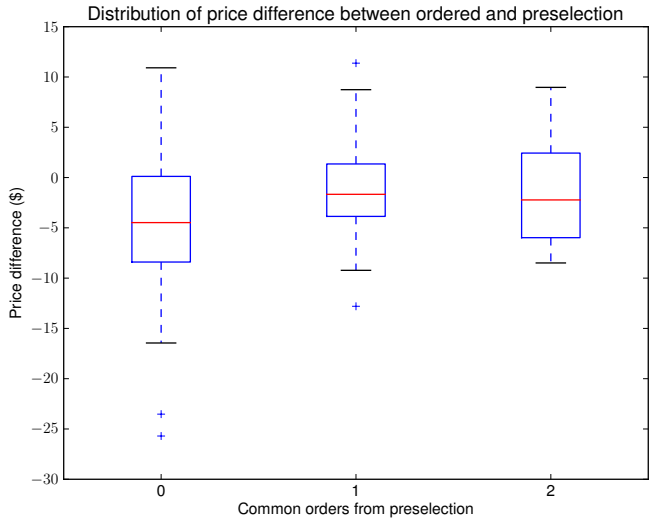

Fig. 4. Effect of price on the ordering behavior of the participants. People who diverted from pre-selection had chosen items that are $4.5 cheaper (-$4.5 for $x = 0$) and those who selected common dishes from pre-selection had lower median price difference (-$1.6 for $x = 1$ and -$2.2 for $x = 2$) that was statistically different ($p < 0.01$) indicating that people who changed sacrificed their taste for economical reasons.

We plan to extend this modeling effort in three dimensions to further quantify the virtual social effects. Due to the limited number of records, there might be a limitation in using the current dataset to model item level social effects (Table IV). However, we should be able to further analyze and quantify the social effects in price segments (2 segments: below $15 and above $15) and table sizes (2 segments: single participant, multiple participants). We also will investigate deeper by modeling the effects of social network structural properties (i.e. centrality and betweenness measures) by incorporating them into the models.

C. Price and People's Choices

In this section we determine the extent price affects people's decisions. The participants are potentially sacrificing their tastes due to economical reasons. By comparing the average price of pre-selection with the price of actual item that was ordered, one can find out whether they have diverted in selection due to price. The results show that people chose items that were on the average $4.50 cheaper than the average price of those items selected during pre-selection when they diverted from their pre-selections (Figure 4). The results show that 33% of the orders had items that are cheaper by more than $4.50 from the average price of the preselected entrées.

We also investigated whether sitting in groups or having virtual influence made people choose different price points causing price matching behavior due to social influence. We compared the average price of a person's order when individually ordered versus average price when ordered in groups. When we compared people in different table sizes, the median price increased among those who dined together in larger groups. This indicates that co-present friends make people spend more at the restaurant.

Among those that diverted due to price, different social information showed different magnitudes in diverting people from their pre-selections. The following percentages diverted due to price in different experimental groups.

- Group 1: 30%
- Group 2: 33%
- Group 3: 39%
- Group 4: 43%

Although the results were not statistically significant, the comparison between experimental groups showed that control group ordered more expensive while the virtual social groups ordered cheaper items possibly guided by other people's cheaper choices present on the menu. This indicates that individuals have less influence in people choosing cheaper items and that normative influence by group of friends had strongest impact. People consider it acceptable to choosing cheaper items when anonymous group of people make such choices, but when they see particular friends that have chosen cheaper items, one does not want to be categorized with that particular friend's behavior.

D. Effects on Time to Order

The ordering time provides an aggregate metric of people's browsing behavior. We can categorize people into three different groups based on the time it took people to order.

1) Segment 1: 0-300 seconds (Up to 5 mins - Knows what to order or decided to follow someone)
2) Segment 2: 300-700 seconds (5 to 12 minutes - Exploring through the menu in dilemma)
3) Segment 3: greater than 700 seconds (12 minutes and above - Uncertain about their choices)

The different time segments show how certain people are in making choices, but also shows how susceptible they are to social information. People who chose what their friends have chosen in Segment 1 are the most susceptible. Those that chose items in the control group in segment 1 are those people that are certain in their choices. When we compared the duration among experimental groups in each duration segment we find that Segment 2 and Segment 3 have significant differences among experimental groups with $p < 0.01$ in Segement 2 and $p < 0.05$ in Segment 3. This indicates that the social information influenced the order duration of different experimental groups when people were in dilemma or uncertain about their choices.

Those that take shorter time either know what they want or converge in choices quickly because they see others who have ordered on the table or among virtual peers in the past.

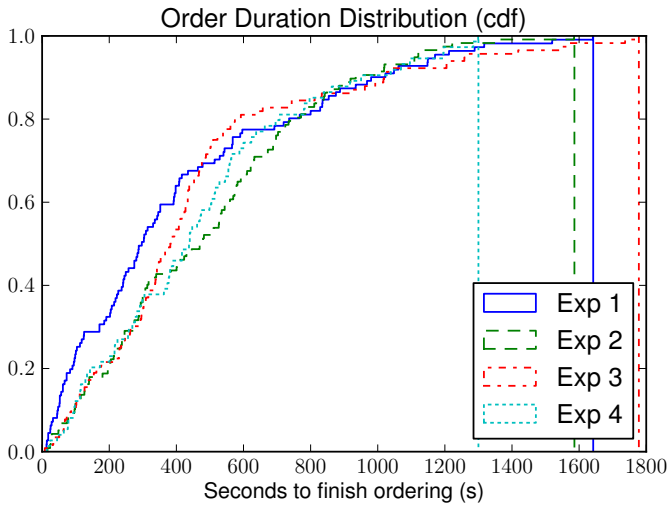

Fig. 5. Social menu affects people's ordering behavior, resulting in more exploration time through the menu.

Those that take longer in time tend to divert from their favorite dishes.

The people in the control group generally finalized the dishes to order in less time. On average people took 130 seconds ($\sim$2 minutes) less to order when they had bare menu versus social menu. People who had their friend labels (experiment 2) took the longest time to order and was significantly longer than control group's duration ($p < 0.05$, Figure 5). This suggests that the social information serves as a means to increase the decision time and individual friend information should be used to increase engagement time.

The ordering duration was compared between table sizes (number of people dining together) to find out the effects of social influence by the co-present diners. Table size had effect on some groups with respect to their ordering time. In the case of different table sized groups, groups with two people differed significantly in their ordering times ($p < 0.01$) compared to other table sizes and took the shortest average time. Control group (experiment 1) had their order duration increase with the table size. In the friends group (experiment 2) the ordering time was also statistically different for the different table sizes with ordering time decreasing as table size increased ($p < 0.05$). We believe this happened because of the social information provided real time feedback when one of the friends on the table decided on an order, allowing one to see all of them on the menu and make one's choice accordingly.

V. Discussion and Future Work

Social information is being universally tagged to every object, transaction, and service. All applications that are built nowadays already have "Share this" feature or "Like it" features. As always-on communication becomes ubiquitous, one's actions and decisions can be readily shared and will affect the decision of others in much shorter time frames than

we have experienced in the past. As a result, people will be communicating with more people than they have imagined as they consume products, services and content.

Just as we tend to become less aware of the travel path when using GPS navigation for driving, social cues in our choices may blindly drive many of our decisions. As we get used to them, lack of such information might create greater uncertainty in our decision making process. It would be important to measure how one becomes accustomed to such information and what experience one has when one cannot obtain such information at the time of decision making.

Further research in many different decision making scenarios are needed to fully understand the implications of social information on people's just-in-time decision making process. Mobile phones are essential elements to this as they are used for on-the-go, in-situ decision making. We get instant messages from friends asking to change time and venue. Alternatives choices are considered by gathering information through the mobile phone and therefore phones are becoming an essential information mediator for shopping.

The results of the study could have been facilitated by using fake social information. This would have allowed us to better observe effects when there are not too many users involved in the trial. For those that plan to perform similar studies, utilizing the information from pre-survey to forge social information could lead to stronger results. We decided to track the evolution in a real world setting and attempted to only use true information generated by the participants.

Further investigation into wider spectrum of product categories will reveal how social network can be useful or harmful for reducing uncertainty regarding product decisions. In the context of economics, friends with purchase experience can help reduce information asymmetry about products and services that can create more efficiency in the market. An open question that will be answered with similar studies is how social information affects people's decisions in different categories of products. There has been previous studies that investigated peer effects and how normative and informational influences affect purchase decisions in different product categories[5]. Most of them involved imagined situations. From our study, we have gotten insights on how the situational context, individuals susceptibility and preferences can change in the real world. Understanding how readily accessible social network affects people's attitudes and choices in different product categories will lead to answering potential approaches that reduce information asymmetry in the market.

From a behavioral aid point of view, the virtual social networks can be utilized to help guide individual's behavior (healthier or cheaper eating habits) in subtle ways. By connecting people with common goals in real time, it can affect the choices people make and guide them closer towards their goals. This can be evaluated through the interventions and behavioral changes observed in larger scale.

VI. Conclusion

Despite our particular propensity towards taste, the results show that people tend to make just-in-time decisions that might be different from what they have indicated as favorites through their pre-selections. There can be many factors towards this decision. Price plays a role where people are willing to sacrifice their tastes for economical trade-offs. People who visit together might change choice based on what the other person has chosen to increase diversity of dishes. They might also want to try something completely new.

The experimental results show that individual friend identifiers are most useful for increasing engagement with the menu potentially providing longer consideration time. It also has the side effect of making people choose dishes that others have not chosen. The popularity information is most useful as short cuts to decision making with the ability to reinforce preplanned choices if larger community agrees with the goals. The normative influence from anonymous group of friends would be most useful in nudging people when there is an economic parameter in the decision making scenario.

Social Menu research showed that virtually mediated social information can impact people's choices in different dimensions when presented at the time of decision making. Various modes of presentation of the social information led to different behavioral outcomes. With the advent of mobile commerce and augmenting physical world with virtual information, it is important to consider what social information helps people to decide better and make more informed or happier decisions. Merely tagging things with social information may lead to unforeseen consequences as people's choices can be fickle.

References

[1] R. B. Cialdini, "The science of persuasion. (cover story)," *Scientific American*, vol. 284, no. 2, pp. pp. 76–, February 2001.

[2] V. Packard, *The Hidden Persuaders*. Pocket Books, 1957.

[3] D. W. Rook, "The buying impulse," *The Journal of Consumer Research*, vol. 14, no. 2, pp. 189–199, 1987. [Online]. Available: http://www.jstor.org/stable/2489410

[4] J. Lukkari, J. Korhonen, and T. Ojala, "Smartrestaurant: mobile payments in context-aware environment," in *ICEC '04: Proceedings of the 6th international conference on Electronic commerce*. New York, NY, USA: ACM, 2004, pp. 575–582.

[5] R. Makgosa and K. Mohube, "Peer influence on young adults' products purchase decisions," *African Journal of Business Management*, pp. 64–71, June 2007.

[6] W. A. Mason, F. R. Conrey, and E. R. Smith, "Situating Social Influence Processes: Dynamic, Multidirectional Flows of Influence Within Social Networks," *Personality and Social Psychology Review*, vol. 11, no. 3, pp. 279–300, 2007. [Online]. Available: http://psr.sagepub.com/cgi/content/abstract/11/3/279

[7] N. A. Christakis and J. H. Fowler, *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives*. Little, Brown and Company, 2009.

[8] N. J. Goldstein, R. B. Cialdini, and V. Griskevicius, "A room with a viewpoint: Using social norms to motivate environmental conservation in hotels," *Journal of Consumer Research*, vol. 35, no. 3, pp. 472–482, 2008. [Online]. Available: http://www.journals.uchicago.edu/doi/abs/10.1086/586910

[9] D. Ariely and J. Levav, "Sequential choice in group settings: Taking the road less traveled and less enjoyed," *Journal of Consumer Research*, vol. 27, no. 3, pp. 279–290, 2000. [Online]. Available: http://www.journals.uchicago.edu/doi/abs/10.1086/317585

[10] R. Iyengar, S. Han, and S. Gupta, "Do Friends Influence Purchases in a Social Network?" *SSRN eLibrary*, 2009.

[11] M. J. Salganik, P. S. Dodds, and D. J. Watts, "Experimental study of inequality and unpredictability in an artificial cultural market," *Science*, vol. 311, no. 5762, pp. 854–856, February 10 2006.

[12] R. Ling and B. Yttri, "Hyper-coordination via mobile phones in norway," pp. 139–169, 2002.

[13] S. Hulkko, T. Mattelmäki, K. Virtanen, and T. Keinonen, "Mobile probes," in *Proceedings of the third Nordic conference on Human-computer interaction*, ser. NordiCHI '04. New York, NY, USA: ACM, 2004, pp. 43–51. [Online]. Available: http://doi.acm.org/10.1145/1028014.1028020

[14] N. Eagle, A. S. Pentland, and D. Lazer, "Inferring friendship network structure by using mobile phone data," *Proceedings of the National Academy of Sciences*, vol. 106, no. 36, pp. 15 274–15 278, 2009. [Online]. Available: http://www.pnas.org/content/106/36/15274.abstract

[15] S. Isaacman, R. Becker, R. Cáceres, S. Kobourov, J. Rowland, and A. Varshavsky, "A tale of two cities," in *HotMobile '10: Proceedings of the Eleventh Workshop on Mobile Computing Systems & Applications*. New York, NY, USA: ACM, 2010, pp. 19–24.

[16] J.-P. Onnela, J. Saramäki, J. Hyvönen, G. Szabó, D. Lazer, K. Kaski, J. Kertész, and A.-L. Barabási, "Structure and tie strengths in mobile communication networks," *Proceedings of the National Academy of Sciences*, vol. 104, no. 18, pp. 7332–7336, 2007. [Online]. Available: http://www.pnas.org/content/104/18/7332.abstract

[17] B. J. Fogg, *Persuasive Technology*. San Francisco, CA: Morgan Kaufmann, 2003.

[18] G. Szabo and B. A. Huberman, "Predicting the popularity of online content," *Commun. ACM*, vol. 53, no. 8, pp. 80–88, 2010.

[19] M. Bierlaire and M. Fetiarison, "Estimation of discrete choice models: extending biogeme," *STRC*, September 2009.