**THE EFFECT OF SOCIAL INTERACTIONS ON TRAVEL BEHAVIOUR: AN EXPLORATORY STUDY USING A LABORATORY EXPERIMENT**

**Yos Sunitiyosoa\*, Erel Avinerib, Kiron Chatterjeeb**

aSchool of Business and Management, Bandung Institute of Technology (ITB), Ganesha 10, Bandung 40132, Indonesia.

bCentre for Transport & Society, University of the West of England, Bristol, Frenchay Campus, Coldharbour Lane, Bristol BS16 1QY, UK

\*Corresponding author. Email: yos.sunitiyoso@sbm-itb.ac.id.

Tel: +62 (0) 22 2531923. Fax: +62 (0) 22 2504249

***Abstract***

This study demonstrates the use of a laboratory experiment for investigating the effects of social interaction on the dynamics of travellers’ choice behaviour. A small-scale exploratory experiment is carried out. Analyses are conducted using statistical tests, descriptive methods and learning models to investigate the net and gross effects of social interaction behaviour, as well as the the direction of change of each individual’s behaviour. The study shows how a laboratory experiment can enhance understanding of the effects of social interaction on travellers’ behaviour at both the system and individual traveller levels.

**Keywords**: travel behaviour, social interaction, laboratory experiment

1. **INTRODUCTION**

The understanding of how travel behaviour develops and changes over time is important in order to identify possibilities for influencing behaviour. A traveller’s decision to change behaviour may be influenced by new information gained from his/her own experience, or may be influenced by the experience and behaviour of other travellers, Hence social interaction between individuals may have an influential role in travel behaviour.

Many decision making situations in transport may be described as social dilemmas, where travellers share the public goods (e.g. roads) and make travel decisions (e.g. travel mode choice, route choice) that influence the well-being of other road users. According to Dawes (1980), a social dilemma can be defined by two principles: firstly, the outcome of a non-cooperative choice is always more beneficial for an individual than a cooperative choice, and secondly, if all individuals make the cooperative choice then everyone will benefit. The classic example of a social dilemma in transport is the choice between travelling by private car or public bus where both modes share the same road space. If all commuters travel by car then they all face severe congestion. When some individuals choose to switch from car to bus, a number of cars are removed from the road and therefore marginally reduce the traffic level and improve the journey for all users. However many people would prefer satisfying their personal well-being (e.g. personal benefits offered by private car) than collective well-being. This results in traffic congestion and other environmental impacts.

Travel demand management (TDM) measures have been used to address the social dilemma and studies have indicated that social interaction and social learning may have important roles in the successful implementation of TDM measures (e.g. Jones and Sloman, 2003; Taniguchi and Fujii, 2007). According to Simon (1956) in his satisficing theory, even if it appears that a decision is made by an individual independently of others, it often involves influence from family, friends, peers or members of a reference group. An individual, making a choice, is influenced by different people in his/her social network. Their influence on the individual choice might change as the decision process evolves. Individuals are also not indifferent to the outcomes received by others (Messick, 1985). Travellers sometimes take into account and are concerned about choices made by other travellers (Van Lange et al., 2000).

Although acknowledgement of the need to study social interactions in relation to travel behaviour is growing, there is not much experience with measuring social interactions in the transportation field yet. The study of social interactions and their influence on travel behaviour has been mostly studied in the framework of multi-agent models, which focus on studying the patterns of social interaction among a population of agents (e.g. Arentze and Timmermans, 2007) and on modelling the diffusion of transport technologies into a population of agents (e.g. Stephan et al., 2007). To the authors’ knowledge, the effects of social interaction on travellers’ intentions and behaviours have not been explored more directly, i.e. by observations of choices in a laboratory or field environment.

It might be argued that many of the behavioural assumptions of transport models are frequently made without reference to existing theories in the behavioural sciences (Stern and Richardson, 2005). Even if efforts have been exerted in modelling the factors that motivate and influence individuals’ travel behaviour (e.g. desires, constraints, habit, learning, social norm), individuals’ use of different decision making procedures in different contexts suggests the need for hypothesis-specific empirical studies, which include laboratory-based experiments. These studies are required to identify the incidence of different decision making procedures, the factors that influence them and the conditions under which these procedures change. In the transport field, laboratory experiments have been used to study travellers’ choice behaviours, particularly the dynamics of route choice decision making (e.g. Mahmassani and Jou, 2000; Selten et al., 2004) and the effects of traveller information services or ITS on travellers’ departure time and route choice making (e.g. Mahmassani and Liu, 1999). However, the effects of social interaction and social learning on individuals’ choice making and behaviour have not been investigated in the transport context.

This paper introduces the use of a laboratory experiment for exploring the effects of social interaction on travellers’ choice making and behaviour. A hypothetical employer-based demand management initiative to reduce employees’ car use, which is framed as a social dilemma situation, is used in the experiment. One of the main features designed into the experiment is a social interaction feature for participants to communicate and exchange information in a repeated decision making environment. The paper is structured as follows. Section 2 briefly reviews relevant studies of social interaction and social learning in travel behaviour and explains the types of social interaction and social learning studied in this paper. Section 3 describes the detailed design of a laboratory experiment to explore the effects of social interaction on travellers’ behaviour, while Section 4 presents the results of a small-scale experiment run. Section 5 discusses the implications of the results and Section 6 highlights further useful studies that may follow from this study.

1. **SOCIAL INTERACTION AND SOCIAL LEARNING**

Jones and Sloman (2003) argued that the existence of the ‘snowball effect’, a phenomenon where long-term effects may be greater than short-term ones, increases the effectiveness of travel demand management measures over time. They stated that there is some evidence that changes may be slow at first, but then accelerate as people see their colleagues and neighbours changing their travel behaviour. Exploring the implementation of voluntary household travel behaviour change programmes, Ampt (2003) argued that strategies that require households to diffuse information both between households and ultimately across communities are likely to be effective. When a person tells someone about what they are doing, they are both reinforcing their own behaviour in the process and giving a level of commitment. This way of communicating is often called ‘word-of-mouth’ communication. A study by Shaheen (2004) considered this way of communicating as a means to diffuse the change of behaviour in a car-sharing programme. Taniguchi and Fujii (2007) in their study of a community bus service found that communication between friends and family plays an important role in promoting bus use. These studies give some indication that social interaction, and the social learning process that follows, might have an important role in the dynamics of travellers’ change of behaviour.

There are at least three possible types of social interaction based on levels of intensity and directness of communication. Directness refers to the way information is gained or exchanged and not the physical presences of individuals who communicate with each other. The first type of social interaction is an *interdependent situation* where individuals’ decisions affect not only themselves but also other travellers (e.g. traffic congestion caused by excessive number of car users on the road). This is the basic level and an indirect interaction since some individuals may not know or realise that they are actually interacting with others through their travel choices.

The second type of social interaction happens through *observation* by a traveller of others’ choices. This type of social interaction is more direct than the first type but it is one-way and does not involve communication or exchange of information with other travellers. Our previous work (Sunitiyoso et al., in press) found that this type of social interaction affects participants’ behaviour and providing more complete ‘social’ information regarding other participants’ choices increases cooperative behaviour compared to the situation when the information is more limited.

The third type of social interaction is the most direct interaction which happens through *communication* or exchange of information between travellers regarding their travel experience (choices and their outcomes) and/or intentions. The communication in this context covers all possible communicating media, including face-to-face, telephone, video and text messaging. This study mainly focuses on the third type of social interaction which is studied by enabling discussion and exchange of information through communication media.

The scale of social interaction depends on the size of a group (or society). In a small group, the actions of a group member may receive high influence due to the feeling of belonging and responsibility one has as a member of a small group. Within a small group, where actions will be easily seen by other group members, an individual may have more responsible feelings about participating in a cooperative action according to the group-interest without thinking of ‘free-riding’ (enjoying benefits at the expense of others). In a larger group, those feelings may not exist so strongly. Olson (1965) stated that small groups are more likely to secure voluntary cooperation than larger ones. He found that repeated social interactions through *communication* between participants can promote cooperation. In a mode choice context, more car users might reduce their car use and take the bus to work if they are aware that others do the same.

Social interaction enables social learning, where individuals learn from others’ experiences, preferences or observed behaviours. In travel behaviour, social learning has not been thoroughly investigated, despite evidence from other disciplines (e.g. economics and behavioural sciences) that this kind of learning process is influential and important (e.g. Pingle, 1995; Offerman and Sonnemans, 1998; Kameda and Nakanishi, 2002). With social learning decision makers have the opportunity to observe the experiences, preferences and behaviours of others prior to making a choice.

McElreath et al. (2005) introduced three different types of social learning models. The first model, the *linear imitation* model, is based on an assumption that each individual refers to a target individual, or target individuals, at random and imitates their choices. The imitation is linear with respect to each choice’s frequency in the population of potential targets. For example, if two alternative choices have been chosen by target individuals with frequency 3 and 2 respectively, then the first choice has 60% chance and the second one has 40% chance to be chosen by the individual. The second model is called the *confirmation* model. It is based on the idea that an individual maintains their behaviour when the target also maintains their own behaviour. The last model is the *conformity* model, which is based on the concept of majority influence in which an individual imitates the choice of the majority (the most frequently made choice).

To explore the effects of these social factors on travellers’ behaviour, a laboratory experiment was used and this is explained in the following section. The experiment is expected to contribute to advancing understanding of the role social interaction and social learning in travel behaviour.

**3. DESIGN OF THE LABORATORY EXPERIMENT**

A laboratory-based travel choice experiment enables the observation of how people make decisions when they are presented with travel choice situations. It also allows the investigation of the dynamic of travellers’ decisions, both in terms of insights into overall system behaviour and into the underlying individual behavioural process. A laboratory experiment generally has features that include the use of hypothetical choice situations, repeated trials and the availability of feedback and incentives to participants. Other features such as communication between participants and the possibility to observe other participants’ choices may be introduced in some experiments, while other experiments may exclude it completely. The design of a laboratory experiment to explore the effects of social interaction on individuals’ behaviour is discussed in the following subsections.

**3.1 Hypothetical situation**

The hypothetical situation used in the study exemplifies a public goods game (for a review, see Ledyard, 1995). In a public goods game, each participant is requested to contribute to collective goods in order to yield benefits for all participants, regardless of whether or not they all contribute. The situation is formulated as a hypothetical employer-based demand management initiative to reduce employees’ car use. In the experiment each participant acts as an employee of a company and takes part in an employer-based initiative that asks the employees to contribute to collective goods by using the bus, as an alternative to the car, for a number of weeks (0-5 weeks) per month. (Note: the number of weeks of bus use is also referred to as ‘contribution’.) Each month the employee is given a budget to pay for transport expenses, covering both car and bus expenses. Based on the participants’ choices, a reward (bonus) is given by the simulated employer to all employees, where the amount of the reward depends on the total contribution (collective bus-use) of the employees. In this experiment the reward is half of the total expenses of collective bus use. The reward is equally distributed between the participants, regardless of the amount of their individual contribution. The payoff function for each participant is formulated as Equation 1:

 (1)

where *Ei(t)* is the earning obtained by individual *i* at time period *t* (representing one month), *Budget* is a fixed amount of money to spend on transport expenses in each month (£75 per month), *CBus* and *CCar* are out-of-pocket costs of using bus (£15 per week) and of using car (£10 per week) respectively, *Ci(t)* is individual *i*’s choice which is the number of weeks per month of using bus (), and *N* is the number of employees in the company (the number of participants in a group).

The values are calculated based on the travel costs (excluding values of time) of a return trip from University of the West of England to Bristol City Centre via the M32 motorway (6.1 miles). The cost of travelling by car is derived from the vehicle operational cost (fuel and non-fuel) calculated using the Department for Transport’s ‘Transport Analysis Guidance: Values of Time and Operating Costs’ (DfT, 2004) and the cost of travelling by bus is based on a return ticket fare. To simplify these values are rounded to the nearest pound.

This hypothetical situation represents a public goods dilemma for a group of individuals where the payoff for non-cooperative choice (car-use) is higher than the payoff for cooperative choice (bus-use), regardless of what other individuals choose. However, everyone will receive a higher payoff when all individuals in the group are cooperative, rather than when they are all non cooperative. The system optimum, where the system cost is at a minimum, can be reached if all participants use the bus for the whole month, producing an earning of £37.5 for each participant. However, the user dominant strategy is to never use bus since this strategy will always give the participant the highest earning by ‘free-riding’ on other’s contributions. If a participant uses this strategy in the extreme situation where all other participants keep using the bus 5 weeks per month then the participant will receive £58.3, while other participants receive only £33.3 each. However, the more people choose this strategy, the lower the earning that will be received by each participant since there will be a lower total contribution. If all participants adopt the strategy of never using the bus then they will each receive an earning of £25. This will result in a lower system efficiency (25<37.5).

**3.2 Repeated decision making**

Hertwig and Ortmann (2001) gave two reasons for studying behaviour through repeated decision making. The first reason is to give participants a chance to adapt to the environment and get experience with the experimental setting and procedure. The second reason is the experimenter’s interests in the impact of experience on behaviour. Although in practice these two types of learning are difficult to distinguish, they are conceptually distinct. The first type of learning (adapting to the laboratory environment) relates to a methodological concern that participants may not initially understand the laboratory environment and task, whereas the second type of learning (understanding how individual choices interact with those of other people) relates to understanding of the potentially strategic aspects of the decision situation. In contrast to a one-off experiment that usually aims to elicit preferences and not to complicate it with ‘intertemporal’ considerations (e.g. Fischbacher et al., 2001), a repeated decision making experiment enables the study of individual’s strategic behaviour as intended to be examined by the experimenter (e.g. Fehr and Gachter, 2000; Ule et al., 2009).

The effects of the first type of learning can be eliminated, or at least reduced, by providing practice rounds for participants without taking account the results in the overall results at the end of the experiment. The effects of the second type of learning are the subject of interest to be studied by the experimenter. In an experiment with social interaction, the study of the effect of learning considers both learning from own experience and learning from other individuals’ experience.

**3.3 Availability of feedback**

As a main requirement of a dynamic decision-making experiment, participants are provided with *feedback* about the outcomes (costs or payoffs) of their choices in order to enable them to evaluate previous decisions and to learn with respect to future decisions. To produce efficient processes of interactive decision making and provide feedback to participants, the experiments utilize a *human-computer interface* as the medium. The experiment utilizes an experimental tool called Z-Tree (Zurich Toolbox for Readymade Economic Experiments) developed by Fischbacher (2007). The software allows the experimenter to design, develop and carry out experiments with features, including communication between computers, data saving, time display, profit calculation and tools for screen layout, as well as communication features such as ‘chat’ (text messaging) services.

**3.4 Social interaction feature**

An experiment generally has several treatments that are applied to participants. Experimental treatments can be defined as the levels of factor(s) or variable(s) controlled by the experimenter. In this study, the factors being studied are related to different aspects of social interaction. Studies have generally found that contributions in a social dilemma situation decrease with repetition. However with communication, repetition is found to increase the amount of contribution (Ledyard, 1995). The requirement is that the communication should be relevant to the problem they face (e.g. Dawes et al., 1977; Dawes 1980). In this study*, social interactions* between participants occur through communication via a ‘chat’ service. The ‘chat’ service enables participants to communicate with other participants by sending and receiving text messages through their computer screens during the experiment. To maintain anonymity, a pseudonym (experimental name) is assigned to each participant. It was asked of participants not to reveal their true identity during the experiment and it was evident that participants adhered to this request. The researchers recorded and analyzed all text messages exchanged during the experiment. This showed that there was one attempt to reveal a user identity, but this did not lead to identification of the individual.

No verbal communication or other direct communication between participants was allowed during the treatment. This maintained the experiment as a controlled environment and maintained anonymity in the interaction process so that it was not interfered with or distorted by relationships between participants that existed prior to the experiment. Nevertheless, relationships between people are likely to be important in social interactions and would be interesting to study further, for example, in a face-to-face communication setting. In this type of communication, different effects may be produced since participants already know one another, in which case social norms, group identity and concerns about reputation might influence behaviour within the group. However, prior relationships between participants are negated in this study to allow isolation of the aspects being studied in the experiment. Some experiments require it to be ensured that each participant does not know the identity of other participants (e.g. Camerer and Fehr, 2004). For example when economic incentives are given, this may distort behaviour in a way the experimenter does not understand (e.g. they may help friends earn more), although other experiments may be intended to study this.

**3.5 Hypotheses and experimental treatments**

Olson (1965) identified two factors that can promote cooperation: repeated interactions and communication among participants. Dawes et al. (1977) also found that relevant communication increased contributions in social dilemma experiments with one-shot decisions. Increased contributions and reduction of ‘free-riding’ behaviour were also found in experiments with repetition (e.g. Isaac and Walker, 1991). The increases are sometimes small but appear to be stable (e.g. Isaac and Walker, 1988). Orbell et al. (1990) stated that communication increases cooperation, either, because it provides an occasion for multilateral promises, or because it generates group identity, or possibly some combination of those two.

In our study the effect of communication is tested by enabling communication between individuals in some of the experimental treatments. However, the communication is restricted by grouping participants into several groups (with recognition that in some real social dilemma situations participants involved may not be able to communicate with everyone else but only with some other participants). The grouping does not change the structure of the social dilemma as each individual still makes a choice individually, but it gives opportunity for the emergence of social learning or influence between individuals inside a group. There is a possibility that strategic behaviour is transferred from the individual level to the group level when all members of a group have a consensus or commitment for whether to contribute or to ‘free-ride’. However, a commitment does not guarantee that every group member will make the agreed choice, since there is still opportunity to ‘free-ride’ as a choice is to be made individually. The choices of a group may also influence those of other groups. This is investigated in one of three experimental treatments where each group is able to observe the average contributions of other groups.

Another effect of communication is on the strategic behaviour of individuals. The effect could be modelled by two types of social learning models: the *confirmation* and *conformity* models. In the *confirmation* model individuals retain or reinforce their previous choice when the individuals with whom they are communicating also previously made the same choice, while in the *conformity* model individuals make their choice following the majority choice of the individuals with whom they are communicating. Of these two social learning models, *conformity* has been more widely studied, using simulation (e.g. Henrich and Boyd, 1998; Kameda and Nakanishi, 2002) and laboratory experiments (e.g. Smith and Bell, 1994). These studies have shown the importance of conformity in individuals’ behaviour, and suggested that a greater understanding of conformity and the use of information that prompts conformity is needed in order to understand social dilemma situations.

Given these arguments, the effects of communication on individuals’ contributions and strategic behaviours are tested with the following hypotheses:

**Hypothesis 1**: Communication between members of a group increases contributions within the group;

**Hypothesis 2**: Information about other groups’ contributions increases contributions within the group (in the context when there is communication between members of a group);

**Hypothesis 3**: Communication influences strategic behaviour of individuals (by reinforcing the original behaviour of participants if communicating partners have similar behaviour or by otherwise changing the original behaviour towards the majority).

Three treatments, differing by the levels of social interaction offered to the participants, are used to test these hypotheses. The first treatment is the baseline treatment, where communication and observation of other groups’ choices are not possible. The other two treatments are used to investigate the effects of communication and ‘social’ information about travellers’ choice behaviour. While in the first treatment, by observing the total payoff, the participant might implicitly learn about others’ behaviours, in the other treatments the ‘social’ information provided is of an explicit and disaggregate nature. The effect of this information is to be tested in the three hypotheses with the first treatment as the control treatment.

Table 1 summarizes the differences between the three experimental treatments which are based on the availability of individual information regarding own past-experience, the possibility for communication between group members and the availability of ‘social’ information regarding other groups’ bus-use. Each treatment has specific characteristics that differ from the others. In Treatment 1 participants can only refer to their own experience (previous choices) when making a decision. In Treatment 2, where participants are divided into several groups, the members in each group can communicate with each other by using the text messaging service provided on their screen (written communication). The mechanism is simple and easy to use; each participant can have a discussion with other participants of the same group by sending text messages and reading other members’ text messages using the ‘chat’ service (see Figure 1 for illustration of the text conversations between group members). Treatment 3 is basically similar to Treatment 2 with the addition that they receive information regarding bus-use of other groups. In Treatments 2 and 3, each participant also receives information about her/his own previous choices (number of weeks of bus and car use) and the outcomes of these choices (costs of bus-use and car-use and earning).

[Insert Table 1 here]

[Insert Figure 1 here]

**3.6 Incentives for participants**

In a laboratory experiment participants may be offered *financial incentives* (e.g. money) to encourage serious and motivated participation. There are a number of different arguments for whether to use incentives or not. Camerer and Hogarth (1999) have shown that monetary incentives increase the effort that subjects put into their decisions. However they stated that incentives, particularly higher incentives, sometimes improve performance but often do not. The use of financial incentives in many cases may bring decisions closer to the predictions of normative models. This is often applied in experimental economics, for example, to test decision-theoretic or game-theoretic models (Hertwig and Ortmann, 2001). Cognitive psychologists may have a different objective that is more in the analytic description of general cognitive processes involved in people’s decision making and they generally avoid the use of financial incentives as a reward of participants’ performance within an experiment. Another argument is that although participants can be assumed to be essentially cooperative and to be intrinsically motivated to participate in the experiment, there is no guarantee that self- motivated responses to an experiment will reflect real-world behaviour (Bonsall, 2002). It may be true that lack of incentive leads to lack of motivation, however, the availability of incentive does not guarantee that participants will have appropriate motivation or will behave as in real life (e.g. participants may concentrate more on obtaining money than making choices naturally). However, if no incentives are given, then there should be an explicit or implicit objective function as a motivation for participants. For example, participating in an experiment with the motivation to advance knowledge, and therefore behaving as in real life, might be an implicit motivation. These pros and cons require careful consideration when deciding whether or not to use financial incentives in a travel choice experiment. In the experiment described in this work it was decided not to use financial incentives. Instead we tried to encourage self-motivated participation by asking participants to make choices as they would have done if the hypothetical situation was real.

**3.7 Providing instructions and explanation**

Attempts must be made to ensure that participants understand all aspects of the experiment before starting the experiment, including the hypothetical situation and the use of the human-computer interface as the medium of the experiment. Participants should be provided with written and oral instructions about the hypothetical situation. A short presentation, using examples, to help participants understand the instructions also needs to be provided. During and at the end of this pre-experiment activity, participants were asked whether or not they understood the instructions clearly and were also given the opportunity to ask questions about the experiment. A practice round was also provided before the experiment started in order to familiarize the participants with the medium of the experiment and the decision-making situation.

Section 3 has provided a highlight of important features of the design of the experiment conducted in this research. For detailed information on the ways to conduct experiments like this, interested readers may refer to Friedman and Sunder (1994) and Kagel and Roth (1997).

**4. SMALL-SCALE EXPERIMENT: RESULTS AND ANALYSIS**

A small-scale experiment was conducted to demonstrate the applicability of the experimental design to study the effects of social interaction. The participants were a group of postgraduate students (*N*=15) at the University of the West of England, Bristol. In the second and third treatments of the experiment the participants were divided into five equal sub-groups of three. The group participated in all three experimental treatments, serially from Treatment 1 to 2 and 3. As there was only one group of participants, the effect of order cannot be investigated. Participants’ involvement in all treatments means that it is more difficult to distinguish a treatment effect from a learning effect.

The dynamics of the average contributions of participants in the experiment is shown in Figure 2, where the average contribution slightly increased between Treatment 1 (2.373) and Treatment 2 (2.587), and then Treatment 3 (2.707). Communication seems to slightly increase the average contributions, in line with Isaac and Walker (1988)’s finding that the increase is sometimes small.

[Insert Figure 2 here]

To test the significance of the increase, a Repeated-Measures ANOVA test is conducted using the General Linear Model (GLM) facility in SPSS (Version 15). The effects of communication between individuals within different groups are investigated using the *group* variable, while variables *treatment* and *round* apply to each individual as they experience all 3 treatments and 10 rounds of choice making within each treatment. Therefore, the variable *round* is nested inside the variable *treatment*. The results of the Repeated Measures ANOVA found that the effects of these variables, as well as their interactions (e.g. *group\*treatment*, *group\*round*, *group\*treatment\*round*), are not significant. There is no substantial evidence that communication alone (Treatment 2) or communication combined with observation of other groups’ choices (Treatment 3) affect the average level of participants’ contributions (bus-use). Hence **Hypotheses 1** and **2** are rejected based on this finding.

To test **Hypothesis 3**, analyses are conducted to investigate the ‘gross’ (or total) changes of behaviour for each individual and the way each individual is being influenced by other individuals inside his/her group through communication. These analyses are discussed in Sections 4.1 and 4.2.

**4.1 Descriptive analysis of individual behaviour**

To study the effects of communication on individuals’ strategic behaviour, analyses are conducted descriptively for each group of individuals. Figure 3a-e shows the changes in average contributions (weeks of bus use) for individuals within their corresponding group. Please note that the names used are not real names but pseudonyms randomly given to the participants at the beginning of the experiment.

[Insert Figure 3 here]

Firstly, we categorise the contributions into three levels: low (0-1), medium (2-3) and high (4-5). For the average contribution, this can be categorised as: low (0-1.50), medium (1.51-3.50) and high (3.51-5). In Group A, a member called *Cameron* increases his contributions substantially in Treatment 2, potentially influenced by *Frank*, but then reduces it substantially in Treatment 3, which might be due to *Morgan*’s influence. In Group B, both *Pat* and *Henry* maintain exactly the same high level of contribution in all three treatments. This could be an example of a confirmation model, where the similarity of previous choices reinforces each other’s choice making. Another group member, *Andy*, on average maintains almost the same medium level of contribution throughout the treatments. The effects of communication in changing individuals’ choices appears more evident in Group C, where all group members (*Alex*, *Reese* and *Charlie*) increase their contributions in Treatment 2 (although only slightly for *Alex*). High level of contribution is maintained by *Reese* and *Charlie* in Treatment 3. An increasing trend also happens in Group D, where a member (*Sam*) who had a low level of average contribution in Treatment 1 increases his/her level of contribution in Treatment 2 and substantially further in Treatment 3. The other two members of Group D generally maintain their high (*George*) and low (*Don*) levels of contribution respectively. In Group E, the trend is decreasing, particularly *Eric* who decreases his/her level of contribution substantially in both Treatments 2 and 3. Another member, Jordan, maintains a medium level of contribution, while Jessie maintains a low level of contribution.

In general across these five groups, it looks like an agreement to have the same choice for all members within each group could not be achieved, or at least could not be maintained across repeated rounds of choice making. There are some rounds where all members of a group make the same choice (22% of rounds (11 out of 50) in Treatment 2 and 24% of rounds (12 out of 50) in Treatment 3. However, there is always a member within each group who did not follow the majority choice and decides to make his/her own choices, either to ‘free-ride’ on other contributions (e.g. to give low level of contribution when others contribute high) or to be ‘pro-social’ (e.g. to give high level of contribution when others make low contribution). The numbers of ‘suspected’ free-riding occurrences are quite high: 28% (14 out of 50) in Treatment 2 and 34% (17 out of 50) in Treatment 3. The numbers of occurrences of pro-social behaviour are lower (16% of rounds (8 out of 50) in Treatment 2 and 24% of rounds (12 out of 50) in Treatment 3). However ‘partial’ consensus, where two of three group members make the same choice, occurs on many occasions (66% of rounds (33 out of 50) in Treatment 2 and 79% of rounds (35 out of 50). In summary, social learning through communication has been used by some participants to optimise collective outcomes (by contributing high) but it has also been used by some others to optimise their individual outcomes (by ‘free-riding’ on others’ contributions). This shows that both cooperators and ‘free-riders’ exist in the experiment. In line with this finding, a relevant study using a one-off experimentation by Fischbacher et al. (2001) showed that a fraction of people are conditional cooperators (50%), another fraction are ‘free-riders’ (30%) and the other fraction are either ‘hump-shaped’ contributors or display no patterns.

**4.2 Analysis using learning models**

To study the existence of *confirmation* and *conformity* models of social learning, thus testing Hypothesis 3, the choices of individuals in Treatments 2 and 3 are analysed. We decide to use a simple method for modelling participants’ choice making, which is based on the probability of a choice being made by an individual. The higher the probability is, the more likely the choice will be selected. These probabilities are obtained using learning models, which include both individual learning and social learning models.

There are many individual learning models which can be used to model learning based on experience, including the simple heuristic model (Harley, 1981), the average return model (Herrnstein, 1970) and the weighted average return model (March, 1996). For simplicity, the *individual learning* model used in our analysis is based on the *simple heuristic* model which specifies the probability of making a choice as a function of the payoffs obtained by making the choice in the past. In this model, the probability Pix(t) of choice *x* being made by individual *i* at time period *t* is the ratio between individual *i*’s accumulated payoff of choice *x* and the individual’s total payoff earned until time period *t-1*. In the travel behaviour context, the payoff can be in the form of reduced travel time or cost. However, in this study, payoff is represented by the earning that an individual receives after making a choice in the laboratory experiment. The rule can be represented in this equation:

 (2)

where *Pix(t)* is probability of choice *x* (;), which is the number of weeks of the bus being used by individual *i* (;) at time period *t* and *Eix(r)* is individual *i*’s earning received from using bus for *x* week(s) at time period *r* (). *S* is the set of individuals and *N* is the number of individuals in set *S*.

The social learning models, *confirmation* and *conformity*, are based on those of McElreath (2005). The *confirmation* model is based on the idea that an individual is practicing confirmation in learning from other individuals, which means that the individual maintains their previous behaviour when the target also maintains their own past behaviour. Otherwise, the individuals rely only upon their own judgement. The model is basically a combination of individual learning and social learning. As seen in Equation 3, the first term is the individual learning term and second term is the social learning term. The strength of reliance on the social learning against individual learning mechanism depends on the value of parameter ** (0≤**≤1). When *i*=0, individual *i* relies only upon individual learning, whereas when *i* =1 the individual *i* relies only upon social learning. *Psix(t)*, the probability of choice *x* being made by individual *i* at time period *t* is calculated as follows:

 (3)

where the probability *Pix(t)* can be obtained from the individual learning model (Equation 2), *Nsix(t)* is the number of target individuals with whom individual *i* communicates and use bus for *x* week(s) at time period *t*, *Nsi(t)* is the total number of target individuals, and *Ci(t-1)*is the choice of individual *i* at period *t-1*.

The other social learning model is the *conformity* model, where individuals imitate the choice made by the majority of other individuals with whom they communicate. If there is no clear majority, individuals make a choice based on their own judgement. When a majority exists, the probability of choice *x* being made by individual *i* at time period *t* is:

 (4)

Choice *x* becomes the majority choice in a group of individuals if it is chosen more frequently by individuals in the group than any *y* choice. For example, in a group which consists of three members, if two members used bus for two weeks and the third member used bus for 4 weeks, then the majority choice is 2. When there is no majority (e.g. when three members make different choices) the decision of individual *i* relies only upon the probability obtained in the individual learning model (). Illustrations of the way the probabilities were calculated in the *confirmation* and *conformity* models can be found in Sunitiyoso et al. (in press, pp. 13-14).

To measure a learning model’s performance in estimating the individuals’ choices in the laboratory experiment, the predicted probabilities of the observed choices (calculated using the learning model) are accumulated across all observations for each treatment. The average of these probabilities is the goodness-of-fit of the learning model, which ranges from 0 to 1 (see Equation 5). The probabilities of each choice *x* (*Psix(t),*;), for each individual *i* are calculated based on actual choices made by him/her in the experiment*,* and the choices of others observed by him/her, as described in the learning models above.

 (5)

We tested the combined models of individual and social learning on the data of Treatments 2 and 3. Since there is no data that can be used to estimate it, the strength of reliance on social learning (**) is assumed to be 0.5, which means that each individual has an equal reliance on both individual and social learning.

The results show how well the choices of participants in Treatments 2 and 3 are estimated using the learning models (see Table 2). The confirmation and conformity models perform almost similarly for estimating choices in Treatment 2 with goodness-of-fit measures of 0.58 and 0.57 respectively. These results indicate that both the confirmation and conformity models have similar possibility to be adopted by participants in Treatment 2. In Treatment 3 the conformity model (goodness-of-fit = 0.68) performs better than the confirmation model (goodness-of-fit = 0.49). We also tested the models with ** equals zero and found that the goodness-of-fit measures are 0.43 and 0.44 for Treatments 2 and 3 respectively. These results show that individuals’ behaviours in these two treatments, where social interaction exists between group members, can be explained better using the social learning models, rather than only using the individual learning model.

[Insert Table 2 here]

The findings indicate that in Treatment 3 participants are more likely to adopt the conformity model (following the choice of majority), rather than the confirmation model (keeping their previous choice if the observed individual(s) also previously made the same choice). A possible explanation is that by observing the behaviour of other groups (Treatment 3), individuals develop a stronger group feeling regarding their own group that makes them more inclined to conform with other members of their own group, particularly in small groups where individuals may have more responsible feelings about participating in a cooperative action (Olson, 1965) and where the communication might have generated group identity (Orbell et al., 1990). However this requires further validation using other methodologies, which is not in the scope of this work.

Given these findings, Hypothesis 3 (which states that communication influences strategic behaviour) could be accepted. However, the testing of Hypothesis 3 has not been based on a conventional test which would provide a stronger significance of the existence of strategic behaviour of individuals. Furthermore, the sample size does not permit us to generalize from the result. The method used has been based on a new approach for analyzing participants' responses in a laboratory experiment through the use of social learning models. It also requires estimation of model parameters which could not be conducted in this study due to limited data. Therefore a larger sample size and further analyses using other methods are required to validate the finding.

**5. CONCLUSIONS**

This paper has presented the design of a laboratory experiment to investigate the effects of social interaction on individuals’ travel behaviour. A method of communicating through anonymous text messaging (‘chat’ service) was provided to participants to test the effects of communication within each subset of participants. To enable understanding of individuals’ learning process, a repeated decision making experiment was conducted. A small-scale experiment demonstrated the experimental design and explored the dynamics of travellers’ choice making and behaviour in a hypothetical travel choice situation that asks participants to contribute to public goods by choosing bus as an alternative to the car in the presence of a virtual incentive based on the group’s overall contribution. Hypotheses regarding the effects of social interaction on the general behaviour of participants, as well as their individual behaviour, were developed and incorporated through three experimental treatments.

Analyses of the results of the small-scale experiment were conducted using statistical tests, descriptive analysis and learning models to investigate the ‘net’ effects of the variable *treatment* (which represented experimental treatments) and *group* (which represents the grouping of participants) on travellers’ choice making, the ‘gross’ changes of behaviour and the direction of change of each individual’s behaviour and the way each individual is influenced by communication with other individuals inside his/her group. It is revealed that the effects of both treatment and group were not significant, so that it can be concluded that in-group communication alone, and together with information about other groups’ choices, did not increase participants’ average contribution. The reason could be explained in the descriptive analysis of each participant’s behaviour where a substantial number of ‘free-riding’ occurrences occurred within groups of participants. This explains that a social dilemma did not only exist for all participants in facing the choice situation, but also exists between members of a group.

The analysis using learning models shows the existence of strategic behaviours that follow social learning models of *confirmation* (reinforcing behaviour if other group members have similar behaviour) and *conformity* (following the majority choice in the group). These two types of social learning, *confirmation* and *conformity*, can be expected to exist in real life.

**6. FURTHER STUDIES**

The study shows how a laboratory experiment can assist understanding of the effect of social interactions on travellers’ behaviour at both the system and individual level. It is hoped that this paper will encourage further studies in transport of social interaction and social learning which have until now been pursued primarily by social psychologists and experimental economists.

In this study social learning models were used for analyzing responses of human participants in a laboratory environment. The outcomes of the analyses could be further studied using a simulation experiment in order to simulate the situation presented in the laboratory experimentfor a larger system with more individuals, more repetitions/rounds and more varied experimental settings (e.g. Henrich and Boyd, 1998; Kameda and Nakanishi, 2002, Sunitiyoso et al., in press). The two approaches of laboratory and simulation experiments can supplement each other to help illustrate conceptual issues related to social interactions and social learning.

In the laboratory experiment discussed in this paper verbal or face-to-face communication is not allowed. Bartle and Avineri (2007) reviewed evidence that face-to-face communication might be expected to have a greater influence on individuals’ behaviour than ‘anonymous’ communication (e.g. using a ‘chat’ service). They identified some studies which have shown that cooperation in social dilemmas is improved when participants communicate with one another face-to-face. Thus, face-to-face communication should be explored in the study of social interaction and may have an important effect on participants’ behaviour during an experiment.

The number of participants in the small-scale laboratory experiment was small, hence the ability to generalize from the findings is restricted. In order to generalise the findings of the laboratory experiment to a wider population further experimental research should be carried out with different group sizes.

As stated by Mahmassani and Jou (2000), experiments provide a useful approach to the study of complex human decision systems, but they are primarily intended to develop underlying theoretical constructs or behavioural mechanisms of individuals. Experiments are based primarily on simulated situations which may not necessarily correspond to actual setting, as the factors considered may be much simpler than a real life situation. Where field study is possible, observation of behaviour in the real world could be used to confirm the substantive conclusions resulting from such experiments. For example, a revealed-preference field study (using panel data) would provide more substantial evidence which would confirm the findings of a laboratory experiment. In a field study, we would need to probe participants on what aspects, particularly social aspects, have influenced changes of behaviour where they occurred. Generally said, a laboratory experiment is not a replacement of a field study. Nevertheless, to make progress in studying social interactions, as a new area in travel behaviour studies, it is informative to start with a simplified research environment such as a laboratory experiment.

**REFERENCES**

Ampt, E (2003) Voluntary household travel behaviour change: theory and practice. *Proceedings of the 10th International Conference on Travel Behavior Research,* Lucerne.

Arentze, T and Timmermans, H (2005) Modelling learning and adaptation in transportation context. *Transportmetrica* 1(1), 13-22.

Arentze, T and Timmermans, H (2006) Social networks, social interactions and activity-travel behavior: a framework for micro-simulation. *Proceedings of the 85th TRB Annual Meeting*, Washington.

Bartle, C and Avineri, E (2007) Pro-social behaviour in transport social dilemmas: A review. *Proceedings of the Workshop of Frontiers in Transportation: Social Interactions,* Amsterdam.

Bonsall, P (2002) Motivating the respondent: how far should you go?. In H. S. Mahmassani (Ed.), *Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges.* Elsevier.

Camerer, C.F. and Hogarth, RM. (1999) The effects of financial incentives in experiments: A review and capital-labor-production framework. *Journal of Risk and Uncertainty*,19. 7-42.

Camerer, C.F. and Fehr, E. (2004) Measuring social norms and preferences using experimental games: A guide for social scientists. In J. Henrich, R. Boyd, S. Bowles, C.Camerer, E. Fehr and H. Gintis (Eds.) *Foundations of Human Sociality: Economic Experiments and Ethnographic Evidence from Fifteen Small-Scale Societies*, 96-124, Oxford University Press, New York.

Dawes, R. M. (1980) Social dilemmas. *Annual Review of Psychology,* 31, 169-193.

Dawes, R., McTavish, J. and Shaklee, H. (1977) Behaviour, communication, and assumptions about other people’s behaviour in a commons dilemma situation. *Journal of Personality and Social Psychology*, 35 (1), 1-11.

DfT (2004) Transport analysis guidance: Values of time and operating costs. Department for Transport, London, UK.Available via Webtag.http://www.webtag.org.uk/webdocuments/3\_Expert/5\_Economy\_Objective/3.5.6.htm. Cited 6 Nov 2006.

Fehr, E. and Gachter, S. (2000) Cooperation and punishment in public goods experiment. *The American Economic Review*, 90 (4), 980-994.

Fischbacher, U (2007) z-Tree: Zurich Toolbox for Readymade Economic Experiments. *Experimental Economics* 10(2), 171-178.

Fischbacher, U., Gachter, S. and Fehr, E. (2001) [Are people conditionally cooperative? Evidence from a public goods experiment](http://ideas.repec.org/a/eee/ecolet/v71y2001i3p397-404.html). [*Economics Letters*](http://ideas.repec.org/s/eee/ecolet.html), 71(3), 397-404.

Friedman, D. and Sunder, S. (1994) *Experimental methods: a primer for economists*. Cambridge University Press.

Harley, C.B. (1981) Learning the evolutionary stable strategy. *Journal of Theoretical Biology*, 89, 611–631.

Henrich, J. and Boyd, R. (1998) The evolution of conformist transmission and the emergence of between-group differences. *Evolution and Human Behavior,* 19, 215-241.

Herrnstein, R. J. (1970) On the law of effect. *Journal of the Experimental Analysis of Behavior,* 13, 244-266.

Hertwig, R and Ortmann, A (2001) Experimental practices in economics: a methodological challenge for psychologists? *Behavioural and Brain Sciences,* 24, 383-451.

Huberman, B. A. and Glance N. S. (1993) Diversity and collective action. In H. Haken, and A. Mikhailov (Eds), *Interdisciplinary Approaches to Nonlinear Systems*, Springer.

Isaac, R. and Walker, J. (1988) Communication and free-riding behaviour: the voluntary contribution mechanism. *Economic Inquiry*, 26(2), 585-608.

Isaac, R. and Walker, J. (1991) Costly communication: an experiment in a nested public goods problem. In T. Palfrey (Ed.), *Laboratory Research in Political Economy*, 269-286.University of Michigan Press, Ann Arbor.

Jones, P and Sloman, L (2003) Encouraging behavioural change through marketing and management: what can be achieved? *Proceedings of the 10th International Conference on Travel Behavior Research,* Lucerne.

Kagel, J. H. and Roth, A. E. (1995) *The Handbook of Experimental Economics.* Princeton University Press, Princeton, New Jersey

Kameda, T and Nakanishi, D (2002) Cost/benefit analysis of social/cultural learning in a nonstationary uncertain environment: an evolutionary simulation and an experiment with human subjects. *Evolution and Human Behavior,* 23, 373-393.

Ledyard, J. O. (1995) Public goods: a survey of experimental research. In Kagel, J. H. and Roth, A. E. (Eds.), *The Handbook of Experimental Economics,* 111-194*.* Princeton University Press, New Jersey.

Mahmassani, H. S., and Jou R. C. (2000) Transferring insights into commuter behaviour dynamics from laboratory experiments to field surveys.*Transportation Research A,* 34, 243-260.

Mahmassani, H. S. & Liu, Y. H. (1999) Dynamics of commuting decisionbehaviour under advanced traveller information systems.*Transportation Research C,* 7, 91-107.

March, J. G. (1996) Learning to be risk avers. *Psychological Review,* 103, 309-319.

McElreath, R., Lubell, M., Richerson, P. J., Waring, T. M., Baum, W.,Edsten, E., Efferson, C. and Paciotti, B. (2005) Applying evolutionary models to the laboratory study of social learning. *Evolution and Human Behavior,* 26, 483-508.

Messick, D. M. (1985) Social interdependence and decision making. In G. Wright*, Behavioral Decision Making*, 87-109. Plenum Press, New York.

Offerman, T and Sonnemans, J (1998) Learning by experience and learning by imitating successful others. *Journal of Economic Behavior& Organization,* 34, 559-575.

Olson, M (1965) *The Logic of Collective Action: Public Goods and the Theory of Group.* Harvard University Press.

Orbell, J., Dawes, R. and Van de Kragt, A. (1990) The limits of multilateral promising. *Ethics*, 100, 616-627.

Pingle, M (1995) Imitation versus rationality: an experimental perspective on decision making. *Journal of Socio-Economics,* 24(2), 281-315.

Root, A. (2001) Can travel vouchers encourage more sustainable travel?.*Transport Policy,* 8, 107-114.

Selten, R., Schreckenberg, M., Pitz, T. C. T., Kube, S., Hafstein, S.,Chrobok, R., Pottmeier, A. and Wahle, J. (2004) Experimental investigation of day-to-day route choice behavior and network simulations ofAutobahn traffic in North Rhine Westphalia. In Schreckenberg, M. &Selten,R. (Eds.) *Human Behavior and Traffic Networks.* ed. Springer, Berlin, pp.1-21.

Shaheen, S (2004) Dynamics in behavioral adaptation to a transportation innovation: a case study of Carlink - a smart carsharing system. Ph.D Thesis, Institute of Transportation Studies, University of California, Davis.

Simon, H. A. (1956) Rational choice and the structure of the environment, *Psychological Review,* 63(2), 129.

Smith, J. M. and Bell, P. A. (1994) Conformity as a determinant of behavior in a resource dilemma. *The Journal of Social Psychology,* 134, 191-200.

Stephan, C. H., Mahalik, M., Veselka, T. and Conzelmann, G. (2007) Modeling the transition to a hydrogen-based personal transportation system. *Workshop of Frontiers in Transportation: Social Interactions.* Amsterdam, Netherlands.

Stern, E. and Richardson, H. W. (2005) Behavioral modeling of road users: Current research and future needs. *Transport Reviews,* 25**,** 159-180.

Sunitiyoso, Y., Avineri, E. and Chatterjee, K. (in press) On the potential for recognising of social interaction and social learning in modelling travellers' change of behaviour under uncertainty. *Transportmetrica*. DOI: 10.1080/18128600903244776.

Taniguchi, A, and Fujii, S. (2007) Promoting public transport using marketing techniques in mobility management and verifying their quantitative effects. *Transportation,* 34, 37-49.

Ule, A., Schram, A., Riedl, A. and Cason, T. (2009) Indirect punishment and generosity towards strangers. *Science,* 326, 1701-1704.

Van Lange, P, Van Vugt, M. and De Cremer, D (2000) Choosing between personal comfort and the environment: solutions to the transportation dilemma. In M. Van Vugt, M. Snyder, T. Tyler and A. Biel (Eds), *Cooperation in Modern Society*, 45-63.Routledge London.

Table 1: Experimental treatments

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Rounds | Own experience | In-group communication | Social information about other groups |
| Treatment 1 | 1 – 10 | Yes | No | No |
| Treatment 2 | 11 – 20 | Yes | Yes | No |
| Treatment 3 | 21 – 30 | Yes | Yes | Yes |

Table 2: Models’ goodness of fit for Treatments 2 and 3 (*H*=heuristic,*Cfn*=Confirmation, *Cfy*=Conformity)

|  |  |  |
| --- | --- | --- |
| Model | Treatment 2 | Treatment 3 |
| *HR only* (=0) | 0.43 | 0.44 |
| *HR + Cfn* (=0.5) | 0.58 | 0.49 |
| *HR + Cfy* (=0.5) | 0.57 | 0.67 |



 

Figure 1: Examples of in-group conversation using the ‘chat’ mechanism

Figure 2: Dynamics of average bus-use in Treatments 1, 2 and 3

Figure 3: Changes of average contributions of group members