How Do You Feel When You Are Driving?: A Participatory Approach

Nova Ahmed
Saad Azmeen Ur Rahman
Rahat Jahangir Rony
Md. Tanvir Mushfique
North South University
Dhaka 1229, Bangladesh
nova.ahmed@northsouth.edu

Abstract
Congestion, lack of compliance to traffic laws, multimodal traffic, opportunistic decision making and poor road conditions are few of the key challenges faced by drivers in a developing country's metropolitan city such as, Dhaka, Bangladesh. The driver's experience is affected by such road conditions which in turn shapes up their driving behavior and thus affects the traffic conditions. However, there hasn't been much work done that formalizes the concept of 'driving experience', especially in the context of developing countries. We have focused our study on identifying the parameters that capture a driver's experiences.

Author Keywords
Driver Attention in Developing Country, Driver Experiences, Measurement of Driver Experiences, Handling Multimodal Traffic, Traffic in Dhaka, Bangladesh

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous; [

General Terms
]: Human Factors, Experimentation, Measurement

Introduction

The urbanization has drastically changed the lives of people d the sense of wellbeing. The days are filled with busy and large amount of traffic, continuous competition to reach destinations are there and these are all part of daily lives. The busy schedules are integrated with our lives and often ignored when personal wellbeing is considered. The concept of wellbeing is not the major concern in developing countries like Bangladesh. The poor traffic condition and factors affecting driver's mood are of concern in modern studies [8], [9] and must be looked through in the developing country context.

We define **Driving Experience** [1] as the overall encounter a person has during the action of driving and what impression it leaves on the person. A good driving experience translate to being able to complete the driving task without harmful distractions and events that may have a negative effect on driver's mood, behavior and ultimately safety. In addition, it has profound effects on health and well-being [6].

Most research work related to vehicle drivers have been done predominantly in the context of drivers in the developed nations. Driving in a developing country is a highly different experience [10] and our goal is to formally study the driving experience from the perspective of drivers in the developing nations, starting with Dhaka. We have studied the roadside conditions and drivers over a one-year time frame through various mechanisms. There is no silver bullet that uniquely identifies the drivers' experiences. However, there are some methods that have been proved to be more effective compared to other methods.

We started our driving experience study with semi-formal and informal discussions with drivers of various vehicles. Our discussions gave us a direction on the factors that affect the drivers the most. Multiple sensors were then deployed to measure various user parameters and environmental parameters to predict driver experiences.

These measures could hep in formulating targeted interventions to enhance driving experience. The sensors were able to measure the roadside conditions but that was not enough to capture the driving experience. To the best of our knowledge, our work is the first instrumented vehicle study in Bangladesh, and very likely, in South Asia.

The traffic situation of urban Dhaka, as a source of problem, impacting wellbeing applies to situations that are unique in its own way. The traffic here is notoriously known for its poor traffic conditions. The presence of vehicles of various speed sharing the same road known as multimodal traffic, poor road conditions, congestion, unruly traffic behavior, poorly trained vehicle drivers, competing nature of commercial vehicles, corrupt law enforcement authority - all have played a role in it. A quick look at a bus labeled *Good driver's do not hit* which shows how common the problem of being hit can be in the city! This situation can only be explained through a real time live experience!

If any one has an experience in this traffic of Dhaka, he or she must have uttered the word is *Bap re Bap!* - Bengali phrase meaning *Dad Oh Dad* literally and close to *Oh my goodness* conceptually.

We have designed a hardware-software system where wearable hardware tries to record user's experiences with minimalistic hardware support and the software system provides a user-defined software intervention system, and the system is naturally named Bap re Bap!. We have spent reasonable amount of time to find out the level of disturbance

[1] We would like to clarify here that our definition and usage of the phrase 'driving experience' is not to be confused with the concept of *how long a driver has been driving* (measured by years or by mileage).

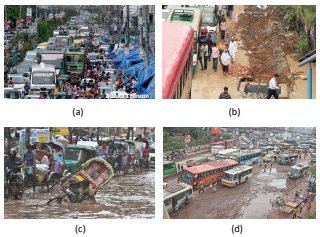

Figure 1: raffic in Dhaka (a) Severe Congestion [5] (b) Excavated Road [23] (c) Flooded road with potholes [20] (d) After rain effects on Road [21].

Figure 2: Pedestrian (a) Jaywalking pedestrians [4] (b) Pedestrian not using foot-over-bridge [7] .

(if any, traffic system has caused and we have gone through a design cycle before we have developed our wearable system.

Traffic in Urban Dhaka

The question of wellbeing naturally occur when the traffic situation of urban Dhaka is observed. It is chaotic and busy and there is continuous occurrences of arguments among drivers, rickshaw pullers, pedestrians and traffic polices! It is lively and unique in its own way. Few facts regarding the traffic conditions would allow us to understand the situation clearly.

Multimodal Unruly Traffic

In most of the roads (with few exceptions of VIP roads not allowing rickshaw) allow vehicles of various speed to coexist on the same road which is referred as multimodal traffic. There are public buses (50 seats), CNG -driven auto rickshaw, private cars, micro buses, truck (after 9PM), motorcycles and often pedestrians sharing the same road. The multimodal traffic has a large impact on the traffic system as each vehicle has its own driving behavior (apart from its different speed). The public buses are unruly in nature, often compete with each other to attract passengers. It is the most rebellious vehicle that takes greedy approach in driving, changing lanes whenever one seems lighter. This behavior imposes a heavy burden on the other light-weight vehicles. On the other hand, the rickshaw pullers occupy the road without any proper training. Many of the rickshaw pullers are seasonal drivers. These slow moving vehicles again approach the road in an opportunistic manner and often blocks part of road without following a particular law.

Poor Road Conditions and Congestion

Dhaka, being at the verge of development has a combination of well built roadways along with poorly maintained ones with holes, broken roads and uneven roads. Sometimes there are semi permanent or permanent water congestion on part of roads for poor drainage system. The uneven local roads are assumed to be a source of stress on roadways, especially, for rickshaw drivers and riders.

Related Work

It is interesting to see how our work is related to various research efforts from different dimensions.

A driver's attention level and the type of attention he or she needs to project at a given time, could be a very close indicator of the driving experience of the driver at that point of time, and ultimately plays a major role in driving safety. A huge array of work exists on driver's attention. Researchers in [24] break down the types of attention-related disturbances (which could lead to bad driving experience) into three categories - 1) inattention, 2) distraction and 3) a competition for attention.

Driver distraction is itself a highly studied area of research with numerous subtopics. Research work conducted by Iqbal et al. [8, 9] provides an in-depth study on the correlation of phone calls and driving distraction. It is evident from their study that, conversations that require cognitive involvement reduces the drivers concentration significantly, which is in line with findings of other researchers [22, 15]. Outside factors like roadside advertisement can be a source of distraction for drivers as well [2]. Work focused on driver attention of particular demographic group exists too; [16] discusses attention related problems in younger drivers, their risk-taking attitude and rash personalities, while works such as [13, 14, 17] seeks to identify factors affecting decreas-

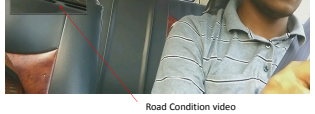

Figure 3: Video Sensing of a Driver and Road.

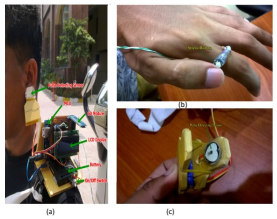

Figure 4: a. Implemented System, b. Stress button, c. Pulse Detecting Sensor.

ing ability to maintain attention in older drivers. The direct and indirect effect of driver's attention has been studied in work by Salvucci [18] and have been found to contribute to as much as 25% of unsafe driving [25].Measuring driver attention is thus a crucial element in the study of driver experiences.

In terms of data collection, a wide array of devices are used for measurements of the various parameters that arise in the studies discussed above and beyond; these devices ranging from state-of-the-art simulators [11] and sophisticated instrumented vehicles (e.g., [1]), to smart phones to sensor-based custom devices. Mobile phone based sensing has been used to study various aspects of drivers in recent years [12]. Low cost sensing to estimate car speed information has been developed by Sen et al. [19]. We, however, opted not to use any road side sensing infrastructure as it was not be feasible to leave unattended sensors in a developing country. .

The challenge of our research however lied in measuring the parameters of interest in the least intrusive yet comprehensive manner in the midst of extreme resource constraints. We must keep in mind about the effect of user bias through the interviews, especially when we are discussing issues with low literacy population as discussed by Dell [3]. We have conducted semi-structured or unstructured long (an hour or more) interviews to address such bias.

Bap re Bap: Design, Intervention and Basic Evaluation

We discuss our system in terms of its design, development and evaluation phases.

Pre-Development Considerations

We have conducted a series of pre development study to understand various sensing methods that may relate to stress along with driver's experiences. We are providing an overview here for completeness. Blood pressure of our subjects during driving has not shown significant indication of driving conditions or external environmental factors. The video based facial expression study has captured the mood of drivers while drivers did not recommend such method. On the other hand, the road conditions were successfully measured using custom designed sensing modules.We have conducted extensive study on many volunteers across the city to find out visible changes due to emotional changes. We have not seen any conclusive pattern. The only visible blood pressure change has been measured after meal of these volunteers! We have studied the facial expression of drivers as can be seen in Figure 3. Here we are taking photo of the road as well as their facial expression. However, this leads to a solution that is compute intensive as well as cost intensive (mobile phones with dual video capabilities are not very cheap). That is why we have chosen the low cost and simple mechanism of pulse sensing which is discussed in the later sub section.

Design of Wearable System

The systems sensor follows the basic mechanism of the heart. The mechanism in short is, when our heart pumps, oxy-hemoglobin blood flows throughout the human body and de-oxy-hemoglobin blood flows from the all body towards the heart. Our system detects the reflectivity changes in our blood vessels and provides us real time data pulse. Figure 4-(a) carries wearable part of the system and also the detecting sensor. Approximately 17 values are saved in a minute in SD Module and when once the stress button is pressed; it saves '1' with the specific time. We can get the pulse at several points of the body such as fingers, ears etc.

Figure 5: Comparison of Stress Measurement of the same user over time using Custom Sensor, Commercial Machine and Manual Method (using pulse counts)

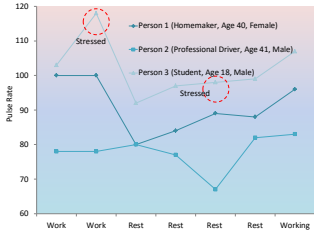

Figure 6: Comparison of Pulse Measurement across three different users using custom sensor

We have considered pulse information extraction from ear to minimize driver distraction.

System Evaluation

We have conducted detailed long term system evaluation to understand how the pulse sensor reflects the changes in movement along with the presence of stress or anxiety or discomfort - any thing that may hamper the feelings of well-being. We have provided our sensor module to four different users of various age groups - two students of age range from 18 to 20, a home maker of age 40 and a professional driver of age 41. We have asked them to use the wearable device over a period of a week at various times and have asked them to note down any of their personal feelings that should be reflected through the sensing outputs. Two of our users have used the device for a significant amount of time (one student and the home maker) over three days while the other two were able to provide us periodic sensing data.

We have measured pulse data using a commercial pulse sensor, manual countdown of pulse rate using fingers over blood vessels along with our custom built wearable system. The component level accuracy of the home maker is shown in Figure 5 where the error rate of custom sensor is not beyond 5% when compared with the machine read data. The manual measurement has a higher level of difference which is probably caused by the human error in counting. The illustration also shows the difference in sensing over the working period and resting period while the resting period record goes higher on times when the user mentions about ongoing stress.

The trend of three different users can be seen in Figure 6 where the resting period can be clearly identified from working one. However, every user has a unique pattern of regular pulse rate. A generic range will not be feasible to identify patter of wellbeing or absence of wellbeing. It must be custom designed based on user's trend of pulse information. Our wearable system is still in its infancy. The testing phase is very challenging as research prototyping is not very common in our country. There is personal reservation among many users regarding device level study while the interview sessions were easy to conduct. We have faced Police interrogation twice while we were conducting field tests with our wearable device!

Conclusions

Driving experience plays a very important role on the traffic behavior and road safety. The experience can be crucial if the traffic situation itself is challenging. We have explored ways to find out about driver's experiences and identified factors that govern driving experience in an urban scenario with chaotic multimodal traffic in the context of Dhaka, Bangladesh. We have conducted instrumented vehicle study, unprecedented in the context of Bangladesh.

References

[1] Thomas E Boyce and E Scott Geller. 2002. An instrumented vehicle assessment of problem behavior and driving style:: Do younger males really take more risks? *Accident Analysis & Prevention* 34, 1 (2002), 51–64.

[2] David Crundall, Editha Van Loon, and Geoffrey Underwood. 2006. Attraction and distraction of attention with roadside advertisements. *Accident Analysis & Prevention* 38, 4 (2006), 671–677.

[3] Nicola Dell, Vidya Vaidyanathan, Indrani Medhi, Edward Cutrell, and William Thies. 2012. Yours is better!: participant response bias in HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing*

Systems. ACM, 1321–1330.

[4] Observer Dhaka. http://www.dhakaobserver.com/english/uploads/images/news/3459.jpg. (????). Last Accessed on July 2015.

[5] Ragib Dhar. http://www.dhakatribune.com/sites/default/files/imagecache/870x488_article_high/article/2013/07/15/4-20130712-Rajib-Dhar-0119.jpg. (????). Last Accessed on July 2015.

[6] E. Gulian, A. I. Glendon, G. Matthews, D. R. Davies, and L. M. Debney. 1990. The stress of driving: A diary study. *Work and Stress* 4 (1990), 7–16. Issue 1. DOI: http://dx.doi.org/10.1080/02678379008256960

[7] Mehedi Hasan. http://www.dhakatribune.com/sites/default/files/article/thumb/2014/11/28/back-Mehedi-Hasan--%281%29.jpg. (????). Last Accessed on July 2015.

[8] Shamsi T. Iqbal, Eric Horvitz, Yun-Cheng Ju, and Ella Mathews. 2011. Hang on a Sec!: Effects of Proactive Mediation of Phone Conversations While Driving. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 463–472. DOI: http://dx.doi.org/10.1145/1978942.1979008

[9] Shamsi T. Iqbal, Yun-Cheng Ju, and Eric Horvitz. 2010. Cars, Calls, and Cognition: Investigating Driving and Divided Attention. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*. ACM, New York, NY, USA, 1281–1290. DOI: http://dx.doi.org/10.1145/1753326.1753518

[10] Md Mozahidul Islam and Charisma F Choudhury. 2012. A Violation Behavior Model for Non-motorized Vehicle Drivers in Heterogeneous Traffic Streams. In *Transportation Research Board 91st Annual Meeting*.

[11] Ing-Marie Jonsson, Clifford Nass, Jack Endo, Ben Reaves, Helen Harris, Janice Le Ta, Nicholas Chan, and Sean Knapp. 2004. Don'T Blame Me I Am Only the Driver: Impact of Blame Attribution on Attitudes and Attention to Driving Task. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems (CHI EA '04)*. ACM, New York, NY, USA, 1219–1222. DOI: http://dx.doi.org/10.1145/985921.986028

[12] Nicholas D Lane, Emiliano Miluzzo, Hong Lu, Daniel Peebles, Tanzeem Choudhury, and Andrew T Campbell. 2010. A survey of mobile phone sensing. *Communications Magazine, IEEE* 48, 9 (2010), 140–150.

[13] J.L. Mathias and L.K. Lucas. 2009. Cognitive predictors of unsafe driving in older drivers: a meta-analysis. *IPG International Psychogeriatrics* 21, 4 (2009), 637–653. DOI: http://dx.doi.org/10.1017/S1041610209009119

[14] Ozioma C. Okonkwo, Michael Crowe, Virginia G. Wadley, and Karlene Ball. 2008. Visual attention and self-regulation of driving among older adults. *International Psychogeriatrics* 20 (2 2008), 162–173. Issue 01. DOI: http://dx.doi.org/10.1017/S104161020700539X

[15] World Health Organization and others. 2011. Mobile phone use: a growing problem of driver distraction. (2011).

[16] Alexander Pollatsek, Donald L. Fisher, and Anuj Pradhan. 2006. Identifying and Remedying Failures of Selective Attention in Younger Drivers. *Current Directions in Psychological Science* 15, 5 (2006), 255–259. DOI: http://dx.doi.org/10.1111/j.1467-8721.2006.00447.x

[17] Alexander Pollatsek, Matthew RE Romoser, and Donald L Fisher. 2012. Identifying and remediating failures of selective attention in older drivers. *Current directions in psychological science* 21, 1 (2012), 3–7.

[18] Dario D Salvucci. 2013. Distraction beyond the driver: predicting the effects of in-vehicle interaction on surrounding traffic. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 3131–3134.

[19] Rijurekha Sen, Bhaskaran Raman, and Prashima Sharma. 2010. Horn-ok-please. In *Proceedings of the 8th International Conference on Mobile Systems, Applications, and Services (MobiSys '10)*. ACM, New York, NY, USA, 137–150. DOI: http://dx.doi.org/10.1145/1814433.1814449

[20] The Daily Star. Last accessed at July 2015a. Horrible Condition of Roads. *http://www.thedailystar.net/horrible-condition-of-roads-38965* (Last accessed at July 2015).

[21] The Daily Star. Last accessed at July 2015b. Road on Eid. http://archive.thedailystar.net/beta2/wp-content/uploads/2013/10/eid01-660x500.jpg. (Last accessed at July 2015). Accessed: 2015-06-01.

[22] David L Strayer and Frank A Drews. 2007. Cell-phone–induced driver distraction. *Current Directions in Psychological Science* 16, 3 (2007), 128–131.

[23] Dhaka Tribune. http://www.dhakatribune.com/sites/default/files/imagecache/870x488_article_high/article/2014/06/02/back-20140601-zakir-0278.jpg. (????). Last Accessed on July 2015.

[24] Pierre Van Elslande, Magali Jaffard, Katel Fouquet, and Véronique Vatonne. 2008. Variety of Attentional Failures in Traffic Accidents. In *Proceedings of the 15th European Conference on Cognitive Ergonomics: The Ergonomics of Cool Interaction (ECCE '08)*. ACM, New York, NY, USA, Article 9, 5 pages. DOI: http://dx.doi.org/10.1145/1473018.1473030

[25] Kristie Young, Michael Regan, and M Hammer. 2007. Driver distraction: A review of the literature. *Distracted driving* (2007), 379–405.