Investigating the Effects of Age on Senior Citizens During Hands-Free Mobile Phone Activity

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***Abstract*— Driving and utilizing a mobile phone becomes legitimate only if it is in hands-free mode. Nonetheless, due to the driver's deflected concentration to the phone and the driving task, utilizing a mobile phone hands-free result in cognitive distraction. Based on the blood pressure (BP) of drivers, this investigation determined real-time age effects of talking on mobile phones hands-free during driving. The cognitive implication was assessed through drivers' BP. During driving and parking in the bay in reverse, the subjects performed two number-related tasks of increasing level of difficulty. The findings indicate that participant's BP during phone conditions increased and surpassed their BP under no-phone conditions. According to qualitative results, the task accomplishment had a profound cognitive effect on the subjects. The qualitative questionnaire yielded empirical proof of the drivers' cognitive abilities, corroborating statistical results and endorsing the hypothesis.**

Keywords—mobile phone; sensor; blood pressure; statistical measures.

I. INTRODUCTION

With the increasing popularity of mobile phones, they have become a paramount tool for daily communication. While this technology is convenient, it can be used at unfitting places and times, which can compromise safety, such as while driving. Researchers have determined that distracted drivers have a greater chance of being distracted from road hazards while driving by their phones. As a result, mobile phones were banned while driving because they cause inattention and cognitive impairment since their attention is diverted from driving tasks [1,2,3]. Mobile phones can also be used hands-free while driving [4,5,6]. Nonetheless, in a situation where the lead vehicle slows down during a crucial part of the conversation, there is a high risk of a collision because the follow-up driver may not react quickly enough. According to [7], blood pressure (BP) is higher in drivers of all ages who experience this. [8] argued that risk-taking is more prevalent among young motorists when driving, such as following vehicles too closely or failing to yield to other drivers. It is habitual for them to overestimate their driving abilities and underestimate the hazards on the roads [9]. They are insufficiently able to recognize and react to dangers because of this driving behaviour, as well as their lack of experience [10]. Compared to drivers between the ages of 35 and 60, younger drivers have less experience, take more risks, and are more likely to be drunk. From teenage years to middle age, fatality rates decline. Over-69 drivers (otherwise known as senior citizens) and middle-aged drivers, on the other hand, tend to be more experienced, less perilous, and more likely to use seat belts [10,11].

U.S. statistics show that young and old drivers are most foreseeably to relate to deadly and serious motor vehicle collisions. Sixteen to twenty-year-olds make up 6.0% of drivers, but 9.6% of all fatal crashes involve teenagers. Age-related traffic-fatality rates are 1.4 times and 1.7 times higher for drivers older than seventy-four and drivers aged 21–24, respectively, than for drivers aged 35–44. There may be unique characteristics within each age group that explain this variable crash involvement. As a result of childish behaviour, lack of knowledge, and more dangerous driving habits, younger drivers are very likely to be associated with road traffic accidents. Senior citizens are generally at a higher risk of fatalities as they age, especially those over 80. In addition to plummeting motor skills and perception, senior citizens have a high crash rate due to a variety of factors such as diminished cognitive skills [11]. This study focuses on senior citizens amongst all age groups.

Driving behaviour while using mobile phones has been exhaustively studied using driving simulation experiments (laboratory experiments) in related research papers [12,13,14,15]. Due to lack of testing independent variables in a real-life setting, driving simulation experiments are limited by low ecological validity and generalizability. Participants' natural behavior has been reflected in the present study using real-time driving. Real-time driving has been used in very few research studies [16,17]. Considering this, it is pertinent to utilize this approach.

While blood pressure measurements have been used to ascertain the effects of mobile phone use in several studies, it is unclear whether prior research have explored the effects of age (senior citizen) on drivers' cognitive performance because of additional cognitive stressors while driving and using a mobile phone hands-free in real-time. This investigation aims to fill in the gap.

This investigation has employed two strategies, namely qualitative and quantitative. In the qualitative survey, the questionnaire was built on knowledge on cognitive load experienced by drivers. Following the qualitative questionnaire answers, the statistical findings derived from this study were confirmed by the empirical proof supplied by the drivers. Thus, the hypothesis was proven. The hypothesis is as follows: If the participant's average blood pressure for the phone condition is greater than it is for the no-phone condition, then they are cognitively loaded. Otherwise, the participant is not cognitively loaded.

The magnitude of cognitive ability needed to complete a given activity determines an appropriate level of cognitive workload [18,19]. Heart rate variability, blood pressure, and Electroencephalogram (EEG) are some of the physiological characteristics influenced by cognitive load. Due to small changes in cognitive load, driving performance measures have limitations compared with physiological methods. Performance measures can detect a high cognitive load condition, but not capable of effectively distinguishing levels of cognitive difficulty, which were applied in the present study as secondary tasks, which is why physiological index such as BP was applied as an indicator of cognitive load in this study [20,21]. BP may be a suitable index of cognitive load due to its credibility and reliability [7]. Mobile phones add a cognitive challenge that increases blood pressure, according to existing research [7]. Blood pressure can be measured using the Intelii IT Blood Pressure Monitor to determine whether talking on the phone hands-free is affected by age. Regardless of where it is placed on the upper arm, this device generates accurate results. Moreover, it has Bluetooth capability for transmitting all measurements to physicians via mobile phone software [22].

The following targets have been used to accomplish the present study's primary goal: Measure the BP of drivers as they talk on mobile phones hands-free while parking in the bay in reverse and acquire and evaluate the data with descriptive and inferential statistics. Verify statistical outcomes based on qualitative data.

II. RELATED WORK

Handsfree mobile phone use involves inserting the phone into a phone holder on the dashboard near the driver. It is also possible to hold the phone while using it, in which case it is considered handheld. It has been illegal in the UK to use handheld mobile phones while driving since 2003 [1]. Hands-free phones are allowed in the UK, but if the police suspect a driver is distracted and not in control, penalties may apply [23,24]. Most states in the US, including California and Hawaii, and all West-European countries prohibit handheld phones. All European countries, however, allow hands-free phoning [25]. The UK House of Commons Transport Select Committee recommends stricter enforcement of the mobile phone laws and stronger restrictions on using them while driving [23,24]. A driver may receive penalty points on their license and be banned from driving for more serious offenses.

Drivers are rarely able to stay concentrated on the road while they are talking on a hands-free phone. It is not easy for drivers to attend to both their mobile phones and driving tasks simultaneously. There is a likelihood that the driving task may be disturbed. If the advancing vehicle slows down while the conversation is ongoing, the driver behind may not be able to react promptly. Blood pressure measures have been utilized to study the effects of talking on a mobile phone hands-free [7].

To investigate the ramifications of talking on a mobile phone during driving, the cardiovascular (CV) mechanism can be analysed. The impact of added tasks (talking) on CV mechanism whilst driving was researched in a study comprising sixty subjects, with a mean age of nineteen years and fifty percent male. Along with other factors, diastolic blood pressure (DBP) and systolic blood pressure (SBP) were digitally recorded. SBP for no task was 116.22 ± 12.54 and SBP for talking was 118.93 ± 11.89. DBP was 65.30 ± 8.43 for no task and 66.81 ± 9.15 for talking. The paper argues that talking on a mobile phone whilst driving constitutes a danger to the cardiovascular mechanism equally as significant as stress, given that CV mechanism has been related to CV disease, such as strokes and heart attacks. As a result, in theory, the more regularly one participates in activities that heighten CV mechanism, the higher the likelihood of CV disease. Insufficient studies have investigated the effect of extra-task involvement on CV mechanism [7].

Due to their inexperience and willingness to take risks, young novice drivers are particularly affected by using mobile phones while driving. Drivers with fewer than three years' experience are described as novices. Drivers under the age of 20 in the UK are considered novices since the minimum driving age is 17. It is common for people to pass their driving tests at any age, so there are novice drivers of all ages. In terms of novice drivers, those with greater than three years of driving experience are categorized as experienced [26,27]. A young driver is defined by the Department of Transport as someone between the ages of 17 and 25 [27].

The hazard perception and cognitive skills of a novice driver are generally inferior to those of an experienced driver. A novice driver's most important skills are hazard awareness, hazard perception, and attention control [9,26,28]. Secondly, novice drivers rarely display adequate attention control, which means paying attention to the relevant information, at the correct timings, in the correct measure. With increasing driving experience and familiarity, mobile phone use while driving diminished in effect. During phoning, experienced drivers reduced their maximum speed less significantly than novices, according to a study. The marginal difference in speed, however, has not been clarified [29,30].

According to a breakdown of UK drivers by age group, drivers over 70 are considered elderly. Aging causes cognitive decline in elderly drivers, but they have enough time to adapt to avoiding behaviours. Elderly drivers are more likely to encounter stressful situations due to cognitive decline. Additionally, they have developed and adapted to safe driving behaviours during a variety of hazardous situations on the road, such as avoiding rush hour routes through cities, for instance [24,31,32,33].

Furthermore, it is important to consider how age affects mobile phone usage. During two different situations (high and low speeds), Forty-eight subjects (twenty-four between the ages of 65 and 73 and twenty-four between the ages of 20 and 26) were tested on their ability to keep up with speed limits and use mobile phones. Among the within-subject independent variables were conversational lengths as well as complicated and straightforward conversational material. Driving behaviour, subjective ratings, task reaction times, and task accuracy were the dependent variables. During small driving loads, brief talk periods, and simple conversation topics, vehicle speed varied little. Conversely, complex conversations significantly affected driving behaviour. Contrary to no call or straightforward conversations, drivers' driving behaviour, measured in lateral acceleration, was less variable under low driving loads. Hands-free mobile phone use significantly affected the performance of older drivers (acceleration, lane deviation, reaction time, and accuracy). On divided attention tasks, younger drivers scored 96.3%, while older drivers scored 66.3%. Younger drivers performed better on a divided attention test without a phone call than with one, but their driving behaviour did not appear to be significantly affected using a mobile phone. Using a mobile phone hands-free may have a significant impact on safe driving among the elderly [33].

During a Naturalistic Driving Study, 3542 participant drivers were continuously monitored using multiple cameras and sensors for up to 3 years. During normal driving segments as well as at the onset of crashes, secondary-task engagement was observed. For 16–20-year-olds, 21–29-year-olds, 30–60-year-olds, and 65–98-year-olds, crash odds ratios were calculated for secondary tasks. All serious collisions (property destruction and greater damage) were considered in the assessment. Although elderly drivers carried out additional tasks significantly less often than middle-aged drivers, distraction caused by additional tasks was always more hazardous for drivers older than 65 and younger than 30. All drivers were impacted by additional tasks involving increased visual-manual demands (e.g. mobile phone use). Elderly drivers, teenagers and young adults were more severely impacted by additional-task involvement than middle-aged drivers. All drivers were affected by visual-manual distraction, but young drivers were more susceptible to be impaired by cognitive distractions [11].

In the research from [34], distractions caused by secondary tasks are a leading contributor of motor vehicle collisions between adults and teenagers. The paper studied the connection between additional tasks, such as dialling on a mobile phone, sending or receiving text messages, reaching for an object other than the phone, and collisions and potential collisions. In total, 42 recently qualified drivers (16 to 17 years of age) and 109 adults with extensive driving experience had cameras, accelerometers, global positioning systems, and a variety of sensors in their vehicles. In the investigation, novice drivers were linked to 167 collisions and near-collisions, while experienced drivers were linked to 518 collisions and near-collisions. For novice drivers, dialling on a mobile phone elevates the likelihood of an accident or near-accident. When experienced drivers dialled on their mobile phones during driving, their risk of a collision or near-collision spiked considerably. In novice drivers, risky attention to additional tasks grew over time, unlike in experienced drivers.

III. METHODOLOGY

A. Subject Selection

The subjects were fit drivers of various ages. There were 16 participants. Five participants' data were eliminated due to recording issues encountered in the experimental trials. A total of two hundred and fourteen simulated data points were developed as well as utilized in this research, along with data from 11 participants [35]: Five were males and six were females. With a mean age of 42.9 and a standard deviation of 16.8, participants range from 18 to 89 years. All participants provided informed consent. Two tasks were completed by participants, one easy and one hard. Furthermore, participants completed questionnaires outlining their individual perspectives on workload. The questionnaire asked about the driver's age, gender, and driving experience level. Each box on the questionnaire form was assigned a weighted percentage value representing cognitive load, with zero percent being the least and hundred percent being the maximum. On the questionnaire, each subject ticked the box that most accurately expressed the effect of cognitive load on their perception during the trial [36].

B. Experiment Protocol

While performing controls, easy tasks, and hard tasks, we collected blood pressure data using the BP measuring device. The control task is parking in the bay in reverse and not using a phone. Before the control tasks began, participants' baseline blood pressure was measured. Following the control task, new measurements of blood pressure were taken [7,37]. The dual task is parking in the bay in reverse and using the phone. The dual task consists of two parts: an easy task and a hard task. The procedure for easy task is thus:

a) The researcher pushes the phone’s power switch.
b) The subject places an audio call by saying “Experiment”.
c) The number corresponding to “Experiment” is recognised and called by the phone.
d) There will be an automated message played, thus: “Count from fifty up to two hundred”.
e) As the subjects drive towards the bays to park, they will respond to the message from the gate.

As for hard tasks, the procedure is similar, however, using a different message: “Count backwards from hundred, taking away three each time”.

C. Data Collection and Data Description

Data was obtained with an Intelii IT blood pressure measurement device. Bluetooth's capability is one of its major advantages. Like mobile phones, pairing was required to connect the BP measuring device to the research phone. The cuff was fitted over the subject's upper arm, so it was in line with the subject's chest so that the tubing fell over the front centre of the subject's arm. By tightening the cuff end, the sensor is placed appropriately and tightly over the arm. When the unit's start button is pushed, the cuff expands. Once the cuff is inflated to maximum and stops inflating, and the monitor shows constant readings, records are taken. This device measures participants' blood pressure numerically, and the experimenter's research phone receives every measurement instantly. A spreadsheet's main data file shows the date in the first column, while the entry time appears in the second column. From left to right, the following columns list the subject's Systolic Blood Pressure in millimetres of mercury (mmHg) and Diastolic Blood Pressure in millimetres of mercury.

D. Feature Extraction and Data Processing.

To obtain precise and credible measurements, blood pressure measurements were acquired within the experimental window [7,37]. The following is a brief explanation of the procedures used to take blood pressure readings: The experimenter explained, and the participants practiced the prescribed bay parking procedure for 15 minutes. A five-minute break was taken by the participants [18,38]. BP measurements were taken at baseline, meaning participants were resting, calm and did nothing during these measurements. Participants performed bay parking without using their phones as they drove from the car park gate. A second measurement of the participants' blood pressure was taken. Five minutes of rest was taken by the participants [18,38]. After the rest, the easy task began. Talking on the phone while bay parking was performed by participants as they drove from the car park gate. Participants' blood pressure was recorded. After resting for 10 minutes [18,38], participants began the hard tasks and proceeded from the car park gate and performed bay parking while talking on the phone. Participants' blood pressure was recorded. The block diagram in Fig. 1 represents the significant parts of the project.

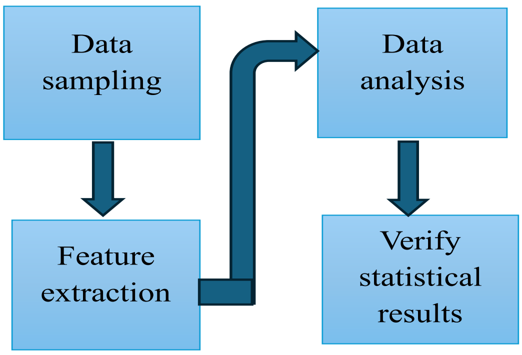

Fig. 1. Block Diagram of the Research

IV. RESULT AND ANALYSIS.

As part of data analysis, the authors have used two main statistical methods. Indexes such as mean and standard deviation have been used to summarize data using descriptive statistics. Inferential statistics where the relationship between the variables was examined have also been applied. While statistical testing offers many advantages, it is not exempt from some drawbacks, such as the complexity of interpreting the data and arriving at credible conclusions due to assumptions about data distribution and variances [39]. Therefore, the present study aims to validate the hypothesis using empirical evidence from participants' self-reports. Qualitative surveys have provided the ground truth (empirical evidence) used to validate the statistical results. Secondary task demand was also investigated by [40] using BP, and subjective data was analysed to confirm results.

To analyse data in this investigation, the simulated two hundred and fourteen data points represents the participants. As shown in the figures below, the values on the x-axis from Fig. 2 to Fig. 8 stands for the blood pressure groups. The height of each bar stands for data points which are contained in each blood pressure group. For example, in Fig. 2, 25 data points are contained within the BP group (114-118) while 20 data points are contained within the BP group (124-128) and so on. Similarly, the values on the x-axis in Fig. 9 represents the group values of percentage cognitive load on the participants. The histograms in figures, Fig. 2 to Fig. 8 represents the distribution of blood pressure range at different age groups while engaging at driving tasks with and without mobile phone use. Table 1 below shows a summary of the statistical parameters calculated from the BP signals such as average (Ave), minimum (Min), maximum (Max) and standard deviation (SD) for no-phone and phone condition.

Since normal blood pressure (blood pressure when not driving) differs from subject to subject, and some may be hypertensive, the reader would be more likely to understand if the BP increment with and without phone is emphasized. As a result, illustration focuses on BP increments from no-phone to phone usage. Fig. 8 below shows BP differences with and without phone for all the participants in this research. Findings show that the average BP with phone for 17-39 years old is 7.21 mmHg more than BP without phone. For middle-aged drivers 40-69 years, the average BP with phone is 6.75 mmHg higher than BP without phone. Whereas for senior citizens (69 years and over), the average BP with phone is 6.35 mmHg higher than BP without phone. Findings show average blood pressure increases for each group. However, drivers (40-69) and senior citizens (69 years and over) have experienced less BP increment from no-phone condition to phone condition, than the young drivers. The results as shown in table 1 supports the hypothesis as outlined above.

The breakdown of subjective cognitive load in terms of percentages due to the added cognitive stressors (easy task and hard task) is illustrated in Fig. 9 below by randomly picking roughly twenty-five data samples from the overall data samples. Twenty-two data points (participants) reported seventy percent or higher response rate, while three participants reported less than seventy percent response rate.

To compare results with other literature, it is imperative to keep in mind that very few studies have explored secondary task demand using BP. This is not surprising since existing methods, such as measuring blood pressure at the finger, are somewhat restricted when driving normally [40]. Since these techniques entail a hand or arm to be kept stationary, they are clearly not compatible with two-handed operation. Using sixty subjects, with a mean age of nineteen years old, [7] examined the impact of additional tasks (talking) on CV reactivity while talking on the phone and driving. As a result, SBP was 116.22 ± 12.54 for no task and 118.93 ± 11.89 for talking. The DBP for no task was 65.30 ± 8.43 and for talking it was 66.81 ± 9.15. These findings support the present study. A driving simulator study [40] assessed drivers' mental workload among 15 participants aged 20 to 25 using data collected from the study. Following short increases in task demands, blood pressure was measured as an indicator of mental effort. As traffic density increased, systolic blood pressure increased, indicating an increased effort investment. Furthermore, participants reported higher mental effort on subjective measures.

TABLE 1. RESULTS FROM BP SIGNALS

Statistical measures of BP	17-39 years	40-69 years	Senior citizens
Ave BP no phone	112.36	114.11	127.10
Ave BP with phone	119.57	120.86	133.45
Min BP no phone	80.00	80.00	92.00
Max BP no phone	131.00	131.00	142.00
Min BP with phone	89.00	93.00	102.00
Max BP with phone	142.00	141.00	151.00
SD no phone	15.00	15.07	14.75
SD with phone	12.45	12.69	13.71

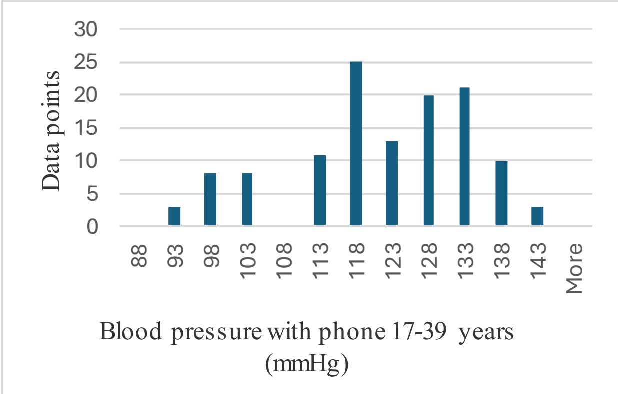

Fig. 2. Blood pressure with phone (17-39 years)

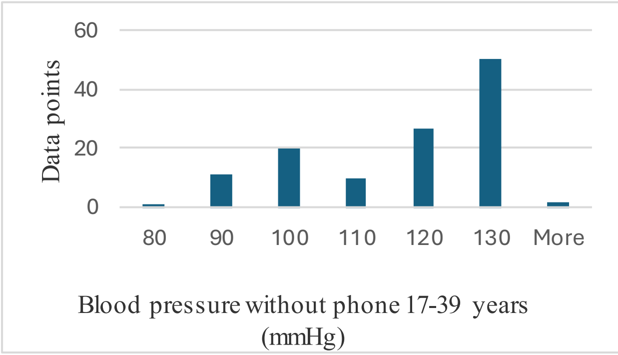

Fig. 3. Blood pressure without phone (17-39 years)

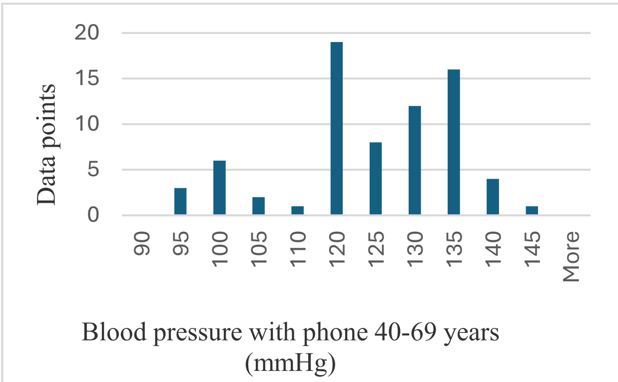

Fig. 4. Blood pressure with phone (40-69 years)

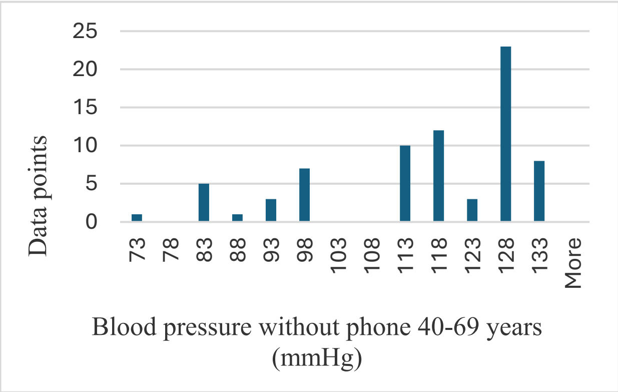

Fig. 5. Blood pressure without phone (40-69 years)

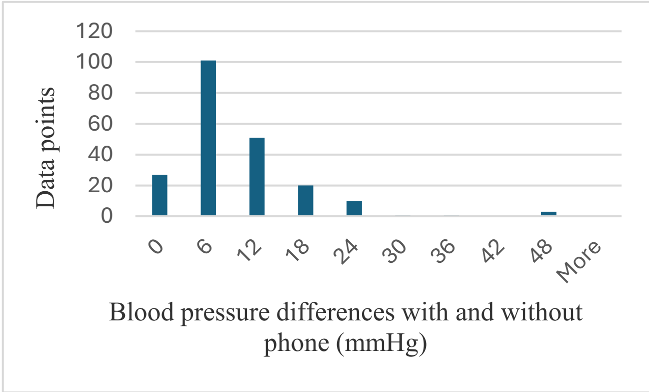

Fig. 8. BP differences with and without phone

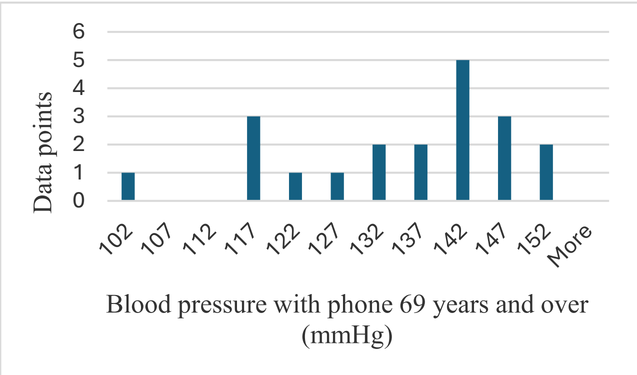

Fig. 6. Blood pressure with phone (69 years and over)

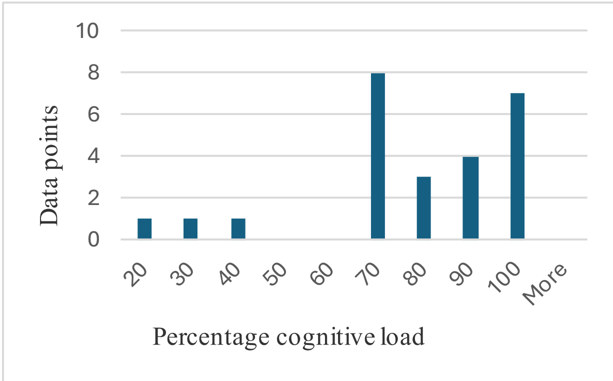

Fig. 9. Distribution of self-reported cognitive load

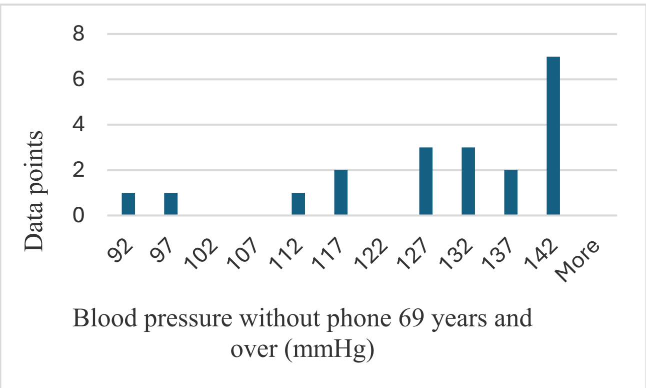

Fig. 7. Blood pressure without phone (69 years and over)

V. DISCUSSION

The present research qualitative approach cantered on the survey, drawing on literature regarding drivers' cognitive load. The responses offered by the participants to the qualitative survey were utilized to establish the ground truth concerning the drivers' cognitive performance. which was used to verify the statistical results obtained from this study, hence the hypothesis was therefore validated. Research on the physiological effects of driving whilst talking on a mobile phone has been limited [7], from literature survey, it is not certain if any study had investigated the consequence of age (69 years and over) on talking on mobile phone hands-free during driving using BP. In this study, talking on a mobile phone hands-free whilst driving gave rise to a notable contrast in drivers' BP between age groups. The overall outcome of this study had shown an average BP increment for each group because of talking on mobile phone hands-free. The results as shown in table 1 supports the hypothesis.

Drivers' competence to accomplish the essential task of driving a vehicle and cope with the distractions caused by additional tasks, such as using a mobile phone, is largely dictated by their driving experience [28,41]. This may explain why drivers (40-69) and senior citizens (69 years and over) have experienced less BP increment from no-phone condition to phone condition, than the young drivers according to findings. Furthermore, in contrast to experienced drivers, findings from [41,42] show that inexperienced young drivers' performance declined more during phone use. However, despite higher experience, performance deterioration of the experienced drivers is also considerable, suggesting that higher experience cannot nullify the effects of increased workload [42].

A scenario in which listening to a car radio instead of hands-free mobile phone use during driving was imagined by the authors, leading to further investigation. As compared with driving without listening to economic news, elderly adults experienced a significant decrease in average driving speed (74 km/h to 66 km/h) while listening to economic news while driving [43]. The study findings indicate that elderly drivers compensated driving performance with safety margins when cognitively engaged.

A few noteworthy limitations and strengths can be found in this study. First, the study sample consists of a representative sample of drivers in London between the age range of eighteen and eighty-nine. The authors used a sample dataset from a small population rather than a population dataset. Some related studies have used small sample sizes. In [44], for instance, only five subjects were analysed from 10 EEG data collected from 10 subjects. As a result of the elevated level of artifacts and noise, data from the other five subjects were ignored. In [40], drivers' mental workload was assessed using only 15 participants. In its experiment, [45] recorded only 12 subjects. Through 214 simulated data from 11 subjects (11 subjects inclusive), the present study overcame limitations caused by the small sample size. Other notable literatures, such as [46,47], have also used data simulation to overcome limitations caused by small sample sizes. The present study is strengthened by the Bluetooth capability of the equipment. The experimenter's research phone received every measurement instantly through Bluetooth throughout the experiment. Additionally, the research involved driving in real-time in a car to maximize generalizability of the field experiment's results.

VI. CONCLUSION

In real-time, blood pressure signals were used to examine the moderating effect of age on talking on mobile phones hands-free whilst driving. The BP under phone scenario exceeded the BP under no-phone scenario in multiple statistical analyses. Subjective data was collected from each participant using a questionnaire. Using the qualitative survey, the drivers provided empirical proof concerning their cognitive performance. The survey responses were employed to verify the statistical results obtained from this study, and the effect of age (senior citizen) on talking on mobile phones hands-free while driving in real-time setting was therefore validated. Findings show that the average BP with phone for young drivers (17-39 years) is 7.21 mmHg more than BP without phone. For middle-aged drivers (40-69 years), the average BP with phone is 6.75 mmHg higher than BP without phone. Whereas for senior citizens (69 years and over), the average BP with phone is 6.35 mmHg higher than BP without phone.

According to these findings from the quantitative method, while the BP under phone scenario is greater compared to the BP during no phone scenario, the participant is cognitively loaded, which results in poor performance. The participant's performance is good if they are lower. In the same manner, the qualitative study showed that the cognitive workload on the subjects grew considerably while engaging in phone activities. Drivers (40-69) and senior citizens (69 years and over) have experienced less BP increment from no-phone condition to phone condition, than the young drivers according to findings.

Despite the pronounced shortcomings, talking on a mobile phone hands-free has some noteworthy merits, including facilitating contacts and making it more feasible, particularly in urgent situations. However, the general conclusion from this study highly advises public members to minimize their talking times, do the necessary talking while driving, and possibly utilize voice enabled mobile phones to reduce distractions.

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