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Driver's Physiological Measures with In Vehicle Secondary Distraction: A Systematic Review

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ABSTRACT

Driving vehicles has become more complex. Thus, drivers who are not engaged with any non-related driving activities, that is performing in-vehicle secondary task, are unusual nowadays. Statistics also shows the higher number of crashes come from distracted driving. In addition, currently, there is limited review have been done to compile and review the physiological method, driving distraction and its effect on the driver. Therefore, this paper aims to review the effect of driver's in-vehicle distraction and secondary task during driving on driver's health and safety. A systematic search was conducted on the basis of the preferred reporting items for systematic reviews by using PRISMA guidelines. Any criteria were imposed for the included sample. The search was focused on in-vehicle secondary task and distraction. Results showed that 21 articles investigated the major ability for in-vehicle secondary task distraction using physiological measures. Findings showed a significant effect of the in-vehicle secondary task and distraction on driver's condition. Drivers' characteristics such as their experience and age are also factors in determining the effect of distraction and secondary tasks on their condition. However, further studies are needed to understand the physiological effect of secondary task on young driver's condition due to the relatively higher number of crash rates from those at a young age.

Keywords: Disturbance; vehicle; road; environment; workload; physiology

INTRODUCTION

Driving is a complicated task that involves multiple cognitive, physical, sensory and psychomotive competencies to be performed concurrently. When driving, there are many factors affecting driver. The interaction between driver and the internal component of the car will affect either the direction of the car or the speed of the car (Khamis et al. 2018). Despite this complexity, drivers who engaged in different non-driving activities such as talking with passengers, listening to the radio, applying make-up and even reading something during their driving operations are not uncommon nowadays (Torkamannejad et al. 2016). Advanced amusement technological implementation, such as road navigation and the Internet into cars and the use of digital driving devices have become more progressively prevalent with the advent of wireless interaction, such as mobile phone (Klauer et al. 2006).

Number of issues such as traffic congestion, frequent crash, air pollution and others effects have been caused by the rapid increase of drivers on the road (Naujoks et al. 2016). Human behavior, vehicle and road environment are the main factors to road crashes (Ismail & Hashim 2015). According to studies by Jaber et al. (2017), accidents occur due to the behavior of drivers of which 35% are young drivers. In addition, accidents are also caused by exceeding the speed limit, drowsiness, road conditions and car conditions. Sleepy driver comes from the unfit driver which can cause crashes (Parnell et al. 2016). However, according to National Highway Traffic Safety Administration (NHTSA), 9 % of fatal crashes were reported as distraction-affected crashes and 3,166 people were killed because of motor vehicle crashes. A self-reported study from Malaysian Institute of Road Safety Research (MIROS) in 2015 showed the drivers' agreement that driving whilst using mobile phones could affect their driving behaviour, and driving using mobile phones may also harm themselves and others. Driving whilst engaging with any other non-related driving activity. Data released by World Health Organization (WHO) show that over 1.2 million people die each day due to the crash caused by young people between the ages of 15 to 29 years old (Metz et al. 2014; Alghnam et al. 2013). Drivers must continuously allocate their attention to driving and non-driving activities when driving because many driving task elements are automated with experience, and drivers can often divide their attention amongst concurrent tasks without any severe impact on driving performance or safety.

Investigating driver's distraction has been of interest to road safety analysts and specialists from the industry for a very long time. A few definitions arise within the writing and commonly incorporated terms such as "attention" or "workload", in expansion to a "stimulus", such as "a protest, individual, task, movement, occasion, happening, development, handle, condition, circumstance, source, or agent" (Jaber et al. 2017; Yahia et al. 2017).

Defining the task that distracts drivers essential for safe driving performance and for the internal or external stimuli of the vehicle (Ngadiran et al. 2008). Full attention is required to the primary task and the non-driving activity when driving. However, drivers can be distracted by an activity, thereby reducing the driver's driving performance. In this regard, drivers drive efficiently at a successful rate, but they fail in ordinary cognitive processes, such as attention-sharing and adaptive strategies (Zafir et al. 2018). Accordingly, discouragement may prevent the performance of secondary tasks at any level because of the complexity of the secondary task or driving demands (Foley et al. 2013).

The factors that distract drivers when they are engaged in other non-driving task or activities, which reach the point that drivers do not pay reasonable attention to and degrade their driving performance, must be determined (Guo et al. 2016). In other cases, if secondary task does not negatively affect driver performance on control, then, no distraction will occur (Dingus et al. 2019). To this end, an event when the driver accepts task safely and adequately because an event or object voluntarily or in voluntarily distracts the driver's attention from the primary task (Hammond et al. 2019).

The cognitive, physical or visual demands that non-driving task sets on the conductor remarkably cause driver's distraction (Papantoniou et al. 2016). Tasks that demand the minimal attention of drivers can efficiently be time shared with slight or no degradation to driving performance. However, some studies show that the impact of using a mobile phone whilst driving is negative because humans have limited cognitive resources at any time (Maciej et al. 2009).

This systematic review seeks to identify the distraction and secondary task that influence the driver's response or behavior on the mental workload or stress while at the same time, also taking into account the driver's experience. Stress can occur as a psychological impact containing emotional and cognitive components that then negatively affect people's mental and spiritual health (Harbluk et al. 2007). This review also aims to understand the effect of the mental workload of the drivers who perform in-vehicle secondary task distractions on physiological responses of the drivers. In addition, this study will focus on the in-vehicle distraction where drivers are more directly exposed to advanced electronic devices in the vehicle rather than the outside of the vehicle. Therefore, this study will discuss the methods, objectives and results of the literature review as shown in Sections 2 and 3, respectively.

METHODOLOGY

LITERATURE SEARCH STRATEGY

A systematic literature search was conducted in WOS, Scopus, ResearchGate, ScienceDirect, Google Scholar and other from other sources by using appropriate keywords. The search strategy is based on the synonyms and relevance of the original words and theme. The search was conducted by selecting only the English language paper and by using the following keywords in our search strategy: distraction, driver's distraction, secondary task and in-vehicle secondary task. Studies were excluded if the keywords are not inline with the search theme, title, year of publication and language. Studies were included if the studies met any of the following criteria:

1. Studies were about in-vehicle secondary task.
2. Studies evaluated driver's performance with in-vehicle distraction.
3. Studies investigated driver's state/condition with in-vehicle secondary distraction task.
4. Studies investigated on driver's physiological measures with in vehicle secondary distraction task.

The selection stages performed systematically following preferred reporting items for systematic review using PRISMA guidelines in Figure 1. A data extraction form was developed to categorise and extract the results appropriately. This form includes elements, such as article specifications (title/years), place of experiment (simulator/naturalistic road/track) and assessment method (process/outcome). In addition, a focus group has been formed to review the selection.

Based on Figure 1, a total of 304 articles were found from the databases. After removing the duplicate articles, 175 articles remained for screening. Then, the articles were evaluated on the basis of their title and abstracts. Finally, 98 studies were selected after performing the previous steps. However, 12 articles were removed from the 98 articles because of their insufficient explanation on measures and the inadequate quality of their studies. Only two articles evaluated the implication of in-vehicle distraction whilst driving. Therefore, from 35 articles, there was 21 articles studied on the in-vehicle secondary task distraction by using physiological measures as presented. Then, analysis of the impact scores were performed to categorise based on the impact ranking as shown in Table 1. The summary of the results is presented in Table 2.

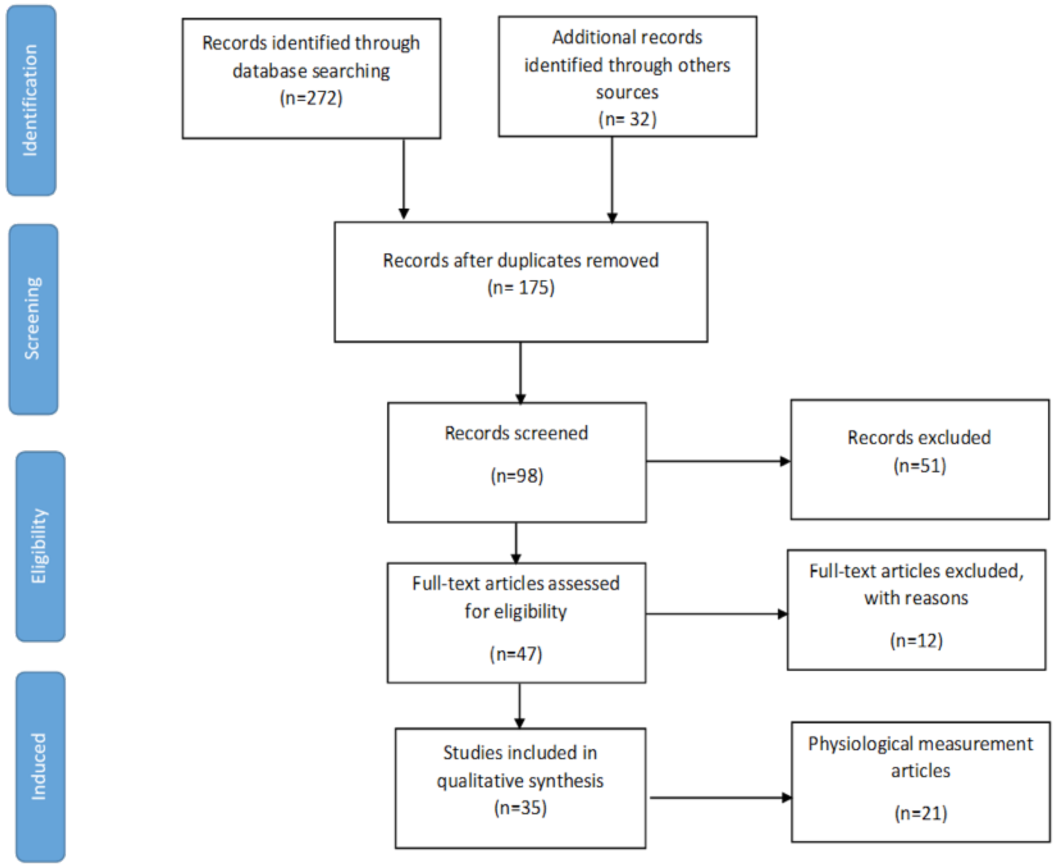

FIGURE 1. Flowchart on the literature search of in-vehicle secondary task distraction

RESULTS

Based on Table 1, the impact scores for each article were analysed based on four criteria or research questions that were stated above. The quality assessments of these articles were represented by strong relevance for the comprehensive overview of the study. The GRADE guidelines helped to developed and summarizing the criteria of each element and aspects for analyzing the strengths and potential flaws of the study. Then, the articles were classifying into three types of impact groups which are; “Strong (70% to 100%), “Moderate” (40% to 69%) and Partial (0% to 39%) impact groups. Each article was analysed again, and quality analysis was applied to the specified impact group. Ten main factors were considered to categorise these articles into the impact group: Defined objective, sample size, characteristics of driver, control group, objective evaluation (direct measure), subjective evaluation (indirect measures), in-vehicle distraction (secondary tasks), simulator study, consistent conclusion and driver workload / performance. Score of the quality were based on a weighted score of 12 criteria. Score ranged from “1” (Yes), “0.5” (Incomplete) to “0” (No). The highest possible score of the article is 22 points.

Table 2 presents the summary of the results and conclusions for these selected articles. Meanwhile Table 3 indicates method and techniques that were applied in previous study which include in-vehicle distraction secondary task.

QUALITY ASSESSMENT OF STUDIES

The quality evaluation of the 21 studies is presented in Table 1. According to Table 1, it shows that all studies are categorised under high quality impact based on ten factors in this systematic review study. Nevertheless, these listed studies do not obtain full scores, which is 22 points due to several aspects. Based on Table 1, three major factors affect the quality score are due to the lack of control group (only 26% complied to this factor), the lack of subjective assessment (only 41% used this method in the past studies) and 61% of the past studies analysed the driving performance or mental workload.

TABLE 1. Quality assessment of 21 selected articles

First Name of Author	Defined Objective	Sample size	Characteristic of Driver	Control Group	Objective evaluation	Subjective evaluation	In-vehicle distraction	Simulator/ non simulator	Consistent conclusion	Driving performance/ workload	Quality qualification	
	3	3	1	1	2	2	3	1	3	3		
Schömig et al. (2011)	1	1	1	1	1	0	1	1	1	1	20	H
van der Zwaag et al. (2012)	1	1	1	0	1	1	1	1	1	1	21	H
Ünal et al. (2013)	1	1	1	1	1	0.5	1	1	1	0	17	H
Schömig & Metz (2013)	1	1	1	0	1	0.5	1	1	1	0	16	H
Jin et al. (2014)	1	1	1	0	1	0	1	0	1	1	18	H
Sonnleitner et al. (2014)	1	1	1	0	1	0	1	1	0.5	0	17.5	H
Almahasneh et al. (2014)	1	1	1	0	1	0	1	1	1	1	21	H
Atchley et al. (2014)	1	1	1	1	1	1	1	1	1	0	17	H
Almahasneh et al. (2014)	1	1	1	0	1	0	1	1	1	1	21	H
Strayer et al. (2015)	1	1	1	0	1	1	1	1	1	1	21	H
Vossen et al. (2016)	1	1	1	0	1	0	1	1	1	0	16	H
Faure et al. (2016)	1	1	1	0	1	1	1	1	1	1	21	H
Kountouriotis & Merat (2016)	1	1	1	0	1	0	1	1	1	1	19	H
Jeong & Liu (2017)	1	1	1	0	1	1	1	1	1	1	19	H
Prabhakar et al. (2018)	1	1	1	0	1	0	1	1	1	0	16	H
Solís-Marcos et al. (2018)	1	1	1	1	1	1	1	0	0.5	1	19.5	H
Pankok et al. (2018)	1	1	1	1	1	0	1	1	1	0	17	H
Čegovnik et al. (2018)	1	1	1	0.5	1	0	1	1	1	0.5	18	H
Welburn et al. (2018)	1	1	1	0	1	0	1	1	1	0	16	H
Jeong & Liu (2019)	1	1	1	0	1	1	1	1	1	1	19	H
Alrefaieet al. (2019)	1	1	1	0	1	0.5	1	1	1	1	21	H
% comply	100%	100%	100%	26%	100%	41%	100%	91%	95%	61%		

1 *Note*: Assessment of the studies (1=Yes; 0=No), Present but incomplete (0.5). Quality: High (H), Medium (M) and Low (L). The highest possible weighted score is 22 points

TABLE 2. Objectives and summary of conclusions

No	Author	Objective	Summary of conclusions
1	Schömig et al. (2011)	Concentrate on situational factors	Drivers anticipate and attempt to prevent possible overload due to dual task situation
2	van der Zwaag et al. (2012)	Effect positive music and negative music in the measure exertion contributed during driving	During listening the music, the rate of respiration was lower
3	Ünal et al. (2013)	Music impact toward driving performance in monotonous vehicle following task	Music listening does not impede execution and improve few parts execution due to expanded excitement.
4	Schömig and Metz (2013)	Secondary tasks decision in driving with control on situational awareness	Drivers understand the driving condition when interacting with secondary tasks
5	Jin et al. (2014)	Effect eye movement whilst driving in distinct kinds of secondary task	Distinct kinds of in-vehicle secondary task influence driver's eye movement differently
6	Sonnleitner et al. (2014)	Effect of a secondary auditory task on the emotional state of the drivers	Auditory secondary task lead to a focusing and, thus, sensory handling
7	Almahasneh et al. (2014)	Behavioral driver distraction	Cognitive distraction while driving has been greatly affected (distracted)
8	Atchley et al. (2014)	Asses the verbal task can enhance alertness observed by EEG	Lane keeping was betters and neurophysiological alertness were enhance when drivers performing verbal secondary task.
9	Almahasneh et al. (2014)	Impact to driver's behavioral condition on various cognitive tasks	Various impact on EEG responses and various frontal cortex localization toward different secondary task
10	Strayer et al. (2015)	Understand cognitive distraction in automobile	Conversation with passengers or talking handheld or hands-free associated with moderate cognitive while use of email system with voice text involved high workload.
11	(WMet al. (2016)	Assess electrophysiology are affected by increased mental workload	More ecologically relevant task, extremely regulated synthetic task can be extended to spatial orientation
12	Faure et al. (2016)	Effectiveness of eye blink behaviour in measuring drivers' mental workload	Introduction of complex cognitive secondary task increased the driver's mental load.
13	Kountouriotis & Merat (2016)	Relationship between the visual and non-visual distraction on horizontal driving	Drivers fail to evaluate due to carrying out the non-visual task, when lead vehicle reduces the speeds.
14	Jeong & Liu (2017)	Most influential factors that affects driver workload	Secondary task types required visual demand were showed higher workload towards driver
15	Prabhakar et al. (2018)	Detecting driver distraction by using pupil dilation, head movement and EEG whilst driver performing secondary task	Pupil dilation, head movement and EEG identified cognitive load increases corresponds to secondary task being carried out.
16	Solís-Marcos et al. (2018)	Impact on additional task efficiency during automated driving	Automated driving results stared closer to the task and considered reduced emotional demand
17	Pankok et al. (2018)	Driver performance and care allocation impacts of display error, and compare findings across two research paradigms.	Display clutter have a major effect on the performance and attention in domains that need more attention than tasks where the disrupted display serves as a support tool for secondary tasks

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18	Čegovnik et al. (2018)	Suitability of a low-cost eye tracker for assessing the cognitive load of drivers	Eye tracker showed increased blink rated, reduced fastening moment and reduced focus with increasing secondary task difficulties
19	Welburn et al. (2018)	Impact of secondary tasks in a cardiac simulation (speaker on the mobile phone, texting and riding without a challenge).	Cell phone talk significantly increases heart and blood pressure cardiovascular reactivity while driving compare to driving without any work.
20	Jeong & Liu (2019)	Difference in driving performance and visual attention in multifunctional setting between different curvatures.	Drivers did not perform well when driving on sharper curves with a task not related to driving.
21	Alrefaieet al. (2019)	Assessing the drivers' physiological behavior (heart rate and pupil diameter)	Secondary tasks have resulted to differences in physiological measurements and a tiny impact on response time.

TABLE 3. Method of previous study on driving distraction

Author	Experiment Place	Lead Vehicle	Sample Size	Male	Female	Group age	Experience	Methods		
								Physiological	Subjective	Performance
Schömig et al. (2011)	S		24	16	8	23-52	By driving frequency a week	ET	-	Y
van der Zwaag et al. (2012)	S			13	6	22-44	>4 years	HR	RSME	Y
Ünal et al. (2013)	S			21	26	19-25	>2 years	ECG	Self-report	
Schömig & Metz (2013)	S		16	6	10	-	-	ET	Self-report	Y
Jin et al. (2014)	S		18	8	10	22-31	>2 years	ET	-	-
Sonnleitner et al. (2014)	T	Y	20	5	20	22-53	-	EEG	-	Y
Almahasneh et al. (2014)	S		42	33	9	18-24	>2 years	EEG	-	-
Atchley et al. (2014)	S		40	25	15	-	>2 years	EEG	DSSQ	Y
Almahasneh et al. (2014)	S		42	22	20	18-24	>2 years	EEG	-	Y
Strayer et al. (2015)	S	Y	38	20	18	18-30	>2 years	ET	NASA-TLX	Y
Vossen et al. (2016)	S	-	16	7	9	-	-	EEG	-	-
Faure et al. (2016)	S	-	24	20	4	20-57	>10 years	EEG	NASA-TLX	Y
Kountouriotis & Merat (2016)	S	Y	15	8	8	-	-	-	-	Y
Jeong & Liu (2017)	S	-	24	16	8	-	-	-	DALI	Y
Prabhakar et al. (2018)	S	-	12	12	10	-	-	ET,EEG	-	-
Solís-Marcos et al. (2018)	NS	-	21	10	11	-	-	ET	NASA-TLX	-
Pankok et al. (2018)	S	-	22	11	11	-	>25 years	ET	-	-
Čegovnik et al. (2018)	S	Y	22	4	18	21-61	>10 years	ET	-	Y
Welburn et al. (2018)	S	-	60	-	-	17-30	-	ET	-	-
Jeong & Liu (2019)	S	-	24	16	8	19-31	>2 years	ET	DALI	Y
Alrefaieet al. (2019)	S	-	36	17	19	20-30	>2 years	ET, Polar H7	Self-Report	Y

ECG=Electrocardiogram, EOG=Electrocardiogram, GSR=Galvanic Skin Response, NASA-TLX=Nasa-Task Load Index, DSSQ=Dundee Stress State Questionnaire, RSME=Rating Scale Mental Effort. [Y = Yes]

DATA EXTRACTION AND EVIDENCE SYNTHESIS

According to the quality evaluation in Table 1, there is a strong evidence that in-vehicle and secondary tasks affect the performance and mental workload of the drivers. In addition, it is related to human behaviors and conditions. Based on the evaluation, no study denied the effects of in-vehicle secondary tasks distraction towards driver. Details of methodological characteristics of 21 selected studies are shown in Table 3.

From the perspective of sample size, only 26% in studies by controlling group. A summary of the study population such as the sample size, gender, experience and age group are summarized in Table 3. All the selected articles demonstrated within their objectives or research context the desire to assess factors of in-vehicle distraction or secondary tasks by evaluating drivers with direct (cardiac, eye, respiratory and brain), or indirect (subjective, questionnaire such as NASA-TLX, DALI and DSSQ or self-report) workload measurement techniques. Table 3 specifies the article characteristics pertaining to the methodologies and techniques implemented.

DISCUSSION

METHODOLOGIES AND TECHNIQUES IMPLEMENTED IN THE STUDIES

In this section, the measurement techniques and summary of conclusions in the evaluated studies are described in details. Basically, this section provides the main parameters that used in the past studies. In each parameter, details of techniques or methods are provided based on the evaluated studies.

CARDIAC MEASURES

Cardiac measure is related to the circulatory system. It comprises the heart and blood vessels which are carries oxygen to the tissues of the body and remove carbon dioxide and other wastes from them. Electrocardiogram (ECG) is used to determine the heart activity by measuring signals from electrodes placed on the arms, torso and legs. It provides information regarding the heart rate of the driver. Variety pattern of result have been found. The complex situation objectively affected mental workload with an increase in heart rate (HR) (Teh et al. 2018). One article in this systematic review uses Polar HR as to measure the HR of the subjects. The findings showed that the HR increases significantly with blood pressure whilst performing phone conversation (Murata & Kohno 2018; Freiherr et al. 2013; Iseland et al. 2018).

EYE MEASURES

The use of eye measures has increased in recent years and this may be because the increased ease of measurement and accessibility of the tools in the recent years. Measures include the blink rate, blink duration and pupil size. Pupil diameter can be varying of millimeters from 2 mm until 8 mm which controlled by a group of muscles. Electrooculogram (EOG) and other Eye Tracker (ET) tools is a physiological method used to measure the artifact of eye blinking. The increase in a small rapid jerky eye movement, especially when the eye jumps from fixation on one point to another such as in reading shows a heavy mental effect in complicated circumstances. However, eye exercise is more likely to depend on sensory requirements rather than behavioural requirements (Li & Chen 2017).

RESPIRATORY MEASURES

Respiratory measures are the measurement that involve in the exchange of oxygen and carbon dioxide between organisms and its environments. These measures include volume, airflow, rate or gas analysis. For the respiratory rate is the most important of the measurement of mental workload (De Waard 1996). In addition, respiratory rate is not very difficult to measure through electrophysiological but others like tension measurements also can be used to monitor breath rate by placing around the chest with a strap to monitor increase or decrease in a strap tension (van der Zwaag et al. 2012).

BRAIN MEASURES

There are many different methods to evaluate brain structures and functions. There are three type and common tools used such as functional Magnetic Resonance Imaging (fMRI), magnetoencephalography (MEG) and electroencephalography (EEG). Of these methods, EEG is the most cost-efficient solution which in the recent studies shows all studies use these methods for brain measures. EEG is used to measure the electrical activity in human's brain without the need to insert electrodes directly into the brain. EEG offers a time-consuming estimate of brain responses to an Event-Related Potential (ERP) stimulus, which is acquired by averaging several comparable brain waveforms to provide an event-related time measurement (Wang et al. 2015; Mahachandra et al. 2015; Wu et al. 2017).

QUESTIONNAIRES

Questionnaires such as NASA-Task Load Index (NASA-TLX), Driving Activity Task Load Index (DALI), Dundee Stress State Questionnaire (DSSQ), Rating Scale Mental Effort (RSME) and self-reports were the most commonly used indirect measurement, and the studies utilized at least one survey form of normal driving and driving with distraction where the drivers reported their difficulty level while driving with in-vehicle distraction and secondary tasks. The questionnaires were combined with direct assessments such as Eye-Tracker, HR electroencephalography, EOG and Polar HR. There were nine physiological measurement studies were combined with indirect measurements and all had high impact scores.

There were three from nine studies (33%) from Table 3 which using questionnaires evaluated workload of the driver while performing in-vehicle secondary task distractions by using NASA-Task Load Index. NASA-TLX is an underlying multidimensional assessment method that offers a weighted average workload score. The six components are Mental, Physical, Temporal demands, Self-Performance, Effort and Frustration. Each of the six components contributes to the workload of the particular task to be measured and its reactions to pair-wise comparison between the six components in determining the subject's perspective (Schiessl 2007; Horrey et al. 2017; Lyu et al. 2017; de Waard et al. 2008).

Furthermore, 10 percent of the studies using RSME and DSSQ. RSME evaluates only the proportion of mental effort invested within an exceedingly difficult task that is marked by a cross in an exceedingly continuous vertical line. RSME has a line of 150 mm markers marked with nine key points of each label with description indicating the level of effort. Notably, RSME is increasingly accustomed to assess mental work on traffic sector (van der Zwaag et al. 2012; Olsson & Burns 2000). DSSQ is used to evaluate the multidimensional patterns of stress response (Saxby et al. 2012; Chen et al. 2014). DSSQ is subdivided into scales of anger, concentration, control and confidence, happiness, encouragement, self-esteem, self-centred focus, irrelevant task and tense arousal. This scale chart is also distinctive because of the efficiency of the variable in the three stages when the pre-drive baseline is taken.

In addition, three studies (30%) used DALI in their research. DALI is also a multidimensional measure that depends on the type of loading task. The basic principle of DALI is the same as the TLX [57]. In both methods, six predefined criteria have been determined by a scale evaluation method, accompanied by a weighting method, to merge the six different scales into one universal score. It also consists of six sub-scales, ranging from low to highly demanding, Attention Effort, Visual Demand, Auditory demand, Temporal demand, Interference and Stress in situation.

Besides, there were two self-reports and one survey are used as indirect measures. Almahasneh et al. reported a recent study that used point Likert from 1-7 (disagree to agree) to measure 4 items consisting of a driver's condition such as bored, tired, drowsy and energetic (Ünal et al. 2013). However, assessments of the performance of secondary tasks were measured in a previous study. These assessments used three points (difficult, neutral and easy) as to measure the level of difficulty of each task given to the subjects (Olsson & Burns 2000). Lastly, one study using to get the perspective of the driver on the presence of distraction in vehicles and during normal driving. Scales 1 to 6 are applied to three parts of the question. The first part is about the dangers of secondary tasks to the driver while driving. Second part is about the ability of the driver to drive with the presence of a secondary task. Part three of the appropriate conditions for drivers in relation to secondary tasks (Schömig & Metz 2013).

EFFECT OF LEAD CARS ON DRIVERS

Based on Table 1, there are four previous studies that establish the car lead in the study. The purpose of the lead car in the study is to limit the speed of the driver to a certain speed (Mahachandra et al. 2015). At the same time, measuring brake reaction time on the driver. The time was measured after the lead car starts to brake (Sonnleitner 2014). In addition, the presence of a lead car is also examined to see how the driver performs while driving concurrently with secondary tasks. The presence of a lead car makes the driver need more steering control towards safe driving (Prabhakar & Biswas 2018).

EFFECT OF IN-VEHICLE SECONDARY TASK DISTRACTION

A total of 21 studies present about in-vehicle secondary task distraction whilst driving. The in-vehicle secondary task distraction is tested using physiological method, subjective method and performance assessment. Therefore, the in-vehicle secondary task demand can greatly affect the driver's workload (Farahmand & Boroujerdian 2018). The perception of the driver whilst performing the secondary task also shows the high workload (Muhrer & Vollrath 2011). Various kinds of secondary tasks include cognitive, physical and auditory secondary tasks. The study of the in-vehicle tasks can also positively affect the driver whilst performing the primary task, such as being alert during driving when the driver wants to engage in the secondary task. These effects may also affect driving performance (Fitch 2013). The driver can slow down the car if they want to keep driving in a safe condition while engaging with the secondary task (Silva & Santos 2014).

EFFECT OF IN-VEHICLE SECONDARY TASK DISTRACTION ON DRIVER'S WORKLOAD

Five articles investigated the driver's workload whilst performing in-vehicle secondary distraction tasks. In previous studies. Driver's workload can be increased whilst engaging with secondary task and performing primary task performance measurement of the driver and their driving performance. Therefore, the driver's workload increases whilst the road becomes complex and the drivers perform in-vehicle secondary task distraction (Papantoniou et al. 2017). However, only one article regarding the workload of young age drivers is available. Blink frequency increases when the tasks other than driving require frequent eye movement from one object to another object (Atchley et al. 2014). Furthermore, in-vehicle secondary tasks increase the driver's cognitive workload on the simulator driving. This can be detected through the frontal lobe of the brain when the theta band increases (Walshe et al. 2017). Studies that comparing in-vehicle secondary task found that visual distraction resulted in high driver cognitive workload. This is due to the driver's attention is reduced to the driving task

(Horrey et al 2017; Zhang et al. 2014; Lansdown et al. 2012; Vogels 2018). Glance improves when the tasks have low workload in studies using eye-tracker (Vossen et al. 2016).

In general, the previous studies suggest that the use of physiological measures on in-vehicle secondary tasks distraction gives high workload towards the drivers. Factors on the technological advancement of the gadget and in many vehicles fails to allow the drivers to pay attention towards safe driving. Another factor related to the in-vehicle distraction as well as mobile phones, other causes of distraction are discussed in this section.

MINDSET OF THE DRIVER

While driving, driver is easy to wander into something other than focusing on keep driving safely. In one study, most of the driver's thought are not related to the driving (Id & Kumada 2018; Lagarde et al. 2017). This shows that mind wandering can affect performance and driver's attitude towards unsafe driving (Geden et al. 2018).

VEHICLE TECHNOLOGY

Increases of technologically advanced vehicles of this era, making it easier or drivers to engage with the distracting activities. This encourage the drivers in terms of mind wandering or doing something else other than focusing on the driving. For example, automated drive that have features like cruise control which allow the driver to maintain the vehicle at a certain speed. This technology requires high levels of driver's attention in order to avoid vehicle colliding with another vehicles or crashes (Zhou et al. 2016).

MUSIC AND AUDITORY DISTRACTION

As an auditory distraction, music and listening for something else like radio reduces the driver attention during the primary task (Mcnabb & Gray 2016). Recent studies suggested that music affect driver's mood and performance which driver lower the speed when listening to the music. However, on physiological measures, music decreases the body stress of the human (Wierda et al. 2010).

EATING AND DRINKING

Eating and drinking while driving is also an in-vehicle distraction that affects driver overall well-being while driving (Young et al. 2008). Drivers are exposed to driving using only one hand to operate the vehicle. Recent studies have found that eating and drinking while driving can be twice as likely to crash (sullman 2012).

RELATIONSHIP BETWEEN DISTRACTION AND DRIVER'S CHARACTERISTIC

Data released by World Health Organization (WHO) shows that over 1.2 million people die each day due to the crash comes from young people between the ages of 15 to 29 years old. Younger drivers from 17 to 29 years old have higher risk of road crashes due to distracted drivers (Guo et al. 2017). In Malaysia, road crash statistics from 2007 to 2017 showed that the number of people involved in this case were slightly higher among young group, with age 16 to 20 years old, which involved 12,013 peoples.

A recent study found that there are differences in driving strategies for younger age and older age [74]. Younger drivers are more likely to be distracted by the use of devices such as mobile phones and others gadget to check social media, texting and having conversation with the passenger. Jongen et al. compared the dual task performance of young experience and young novices under the influence of alcohol (Jongen et al. 2018). Previous studies have suggested the presence of passenger can reduce the visual attention of male driver (Beanland et al. 2012).

CONCLUSIONS

This review revealed that in-vehicle secondary task degrades driving performance and response. The results of numerous examined studies which include cognitive, visual and physical distraction whilst driving, have a negative impact on driving performance. However, previous studies suggest that although an important safety hazard can be demonstrated by the physical distraction that involved devices (e.g. mobile phones), the cognitive distraction involved in a discussion can also remarkably influence driving performance. In conclusion, studies regarding in-vehicle secondary task, driver's performance and driver's condition (e.g. behavior) have been explored and answered in these extensive review studies. However, measurement of mental workload regarding its effects on experience of driver with in-vehicle distraction cannot be definitely answered amongst young novice and experienced drivers. As reported by WHO, the young drivers from 15 to 29 years old contribute to the highest crash rate. A previous study in urban areas shows the high crash rate that occurred among young drivers. This phenomenon is possibly due to the young drivers' less experience in driving, which some studies show high perception on mental workload of drivers whilst driving in the more complex area than in the monotonous area. However, the technique used for investigating the subjective rating of mental workload seems to play an important role in the interaction analysis between the secondary task and the subjective rating of different road environments. Furthermore, the use of physiological method appears to correlate EEG and HR in determining the driver's mental workload whilst driving under the secondary task conditions. Future work is evidently required within the field of physiological and subjective measures of mental workload to better understand the occurrence of mental workload among the young generation between young novice and young experienced and between genders are also important as they may impact performance and disturbed driving behavior.

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DECLARATION OF COMPETING INTEREST

None.

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