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Investigating the Effect of Performing Secondary Tasks on Reaction Time While Driving by Computer Analysis †

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Abstract: Performing secondary tasks affects the performance of primary tasks. Engaging in secondary tasks while driving often leads to accidents. Therefore, this study aimed to investigate the impact on reaction time when drivers perform secondary tasks while driving. The participants of this study were 30 participants, including 11 males and 19 females. During driving, participants watched a driving video. When a warning triangle appeared in the center of the road, participants immediately pressed the Enter button. When the participant pressed the Enter button, the computer automatically recorded the time of the button press. In a within-subjects design, all participants took part in secondary tasks during the primary driving task, and outcomes were compared between secondary tasks (no task, conversation with the passenger, and listening to the radio). The results show that the reaction time during conversation with the passenger in the primary task was significantly longer than that during listening to the radio or having no task. However, there was no significant difference in reaction time between having no task and listening to the radio. The average reaction time with no task was longer than while listening to the radio. Fatigue increased the reaction time for no task. Having a conversation with the passenger did not affect the average reaction time for both tests due to the conversation with the passenger mitigating the effects of fatigue. The results of this study provide a reference for further research on driving behavior.

Keywords: task performance; reaction time; driving behavior; cognitive load

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1. Introduction

The components of transportation are people, vehicles, roads, and the environment. Traffic accidents are related to human error [1]. The World Health Organization's Global Status Report on Road Safety 2018 stated that approximately 1.35 million people die each year due to traffic accidents worldwide [2]. When drivers are exposed to external stimuli or their attention is diverted from the driving task, the risk of accidents increases [3]. Distraction leads to unsafe outcomes, especially in complex driving situations as it reduces risk awareness and increases the likelihood of accidents [4]. Therefore, inattentiveness is a major cause of accidents or rear-end collisions [5].

Most of the risks from driver distraction result from the cognitive effects of diverted attention from the current task, although inattentiveness stems from external stimuli [3]. Distraction leads to unsafe outcomes during driving, especially in complex driving situations, as interference reduces risk awareness and increases driver response times [4].

Vision, as the primary tool for sensing and receiving, leads to direct sensory responses to external stimuli [6,7]. It is also the most important sense for drivers to obtain information about their surroundings while driving. Therefore, vision has a considerable impact on driving safety [8]. In driving accidents, many drivers have experienced visual fatigue during long driving or when driving in monotonous conditions [9–12]. Visual fatigue refers to the excessive strain on the visual organs, surpassing compensatory ability [13]. According to the American Optometric Association, prolonged use of the visual system reduces efficiency in visual processing functions [14]. Fatigue impairs the ability to maintain speed and stay in the lane, increases reaction times, and leads to decision-making errors, thereby increasing the risk of traffic accidents [15]. Perception–response time (PRT) refers to the time interval between the moment a driver perceives a danger on the road and takes action in response [16]. Driver distraction is caused by diverted attention from the current task. According to data from the National Highway Traffic Safety Administration (NHTSA), distractions include engaging in deep conversations with passengers, talking on the phone, holding objects, singing, dancing, smoking, adjusting the stereo or air conditioning, and eating [4]. Therefore, we investigated the impact of drivers performing secondary tasks while engaged in primary driving tasks on their response times.

2. Materials and Methods

2.1. Experiment

The participants in this study searched for the warning triangle signs in videos. The independent variables were the participant's ethnic group and the secondary task (no task, conversation with the passenger, and listening to the radio), while the dependent variable was the participant's reaction time. The test was conducted by watching a pre-recorded driving video on the road. When a warning triangle appeared on the road, the participant pressed the confirmation button immediately. The reaction time was defined as the time taken for the participant to press the Confirm key after noticing the warning triangle. We used a within-subjects design, with each participant performing the following three secondary tasks.

1. No task

The driver had no specific tasks but driving. The participants focused on the primary task and did not perform secondary tasks.

2. Conversation with the passenger

The conversation with questions comprised a series of general knowledge and arithmetic problems in simple and complex categories [17]. The participants performed addition for each arithmetic problem and classified the result as either odd or even [18]. The conversation samples included general knowledge and personal topics [17]. Due to the difficulty in controlling the influence of intermediate variables, casual conversation was not used [19].

3. Listening to the radio

The participants listened to the radio while driving. The radio content included information such as music, traffic conditions, road construction, natural disasters, and emergency rescue updates. Ear Pods were used for 30 min at 56−64 dB.

The height of the car warning triangle was 38.5 cm (Figure 1). The triangle was placed 150 min in front of the car. To make the simulation environment look realistic [20], a GoPro camera was used to record driving conditions on the road. The warning sign was placed 150 m ahead of the vehicle (Figures 2 and 3). The camera recorded the visual transition of the triangular warning sign from far to near distance. Non-linear video production software was used to edit the video. To provide the participants with visually

immersive and naturally realistic interactive means [21], a mobile phone with GoVR Player software and Google Cardboard VR headwear glasses were used. The Google Cardboard VR headwear glasses were composed of two 45 mm focal length lenses and formed a virtual distance in the optical structure. The edited video was processed into the GoVR Player app to split the screen into left and right frames, corresponding to each eye. This allowed viewers to experience a sense of immersion, as the brain overlays the images through the convex lenses of the VR headset, creating a three-dimensional visual effect.

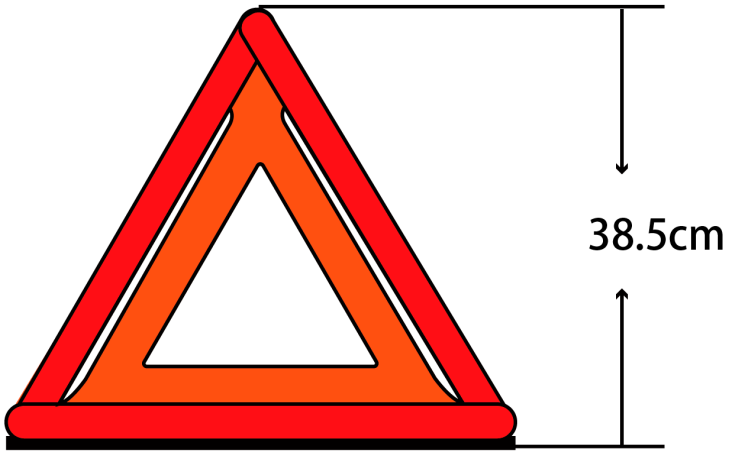


Figure 1. Height of warning triangle sign.

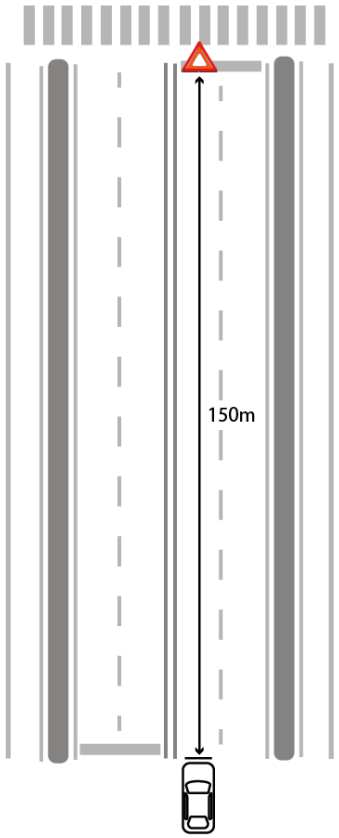


Figure 2. Distance of 150 m from starting point.

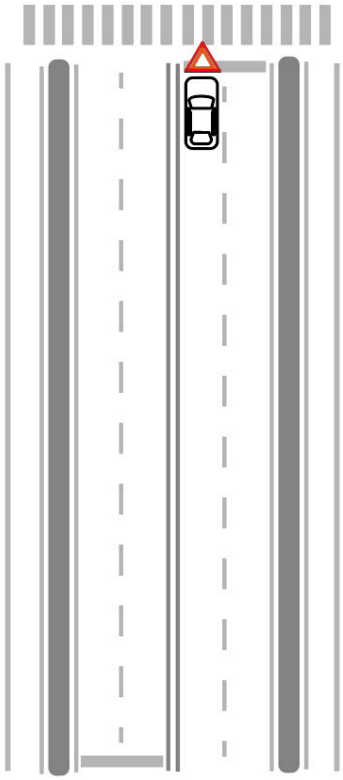


Figure 3. Driving forward to front of triangular warning sign.

2.2. Experiment

There were 30 participants in this study (11 males and 19 females). The average age was 29.50 years old (Standard Deviation (SD) = 11.89) (Table 1). All participants had a regular driver's license and driving experience with an average of 7.7 years. The participants had normal vision or corrected vision of 0.8 (20/25) [22].

Table 1. Descriptive statistics of participants.

Gender	N	Min.	Max.	Mean	SD
Male	11	20	65	30.64	13.46
Female	19	20	65	28.84	10.84
Total	30	20	65	29.50	11.89

3. Results and Discussion

We investigated the effects of no task, a conversation with the passenger, and listening to the radio on the reaction time of the participants. The reaction time of the participants was measured whenever triangular warning signs appeared. The triangular warning sign appeared 16 times, and the Confirm key was pressed 480 times. The average reaction time in each task was 3.9 (SD = 5.2), 3.7 (SD = 4.9), and 6.7 (SD = 13.9) (Table 2).

Table 2. Data of secondary tasks.

Secondary Task	N	Min	Max	Mean	SD
No task	480	0.0	46.0	3.9	5.2
Listening to the radio	480	0.0	47.0	3.7	4.9
Conversation with the passenger	480	0.0	80.0	6.7	13.9

The average reaction time in conversations was significantly higher than that for listening to the radio (t = 4.687, $p = 0.00$) and no task (t = −4.274, $p = 0.00$). However, there was no significant difference between the average reaction time when listening to the radio and the average reaction time when performing no task (t = −1.041, $p = 0.298$) (Table 3).

Table 3. Paired sample *t*-test results for secondary tasks.

Paired Sample *t*-Test	t	*p*	T Test
No task–Conversation with the passenger	−4.274	0.000	No task < Conversation with the passenger
Listening to the radio–No task	−1.041	0.298	Listening to the radio = No task
Conversation with the passenger–Listening to the radio	4.687	0.000	Conversation with the passenger > Listening to the radio

The reaction time for the 9th time was longer for no task (mean = 12.62) than listening to the radio (mean = 11.26) and conversation with the passenger (mean = 19.65). Therefore, the response time of the 9th time was eliminated, and the triangle warning label was checked for differences in response time (Table 4). Alhaag and Ramadan noted that muscle fatigue caused by muscle activity occurs 10 min after participants view the images [23]. There were significant differences in average reaction times for listening to the radio (t = −2.274, $p < 0.05$) and no task (t = −2.573, $p < 0.05$). Therefore, holding a conversation during the driving task mitigated participants' fatigue, resulting in no significant difference in reaction time (Table 5).

Table 4. Descriptive statistics related to the number of appearances of warning signs.

Descriptive Statistics					
No task					
Times	N	Min	Max	Mean	SD
1	30	1.49	8.00	4.47	1.88
2	30	1.15	7.00	2.86	1.48
3	30	1.49	7.00	3.16	1.25
4	30	1.00	7.00	2.74	1.47
5	30	1.00	7.00	3.24	1.62
6	30	1.00	5.00	2.85	1.11
7	30	0.00	6.00	3.44	1.55
8	30	1.15	6.00	3.09	1.33
9	30	1.29	46.00	12.62	18.39
10	30	1.00	6.00	2.83	1.26
11	30	1.62	7.00	4.55	1.40
12	30	0.00	6.73	3.84	1.69
13	30	1.70	7.00	3.67	1.77
14	30	1.47	9.00	3.64	1.94
15	30	1.49	8.00	3.55	1.72
16	30	1.00	6.40	3.29	1.54
Listening to the radio					
Times	N	Min	Max	Mean	SD
1	30	1.85	7.00	3.74	1.73
2	30	1.00	5.00	2.73	0.99
3	30	1.84	6.00	3.12	1.22
4	30	1.00	6.00	2.63	1.14
5	30	0.00	6.00	2.88	1.44
6	30	1.00	7.00	2.79	1.50
7	30	1.00	9.00	3.79	1.92

Table 4. *Cont.*

Descriptive Statistics					
Listening to the radio					
Times	N	Min	Max	Mean	SD
8	30	0.00	6.77	2.96	1.58
9	30	1.00	47.00	11.26	17.62
10	30	0.00	7.00	2.74	1.51
11	30	2.00	7.00	4.20	1.35
12	30	1.75	7.00	3.74	1.51
13	30	1.86	8.00	3.37	1.66
14	30	0.00	6.00	3.09	1.56
15	30	1.00	8.00	3.48	1.77
16	30	1.24	7.00	3.29	1.58
Conversation with the passenger					
Times	N	min	max	Mean	SD
1	30	0.00	79.38	6.41	13.91
2	30	0.00	39.45	3.98	6.87
3	30	1.00	79.29	5.80	13.96
4	30	1.00	78.92	4.91	14.03
5	30	0.00	79.96	5.41	14.17
6	30	1.00	38.84	4.23	6.71
7	30	1.00	79.53	5.61	14.04
8	30	1.00	78.81	5.63	13.90
9	30	1.00	78.79	19.65	23.59
10	30	0.00	79.32	5.32	14.04
11	30	0.00	80.07	8.56	15.94
12	30	0.00	39.09	5.80	6.62
13	30	1.78	79.36	6.54	13.89
14	30	0.00	79.03	6.36	13.90
15	30	0.00	79.82	8.08	16.01
16	30	1.89	38.99	5.48	6.59

Table 5. Independent sample *t*-test for reaction times for different tasks.

Secondary Tasks	Tasks	N	Mean	t	*p*	*t*-Test
Conversation with the passenger	Former	240	5.2466	−1.128	0.260	Former = Latter
	Latter	210	6.5931			
Listening to the radio	Former	240	3.0809	−2.274	0.023	Latter > Former
	Latter	210	3.4146			
No task	Former	240	3.2320	−2.573	0.010	Latter > Former
	Latter	210	3.6255			

4. Conclusions

In three different tasks, the participants' reaction times during conversations while driving were significantly longer than during radio listening and while performing no task. Reaction times for no task and radio listening were not significantly different. For radio listening and no task, reaction times in the latter part were longer than in the former part, indicating significant fatigue. However, there were no significant differences in the conversation tasks in the former and latter parts. This may be because the first part of the conversation involved arithmetic problems, while the latter involved common sense, offsetting fatigue effects. Talking to a real person or through a digital mode while driving reduced drivers' risk awareness, increasing reaction times due to distraction. These results provide important insights into driving behavior.

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