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Driver's Emotion Neutralizing Infotainment System(DENIS): considering Driver's Reaction Time and Mood Regulation

운전자 감정 조절 인포테인먼트 시스템(DENIS):

운전자의 반응시간 및 기분 조절에 대하여

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산업공학과

허 정

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Abstract

Driver's Emotion Neutralizing Infotainment System(DENIS): considering Driver's Reaction Time and Mood Regulation

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As autonomous driving became commercialized at a higher stage, the possibility and ease of people watching vehicle infotainment increased. Accordingly, the user's emotional ups and downs are inevitably affected, and there will be a difference in the user's reaction time depending on the expected degree of emotion activation. Considering the driver's reaction time is essential because drivers cannot be free from Take Over Requests when the self-driving stage is less than three levels and require faster response speed or cognitive ability to be safer in dangerous situations. Therefore, this study showed the difference in reaction time according to the user's mood and developed an initial prototype that provides infotainment corresponding to the user's emotional state.

Keywords : Industrial Engineering, Autonomous Driving, Infotainment, Take-Over Request
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Chapter 1 Introduction

1.1 Background

Various studies study driver behavior in autonomous driving situations. For safety, TOR is essential for autonomous driving because the driver must respond to the TOR situation. Previous studies have experimented with seven multi-mode signals (i.e., visual, auditory, tactile, visual, visual, auditory, and visual-auditory) to respond to TOR situations (Huang, 2019). In the case of emergencies, it is crucial to determine whether the driver is performing non-driving-related tasks (NDRT) when switching from autonomous driving mode to manual driving mode is necessary. In preparation for this, even in level 3 automation, drivers' continuous interest in preparing for the TOR situation is still essential (Na Du, 2020).

Recently, interest in vehicle infotainment has been growing. Vehicles have developed to increase power and fuel economy performance and improve drivability and stability. However, values in directions other than driving functions are also pursued as necessary. As commercialization approaches due to the technological development of self-driving cars, Korea is also planning to commercialize level 4 self-driving cars by 2021 (김상영, 2018). Research on content consumption platforms for autonomous vehicle passengers is also widely conducted, as there is a time when the driver does not drive the vehicle directly (이윤희, 2017). The interaction between autonomous vehicles, vehicle occupants, transportation systems, and UI's importance is also emerging. This paper shows the reaction time among different moods and provides infotainment that creates moods with the participants shown the best reaction time.

1.2 Research Objectives

There are two main objectives of this study. One is to check the reaction time according to the driver's mood regulation when a TOR occurs below the level of autonomous driving 3. Another purpose is to identify the optimal infotainment that brings the driver's emotions back to their normal emotions.

1.3 Organization of the Thesis

The thesis is composed of five chapters. The first chapter introduces the background and goal of this research. In chapter two, we summarize the findings from previous studies related to the central theme of this thesis. In chapter three, we propose various solution approaches. The fourth chapter shows the results of computational experiments are presented. Finally, in chapter five, we give concluding remarks and possible future research directions for this thesis.

Chapter 2 Literature Review

2.1 Overview

Since the primary goal of this study is to check the reaction time according to the participants' emotional change and identify the optimal infotainment, research regarding infotainment is discussed first, followed by a review of the literature about mood regulation and reaction time in TOR situations. This chapter aims to summarize the concepts, definitions, and significant findings from previous literature related to the scope of this study.

Table 1. Summary of acronym utilized in the study

Acronym	Definition
TOR	Takeover Request
NDRT	Non-driving Related Task
OTA	Over-The-Air
IVI	In-Vehicle Infotainment

2.2 Autonomous Vehicle

According to Article 2 of the Motor Vehicle Management Act, an autonomous vehicle means "a vehicle that can be operated on its own without the manipulation of drivers or passengers." It is promoting the development of level 4 autonomous vehicles worldwide with the goal of 2028 (Kim Hee Yeon, 2017). It is promoting the development of level 4 autonomous vehicles worldwide with the goal of 2028 (Heeyeon, 2017).

Moreover, today's autonomous vehicles are semi-smart. It has sensors that detect the surrounding environment and make the driver aware of dangerous situations. Also, it helps the driver control the vehicle's speed, integrates with mobile phones, and offers enriched services (Contreras–Castillo, 2019).

Automotive vehicles are divided into six levels, from level 0 to level 5 (see Fig.1). These six levels represent the capabilities of vehicle automation. The level determines whether the human driver or the system is responsible for driving a vehicle. Level 3 is semi–automation, whereas level 5 provides full automation. Currently, most vehicles in public belong to 2 to 3 levels of automation. Even at the semi–automation level, drivers should engage in driving and have responsibility for monitoring the system. For safety, the driver must respond to TOR during the semi–autonomous driving mode. The driver should continuously pay attention during autonomous driving since the driver should handle the steering wheel to take over manual driving from autonomous driving. For the driver's safety, tracking the driver's status is crucial in autonomous driving to prepare when a takeover request appears. Keeping the driver inside the system and understanding the driver's status, such as emotional states and gaze behaviors, are the main focus of safely adapting to semi–autonomous driving modes such as level 3 automation in vehicles. Especially in TOR situations, where the drivers are required to be inside the system, drivers must be able to operate the autonomous vehicle system appropriately.

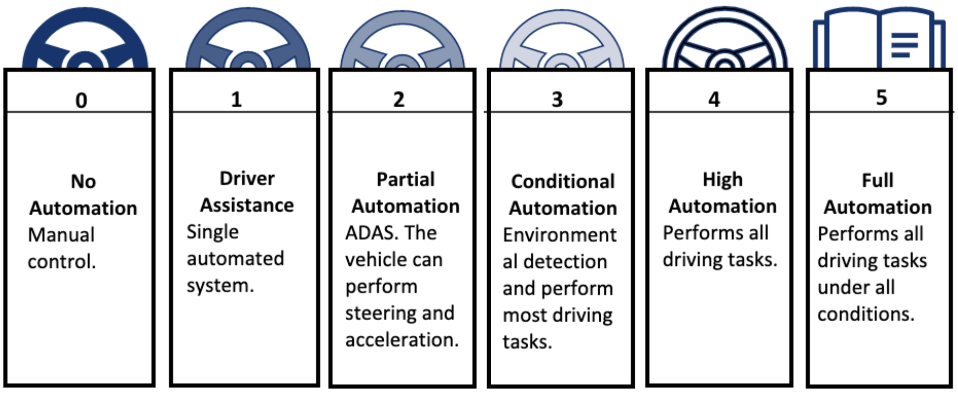

Figure 1. Six stages of self–driving vehicle

2.3 Infotainment

An automotive infotainment system refers to an integrated system of information, which means necessary information such as driving and directions, and entertainment, which refers to various entertainment and human-friendly functions (구보람, 2016). Infotainment has been focused on as one of the critical services in the automobile industry (Choi, 2020). It is a device for checking various information and manipulating functions provided by cars and traditional functions such as navigation and audio. In addition, it has increased convenience by applying server-based voice recognition functions and OTA (Over-The-Air) technology that updates navigation information or software wirelessly. Moreover, car dashboards are now connected to the Internet or integrated with the driver's cell phone, enabling a better auditory experience by listening to one's choice of music than just classical radio playback (Coppola R., 2016). Soon, users will be able to watch virtual reality movies through In-Vehicle Infotainment (IVI) (Choi, 2020). Furthermore, using edge computing, infotainment services can be efficiently provided in cars (Yaqoob, 2019).

Although users still recognize vehicle infotainment as a car audio system or navigation system, it is predicted that the perception of vehicle infotainment will gradually change as the platform is strengthened and various functions are installed. Therefore, infotainment, which can give new convenience value, is growing as a critical element of next-generation vehicles. Depending on the speed of development of this infotainment system, drivers also need learning and experience to operate the infotainment system, which is directly related to life-threatening safety issues. Proficiency and experience in the use of functions in automotive systems put a physical, psychological, and cognitive burden on the driver, so manuals are needed as a guide to help him learn properly (박아영, 2019).

As autonomous driving technology advances, cars change into living spaces, and new services using information technology (IT) are researched and developed accordingly (Kim, 2016). Therefore, it is crucial to develop infotainment by considering the context of a vehicle that is a space and a means of transportation that spends much time in everyday life. As demand for vehicle communication increases, connected cars are gradually increasing, and the importance of infotainment that directly interacts with users is increasing. In vehicle interior design, the display size tends to increase because it delivers more information as graphic elements than before, and the need for entertainment elements has increased (Kim, 2017). Currently, not only automakers but also IT companies are fiercely competing to develop infotainment. Through Google Android Auto or Apple's CarPlay, the OS used in smartphones is mirrored on car displays, allowing users to use voice recognition, music streaming, and real-time navigation used in smartphones. According to market research company IHS Markit, the vehicle infotainment system is expected to grow to 68.19 million units by 2022. As interest in future cars, such as connected cars and autonomous driving, increases, the infotainment market is also growing. In addition, to use software applications safely in the car, it is necessary to couple them with the infotainment system and its user interface (Sonnenberg, 2010).

According to previous studies on information display items in the vehicle, 38 information display items can be displayed to the driver through in-vehicle displays (구보람, 2016). In this study, to distinguish the optimal infotainment according to the driver's emotional state, the experiment focused on related factors to make the driver's emotional state from sad or very happy to normal. The following table 2 shows the types of infotainments that are currently widely used.

Table 2: Self-driving car infotainment system types and purposes

Infotainment System	Purpose
Media	Providing immersive content such as videos using AR/VR
Advertisement	Provide advertisements for nearby facilities after driver position detection
Music	Music playlists are provided differently depending on driving conditions
Game	AR/VR game function is provided, and many players are allowed to participate in the game through interworking with other vehicles
Education	Conduct classes outside of the classroom through the in-vehicle video provision function

2.4 Mood Regulation and Mood Maintenance

Mood regulation controls the user's mood by targeting a mood of hope that is different from the present. Mood maintenance means taking action to maintain it because the driver is already in the right mood.

Existing studies use photos or music provided by IAPS to control users' moods to induce emotional stimulation and adjust it to the desired emotion (Çano, E., 2016). Moreover, there is a high correlation between music, mood and driving comfort, and safety. Moreover, self-reported depressed mood is related to slowed reaction time (Kvelde, T, 2010). In addition, the neutral atmosphere responded quickly and correctly to changes in the speed of the leading vehicle, showing a good response speed in dangerous situations (Zimasa, T., 2019). In other words, drivers in a neutral atmosphere have more time to detect and respond appropriately when driving requires continuous care or when additional risks arise (Chapman & Underwood, 1998) (Underwood & Chapman, 2002).

The effect of mind wandering for drivers in a sad mood showed that the ability to respond to changes in the leading speed car was impaired. We also found psychological theories that sad individuals process information more slowly due to systematic information processing methods (Luce, Bettman, & Payne, 1997).

Positive and negative feelings affect the driver's driving performance (Zimasa, T., 2019), (Bolmont, B., 2000). People may listen to music to check their mood or to get out of a bad mood (Schäfer, T., 2013). Therefore, appropriate music recommendations based on the driver's mood are essential (van der Zwaag, 2013), (Çano, E., 2016). Also, good background music can be a helpful tool to improve driving performance or comfort. The emotional experience in a fully autonomous vehicle is to be aware of the change in communication caused by the interaction between the emotional and cognitive reactions caused by the elements constituting the indoor space and the user's actions. In order to plan based on emotional elements in the emotional experience design of a fully autonomous vehicle, an action-oriented analysis that causes emotional and cognitive reactions is primarily necessary (Kwon, 2018).

Moreover, as autonomous vehicles widely develop, many researchers who work in the automotive human-machine interface (HMI) domain focus on advanced driver assistance systems (ADAS). In addition, researchers try to integrate human emotions into the experience to develop HMI and supply a better user experience (Kong, 2018).

2.5 Reaction Time in Take-Over Request Situations

Reaction time can be defined as a period from when a risky situation appears to when the driver takes control of the situation (Ackermann, J., 1997). Moreover, safety is always the highest priority for drivers. For a level less than level 3 of an autonomous vehicle, the driver cannot be completely free from the handle, so a quick response to the take−over request is essential. If the vehicle is self−driving at 40 km/h and the control is desired to be effective every 1 m, the response time should be less than 90 ms (Kato, S., 2015). Information materials of the National Board of Traffic Safety (KRBRD)’s statistical data show that in Poland, approximately 70 percent of accidents result from the incorrect operation of a driver (Jurecki, R. S., 2012).

Furthermore, studies on drivers' reaction times are crucial in automobile vehicles. Nevertheless, it is not easy to measure the reaction time precisely, and for most people, as the driving task increases, the reaction time also increases (Jurecki, R. S., 2014). Moreover, drivers' reaction time can vary rapidly due to motivation, workload, and fatigue (Ma, 2006). Past studies use reaction meters to measure reaction time and, usually, the period from the onset of the light or sound stimulus to the moment of the driver's particular action, such as pressing a button (Jurecki, R. S., 2012). In this study, the sound is used as a stimulus to measure the driver's reaction time.

Chapter 3 Experiment

3.1 Overview and Hypothesis

Considering the results from previous studies, the present study proposes the following hypothesis. The experiment method is as follows. In this experiment, we surveyed the feelings we felt after seeing the pictures and then surveyed the feelings participants felt once again after showing the music and the video.

1) An in-vehicle infotainment system that is optimal for neutralizing people’s feelings may vary.
2) In the low/high state, the reaction time (TOR performance) will be worse than in the neutral state.

3.2 Methods

3.2.1 Participants

A sample of 13 licensed drivers, six males and seven females, were recruited to participate in this experiment. The participants were asked to survey the length of driving experience, frequency of driving per month, basic knowledge about automatic driving vehicles, and whether one thinks one tends to be emotional. The average age of the participants is approximately 28 years (min = 23, max = 34), and the corresponding standard deviation is 2.77.

Table 3: Average and standard deviation of the questionnaire

	How many times have you heard	What do you think of self-driving cars?	What is your understanding of autonomous

	of self−driving cars?		driving technology?
Average	4.15	3.53	3.38
Standard Deviation	1.143	0.96	1.26

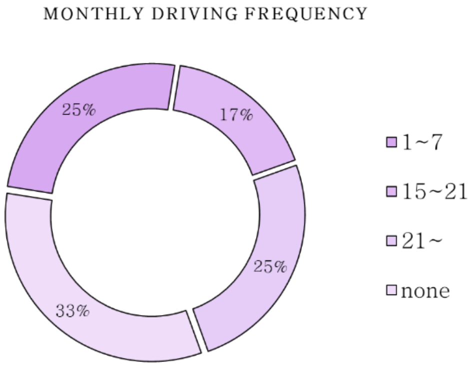

Figure 2. Monthly driving frequency of the participants

For monthly driving frequency, about 25 percent answered as 1−7 days and more than 21 days. About 17 percent answered as 15−21days, and about 33 percent answered as none. For self−driving car driving experience, one person answered positive, and that person drives a self−driving car 1−7 days per month. For the question about how many times they heard about self−driving cars, the average was 4.15. One being the most negative and number 5 being the most positive.

Furthermore, for the question about what they think of self−driving cars and their understanding of self−driving technology, the average was 3.53 and 3.38, which is moderately high. Therefore, only a few participants had a self−driving car experience. However, most of them had moderately high knowledge about self−driving cars, had heard about them many times, and had a positive recognition of self−driving cars. Figure 3 to 6 shows the result of a primary survey.

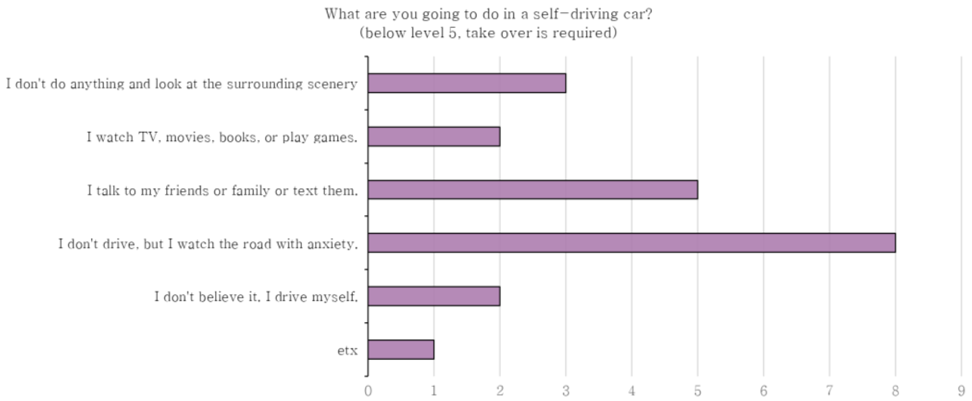

Figure 3. Questionnaire result of the participant' s action a in self-driving car when TOR is required

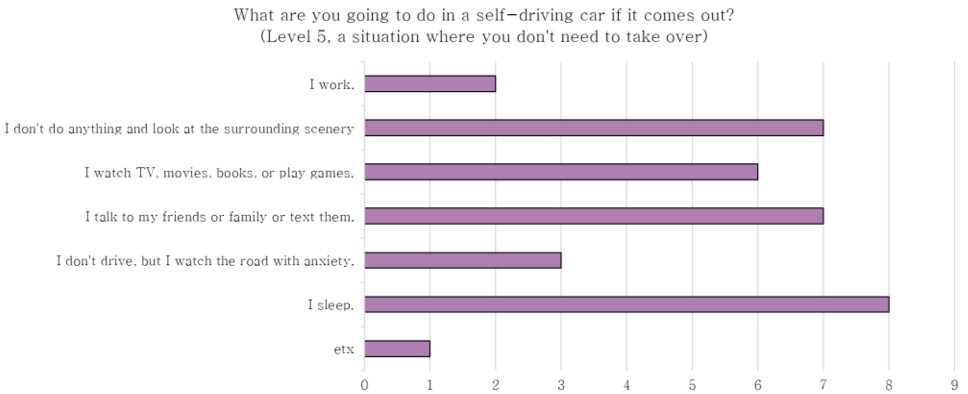

Figure 4. Questionnaire result of the participant's action in a self-driving car when TOR is not required

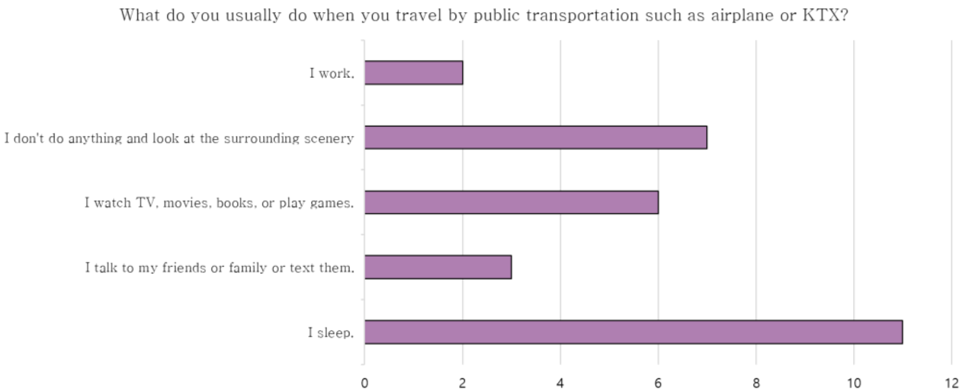

Figure 5. Questionnaire result of the participant' s actions when they ride either airplane or KTX

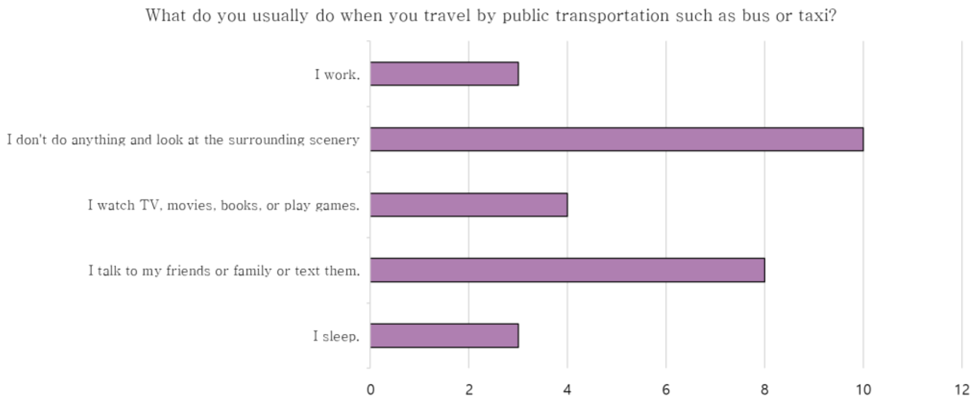

Figure 6. Questionnaire result of the participant’s actions when they ride either a bus or taxi

All participants were asked to conduct the experiments in a quiet and comfortable place (e.g., at home). Furthermore, since this experiment was done alone without a supervisor, the participants experimented in a place where they felt comfortable so that their emotions did not change during the experiment. This experiment took about 30 minutes, and while the experiment went on, we asked the participants to keep their posture correct and keep their hands on the armrest. Furthermore, sit at a sufficient distance from the keyboard.

3.2.2 Apparatus

The experiment was conducted using a personal computer, webcam, headset, and oCam. Before the experiment begins, run the oCam, enter the recording menu from the option, and change the resolution from the resize item to the resolution that matches the participant's solution. Furthermore, set the quality to high (slow) – BICUBIC. Moreover, participants are asked to turn on the camera on their personal computer or laptop and start recording one's faces without a mask. Set the camera's height to the height parallel to the participant's face, and the entire face should come out front. Also, the participants should wear a headset to listen to the sound.

Geneva Affected Picture Database (GAPED), which contains 730 emotional photographs and is designed to increase the availability of visual and emotional stimuli, was used to measure the participant's moods (Dan-Glauser, E. S., 2011). Four specific harmful contents were selected, including spiders, snakes, and scenes that induce emotions related to violations of moral and legal norms (human rights violations or animal abuse). Also, positive pictures mainly depict natural scenes and human and animal babies, while neutral pictures mainly depict inanimate objects. The figure was graded according to the represented scene's atomic force, awakening, and consistency with the internal (moral) and external (legal) norms. Each emotion category contains more than 100 pictures. Inspirational images have been collected through extensive online web searches on various compositional topics. All photos were cut into 640 x 480 pixels, then centered, resized, and graded.

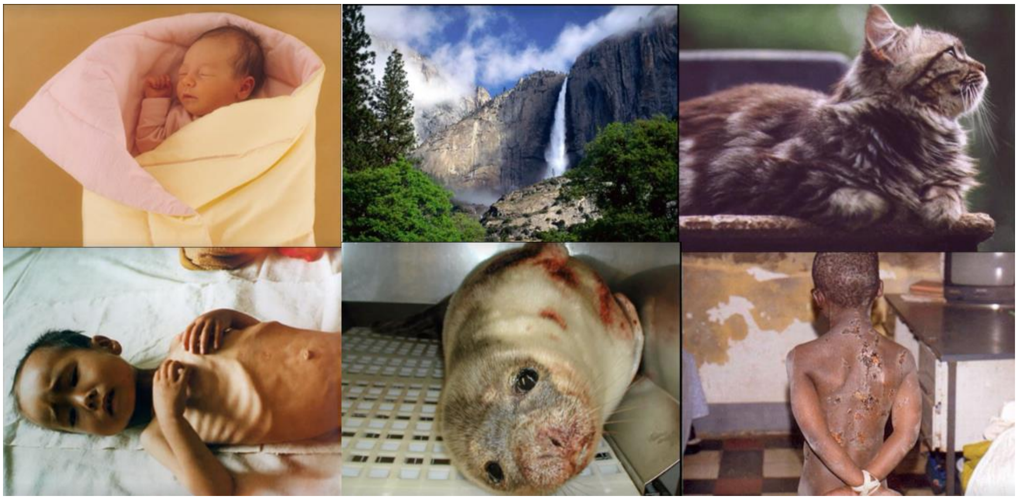

Figure 7. Example of GAPED images used

We used Orange Data Mining (ver. 3.27.1) to classify the image as low, neutral, and high. This program analyzes artificial intelligence data without coding created by the University of Ljubljana in Slovenia.

3.2.3 Measures

Mood

The driver's mood/status was measured with a questionnaire after watching selected pictures. Using the Geneva Affected Picture Database (GAPED), two specific harmful contents, two specific positive contents, and one neutral content were selected. For harmful content, scenes that induce emotions related to violations of moral and legal norms (human rights violations and animal abuse) were selected. In addition, for approving content, human and animal babies and natural scenery were selected. Lastly, neutral content depicting inanimate objects was selected.

Table 4: Negative and positive contents used from GAPED dataset

Negative Contents	Positive Contents
human rights, violations, and animal abuse	human and animal babies, and natural scenery

Reaction Time

Participants hear a notification during the slide show and press the space bar on their keyboard then the slide moves on to the next slide. A red dot was placed on the bottom right side to detect when the participants moved to the next slide so that the participants did not notice (see Fig. 8). Since the fundamental task for this experiment includes measuring the reaction time during takeover request, reaction time was measured by the time to move on to the next slide. Also, to check the reaction time, I categorized the data into seven different groups, shown in table 5. From zero to two, it is a neutralizer that invokes the participants to either maintain a neutral mood or to regulate the mood from positive/to negative to neutralize.

Moreover, three and four are a stimulus to invoke the mood to either be positive or negative.

Table 5: Categorization of the mood regulators (neutralizer, positive, and negative)

	Categorization
0	Neutral – Setting
1	neutral – Audio Only
2	Neutral – Visual + Audio
3	Positive
4	Negative

Figure 8. Examples of reaction time checking slide (red dot on the right side)

3.2.4 Experimental Design

The experiment consisted of five trials with three different contents (neutral, positive, negative) and two different infotainments (audio only, audio + visual). When choosing neutral, positive, and negative contents, the figure was referenced because the emotional value for each photo was shown in the GAPED. GAPED contents were marked as 0−100, and the higher the image, the better the participants felt, and the lower the image, the worse the participants felt. We selected 20 photos with scores ranging from 47 to 52 for neutral photos. Forty photos with a score of 95 to 100 for positive photos and 40 with a score of 0 to 8 for negative photos were selected. Each photograph was set to change every five seconds automatically, and the positive and negative photographs were divided into 20 photographs, and the experiment was repeated twice.

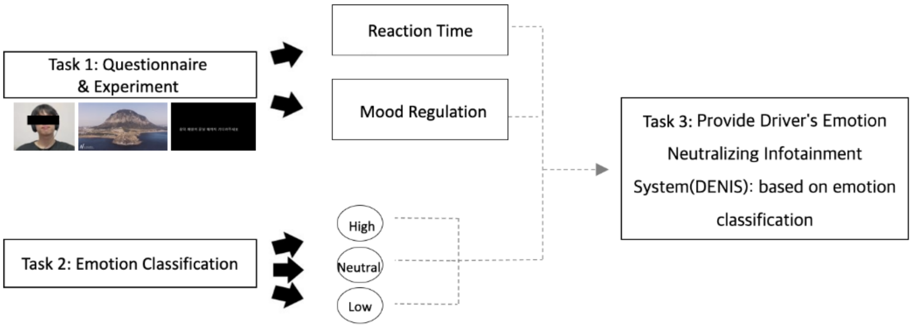

Figure 9. Experimental process

As for infotainment, I searched on YouTube for "comfortable music/video" and chose one that has many views and is not too long. As a result, a calm piano music video with 14,276,557 views was uploaded in June 2019 as an audio−only infotainment. The music that came out was Back in the moment by Honey and Clover and Lost Stars by Begin Again, played with piano. In addition, visual stimuli had to be excluded, so only black screens like Fig. 10 were displayed during the experiment to provide only the auditory stimulus. In addition, as a video including auditory and visual stimulation, it was uploaded in April 2020 and used as a travel video for Jeju Island with 135,848 views, shown in Fig. 11.

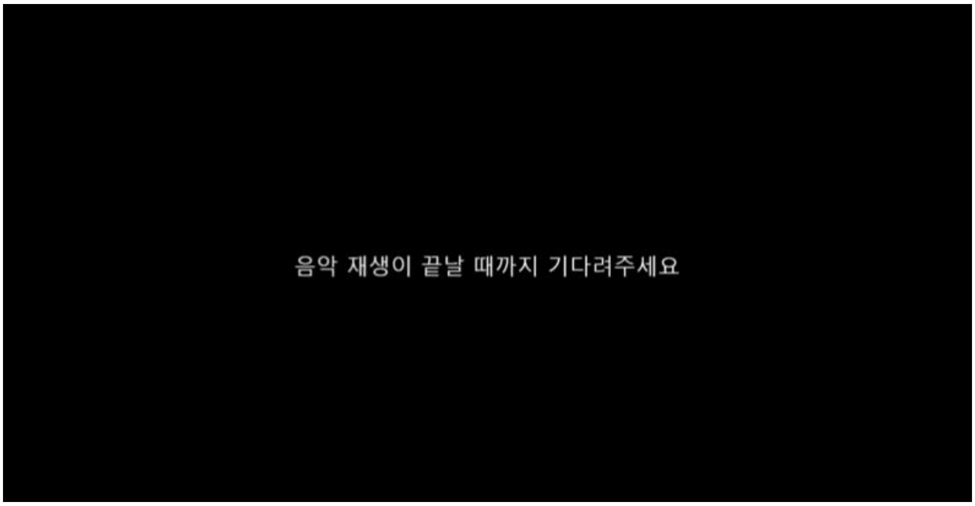

Figure 10. Example slide of neutralizer (audio only)

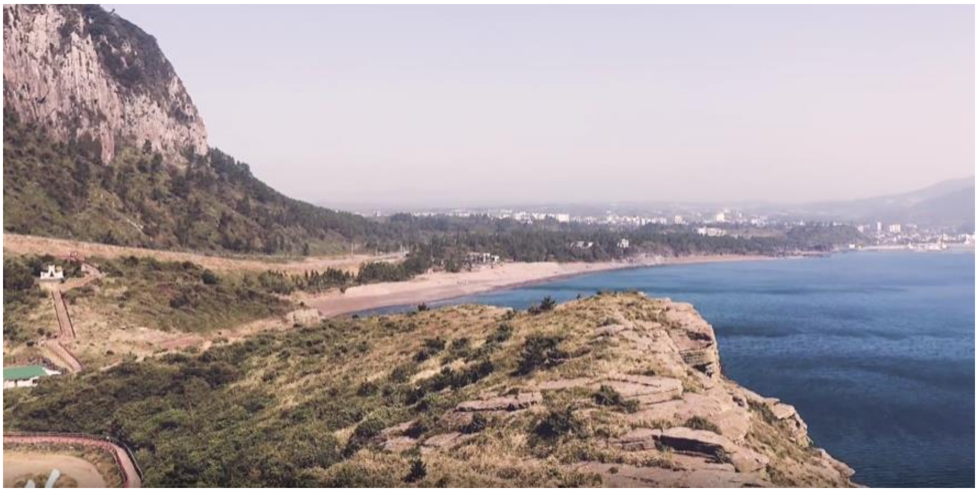
Figure 11. Example slide of neutralized (audio + visual)

The subjects wrote a self-assessment questionnaire (questionnaire 1) to assess the tension before obtaining the data. A total of 10 questionnaires were conducted, and questionnaire 1 was a questionnaire to check the status of participants before starting the experiment. Questionnaire 1 was about participants' self-evaluation responses. Yonsei University used the questionnaire to develop emotional element technology. It consists of 20 questions, such as "I am calm" and "I am nervous." The most significant number represents the subject's state by calculating the frequency of 1-4 answers to each question. One is the most anxious, and 4 is the most relaxed state.

Furthermore, Questionnaires 2-10 were used to measure emotional factors at Yonsei University. It is used to subjectively evaluate the emotional response to the video by having the subject fill it out himself after each video is finished. Questionnaire 2 was used after a 2-minute break to see if the participant's mood was centered. Questionnaire 3 was done after watching neutralized contents, questionnaire 3 and 7 was used after watching positive contents, questionnaire 5 and 9 was used after watching harmful contents, and questionnaire 4, 6, 8, and 10 were used after listening/watching specific music/video.

3.2.5 Experimental Procedure

Before starting the experiment, I asked for an introductory personal information questionnaire about their names, ages, gender, and whether one is emotional. In addition, regarding the driving experience of self-driving and non-autonomous vehicles, the driver's experience is required to select each monthly driving frequency. Finally, to find out the behavioral types of public transportation use, we asked what kind of behavior they usually do when they use public transportation such as airplanes/KTX and what kind of behavior they do when riding taxis/buses.

Participants were briefed about the procedures that would be undertaken for the study. While the experiment was going on, participants were asked to keep their posture correct, put their hands on the armrest, and not keep their hands on the space bar. The experiment was conducted through PPT, with participants reading and following the description of the experiment at the beginning. For setting, participants were asked to download a software called oCam in order to record their monitor screen. oCam is an easy-to-use screen recording program developed by the South Korean software company OSOFT. A function to record a PC monitor screen in real-time is also provided. Also, participants were instructed to turn the camera on and start recording their faces without a mask. The camera's height should be parallel to the camera's height, and the entire face should come forward. Also, they wear a headset to listen to the sound.

During the 100 seconds when the image contents were presented, participants looked at the picture and pressed the space bar to see the reaction time when they heard the sound in the middle. Participants pressing a button to skip to the next slide was to measure the rate at which participants would respond when they were notified defenselessly. In particular, the emotional value was to see if there was a change in the participants' emotions when they looked at the other pictures. If there was, it was also related to the rate of reaction.

Furthermore, after the video stimulation, the mood was evaluated through a questionnaire, and the two-minute information was provided to measure the participants' mood changes. In the end, the participants saved a video recording of their faces and an oCam recording and debriefed.

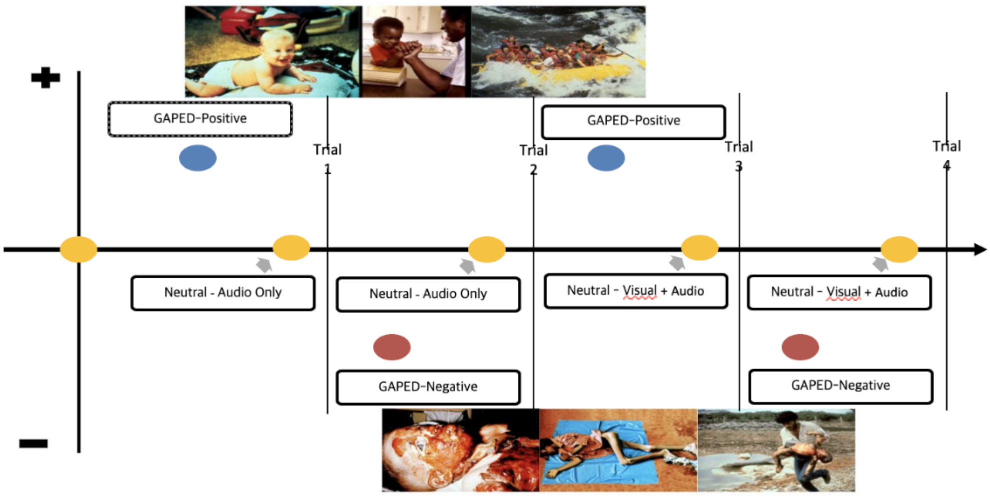

Figure 12. Experimental Process 1

3.2.6 Data

Seven hundred two responses were collected for mood regulation, and it was divided into nine stimuli groups (see Table. 6). Stimuli group one showed the participants' mood after neutralizer such as setting, and groups two and six showed mood after positive stimuli. Groups three and seven showed mood after negative stimuli. Groups three and five showed mood after the neutralizer (audio only), and groups seven and nine showed mood after the neutralizer (audio + visual).

Table 6: A brief overview of responses to questionnaires asking about emotions

No.	Questionnaire No.	Stimuli Group	1	2	3	4	5	6
1	2	Neutral	1	1	1	1	1	1
1	3	Positive 1	1	1	1	1	1	1
1	4	Neutral (audio only) 1	1	1	1	1	1	1
1	5	Negative 1	3	2	2	1	1	4
1	6	Neutral (audio only) 2	5	5	6	7	7	7
1	7	Positive 2	6	5	6	6	5	5
1	8	Neutral (audio + visual) 1	5	5	5	5	4	5
1	9	Negative 2	2	1	2	1	3	2
1	10	Neutral (audio + visual) 2	5	6	6	7	5	7

Sixty-five responses were collected for reaction time and divided into five groups (see Table 7). Experiment one showed reaction time in a neutral mood, and one and three showed a positive mood. Two and four showed reaction time in a negative mood.

Table 7: A brief overview of reaction time by different stimuli

Number	Experiment Number	Stimuli	Reaction Time
1	0	neutral	1.95
	1	high	4.73
	2	low	2.07
	3	high	1.88
	4	low	1.72
2	0	neutral	1.61
	1	high	2.1
	2	low	1.88
	3	high	1.4
	4	low	1.55

The 13-video data (1920x1080 (FHD)) was converted to 22,775 actual facial expression image datasets (frame/sec). Approximately 1,750 images dataset per participant were collected (see Fig. 13).

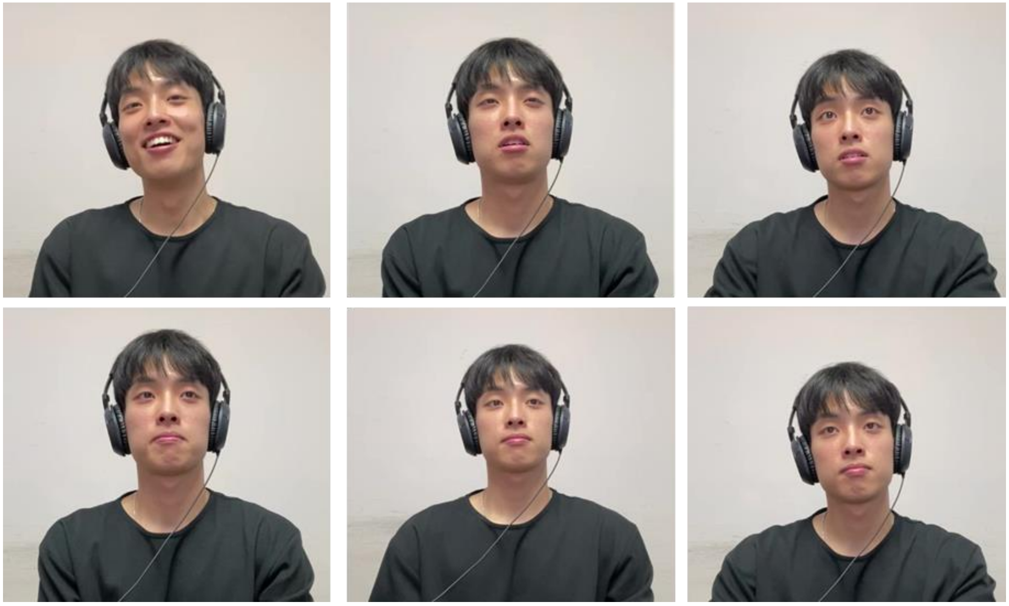

Figure 13. A brief overview of the facial expression dataset

3.2.7 Data Analysis

The dependent variables in this study were analyzed through a Kruskal–Wallis test at a significance level of 0.05. All statistical analyses were conducted using the statistics program SPSS (ver. 26).

Moreover, emotional state image classification is conducted through a deep-learning analysis approach (see Fig. 14). We first collected the participant's facial expression data by recording their faces during the experiment. Furthermore, we converted the video data to image data (frame/sec). Then label the image data as low, neutral, and high depending on the infotainment. Furthermore, I used Orange3 to see if artificial intelligence recognizes the image data well. To do that, I imported the images and embedded them, then used SVM, random forest, and neural network to train the data (see Fig. 16). Then, I tested the data to check the F1 score.

Figure 14. Data analysis process of image classification

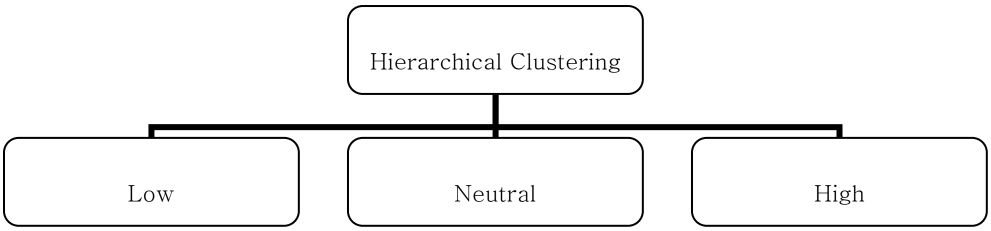

Figure 15. Hierarchical clustering of image classification

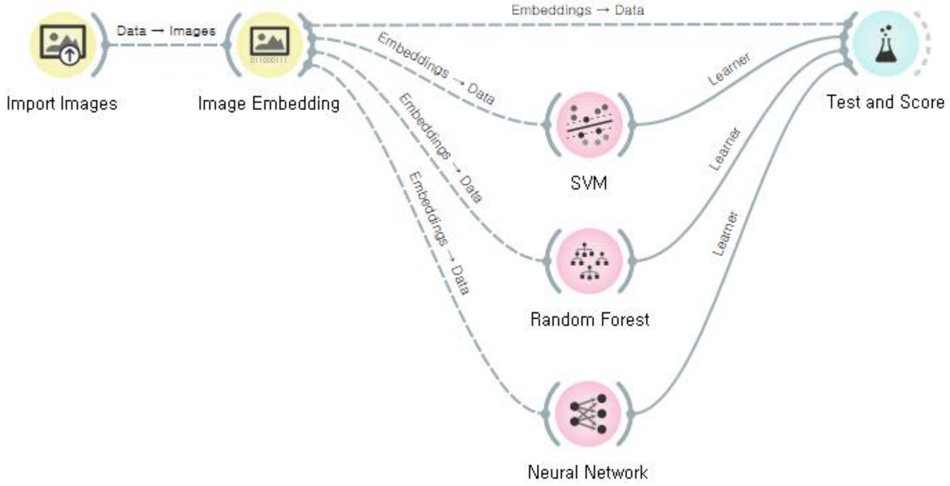

Figure 16. Image classification process using Orange3

3.2.8 Subjective Label Annotation

The emotional state annotation was labeled in three ways. Depending on the stimulus, the participant's facial images were labeled 1–3 (see Fig. 17). If the participant was in the stage of neutralizer, it was labeled as 1 (neutral). When watching a positive stimulus, it was labeled as 2 (positive), and when watching a negative stimulus, as 3 (negative).

Table 8: A brief overview of the emotional state labeling dataset

Name	State
scene00001.jpg	1
scene00031.jpg	1
scene00061.jpg	1
scene00091.jpg	1
scene00121.jpg	1
scene00151.jpg	1

3.3 Results

The results of the analyses are presented in sequence based on the research questions of this study. The results of reaction time are presented first, followed by mood regulation. Descriptive statistics Kruskal-Wallis test of variance are illustrated and summarized through tables and figures. Furthermore, the result of image classification is illustrated and summarized through tables.

3.3.1 Reaction Time

Figure 18 shows the reaction time of the participants based on the categorization from Table 7. This was to see whether there is a difference in reaction time according to people's moods by dividing the variables into five (see Fig. 18).

The Kruskal-Wallis test is a nonparametric test comparing the distribution of groups of three or more groups; it can be used instead of One-Way ANOVA of parameter statistics. Also, it is a nonparametric test method used when the normality assumption is not satisfied in ANOVA, and unlike ANOVA, results on median values can be obtained.

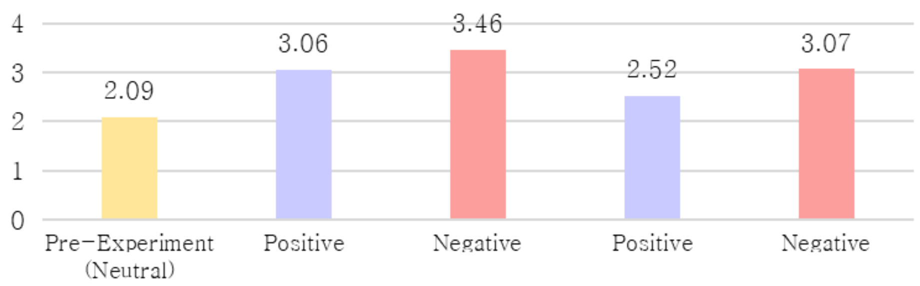

Figure 17. A brief overview of the reaction time labeling dataset

The mean and standard deviation of the variables for reaction time are presented in table 9. From the table, it can be seen that generally, the pre-experiment (neutral) group had lesser reaction time mean and standard deviation (1.93 (±0.98)) than the positive group (3.05 (±1.54), 2.51 (±1.39)) and the opposing group (3.46 (±1.60), 3.07 (±1.48)). Furthermore, the positive group showed better results than the hostile group.

Table 9: Descriptive statistics for reaction time

Group	Mean (SD)
Neutral	1.93 (±0.98)
Positive1	3.05 (±1.54)
Negative1	3.46 (±1.60)
Positive2	2.51 (±1.39)
Negative2	3.07 (±1.48)

The result of the normality test is presented in Table 10. In the Kolmogorov-Smirnov result, the normality is not satisfied because the significance level of the rest of the group, except for the neutral group, is p=0.05 or less. Shapiro-Wilk also did not satisfy normality with a significance level of p=0.05 or less, so the analysis was conducted with a nonparametric test.

Table 10: Result of normality test for reaction time

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Test Statistic	Degrees of Freedom	Probability of Significant	Test Statistic	Degrees of Freedom	Probability of Significant
Neutral	0.212	12	0.143	0.796	12	0.009

Positive1	0.283	12	0.009	0.809	12	0.012
Negative1	0.252	12	0.034	0.840	12	0.028
Positive2	0.337	12	0.000	0.731	12	0.002
Negative2	0.305	12	0.003	0.806	12	0.011

The result of the Kruskal–Wallis test for reaction time is summarized in Table 11. Results showed that the probability of significance is 0.017, which is less than 0.05 and rejects the null hypothesis.

Table 11: Summary of a hypothesis test for reaction time

Null Hypothesis	Test	Probability of Significance	Decision
The distribution of reaction time is the same across categories of stimulus.	Independent Samples Kruskal–Wallis Test	0.017	Reject the null hypothesis.

The summary of the independent sample Kruskal–Wallis test for reaction time is summarized in Table 12. Results showed the test statistics (χ^2 (chi–square)), which is χ^2 = 12.05, p=0.017). In other words, there is a statistically significant difference in reaction time across different stimuli.

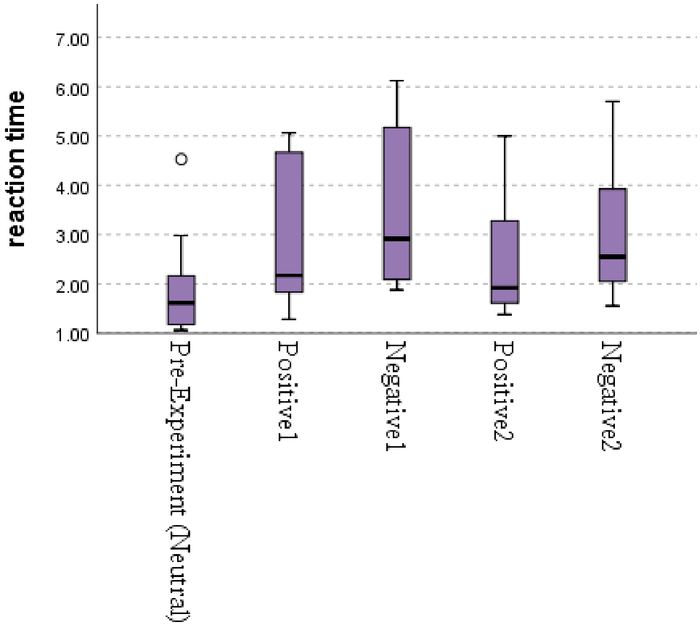

Figure 18. Reaction time

Table 12: Summary of independent−sample Kruskal Wallis test for reaction time

Total N	60
Chi−square	12.05
Degrees of Freedom	4
Asymptotic Sig.(2−sided test)	0.017

Pairwise comparison is a way of comparing two groups. As a result of the Kruskal−Wallis test, a p−value of 0.017 came out, The table below (table 13), shows which groups differed from each other. The pairwise comparison was used for conducting post hoc tests on a Kruskal Wallis test. We can see from the table below that there is a statistically significant difference in Neutral−Positive1 ($p = 0.046$), as well as between the Neutral−Negative2 ($p = 0.10$), Neutral−Negative1 ($p = 0.002$), Positive2−Negative1 ($p = 0.043$).

However, there was no difference in the comparison between groups Neutral–Positive2 (p = 0.314), Positive2–Positive1 (p = 0.323), Positive2–Negative2 (p = 0.113), Positive1–Negative2 (p = 0.551), Positive1–Negative1 (p = 0.298), Negative2–Negative1 (p = 0.657).

Table 13: Summary of pairwise comparison for reaction time

Sample1–Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.
Neutral–Positive2	−7.167	7.128759	−1.005	0.314744
Neutral–Positive1	−14.208333	7.128759	−1.993100	.046
Neutral–Negative2	−18.458333	7.128759	−2.589277	.010
Neutral–Negative1	−21.625000	7.128759	−3.033487	.002
Positive2–Positive1	7.041667	7.128759	0.987783	.323
Positive2–Negative2	−11.291667	7.128759	−1.583960	.113
Positive2–Negative1	14.458333	7.128759	2.028170	.043
Positive1–Negative2	−4.250000	7.128759	−0.596177	.551
Positive1–Negative1	−7.416667	7.128759	−1.040387	.298
Negative2–Negative1	3.166667	7.128759	0.444210	.657

3.3.2 Mood Regulation

For mood regulation, we checked whether there is a difference in mood according to different infotainments. The Kruskal–Wallis test is used for this analysis. Figure 17 shows the mood regulation of the participants based on the categorization from Table 7.

The Kruskal–Wallis test is a nonparametric test comparing the distribution of groups of three or more groups; it can be used instead of One–Way ANOVA of parameter statistics. Also, it is a nonparametric test method used when the normality assumption is not satisfied in ANOVA, and unlike ANOVA, results on median values can be obtained.).

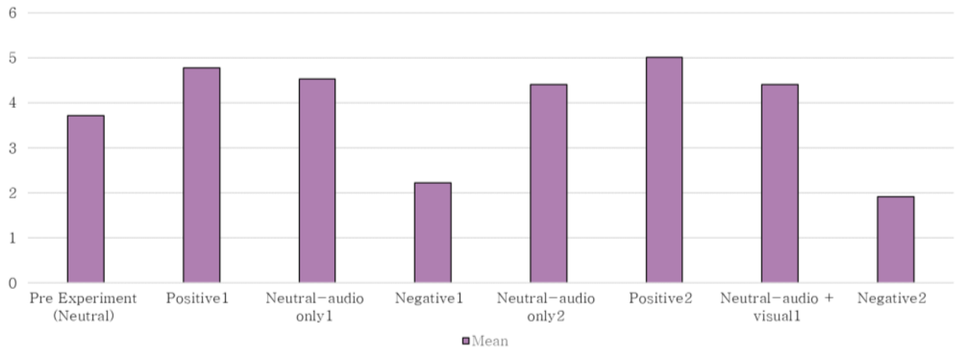

Figure 19. A brief overview of the mood regulation labeling dataset

The mean and standard deviation of the variables for reaction time are presented in Table 14. From the table, generally, the neutral group had lesser reaction time mean and standard deviation (1.93 (±0.98)) than the positive group (3.05 (±1.54), 2.51 (±1.39)) and the opposing group (3.46 (±1.60), 3.07 (±1.48)). Furthermore, the positive group showed better results than the opposing groups. Moreover, for the neutralizer, there was not much difference between the neutral audio only) group and the neutral (audio + visual) group.

Table 14: Descriptive statistics for mood regulation

Group	Mean (SD)
Neutral	3.71 (±1.59)

Positive1	4.78 (±1.792)
Neutral–audio only1	4.52 (±2.04)
Negative1	2.21 (±1.34)
Neutral–audio only2	4.41 (±1.34)
Positive2	5.01 (±1.37)
Neutral–audio + visual1	4.41 (±1.71)
Negative2	1.92 (±1.25)
Neutral–audio + visual2	4.51 (±1.51)

The result of the normality test is presented in Table 15. In the Kolmogorov–Smirnov result, the normality is not satisfied because the significance level of all the groups shows a p–value less than 0.05. Shapiro–Wilk also did not satisfy normality with a significance level of $p<0.05$, so the analysis was conducted with a nonparametric test.

Table 15: Result of normality test for mood regulation

Group	Kolmogorov–Smirnov			Shapiro–Wilk		
	Test Statistic	Degrees of Freedom	Probability of Significant	Test Statistic	Degrees of Freedom	Probability of Significant
Neutral	0.224	78	0.000	0.902	78	0.000

Positive1	0.177	78	0.000	0.884	78	0.000
Neutral-audio only1	0.194	78	0.000	0.859	78	0.000
Negative1	0.231	78	0.000	0.822	78	0.000
Neutral-audio only2	0.208	78	0.000	0.924	78	0.000
Positive2	0.214	78	0.000	0.890	78	0.000
Neutral-audio + visual1	0.224	78	0.000	0.879	78	0.000
Negative2	0.294	78	0.000	0.745	78	0.000
Neutral-audio + visual2	0.188	78	0.000	0.923	78	0.000

The result of the Kruskal-Wallis test for reaction time is summarized in Table 16. Results showed that the probability of significance is 0.000, which is less than 0.05 and rejects the null hypothesis.

Table 16: Summary of a hypothesis test for mood regulation

Null Hypothesis	Test	Probability of Significance	Decision
The distribution of mood is the same across categories of stimulus.	Independent Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.

The summary of the independent sample Kruskal−Wallis test for reaction time is summarized in Table 17. Results showed the test statistics (χ^2 (chi−square)), which is χ^2 = 209.484, p=0.000). In other words, there is a statistically significant difference between the mood across different stimuli.

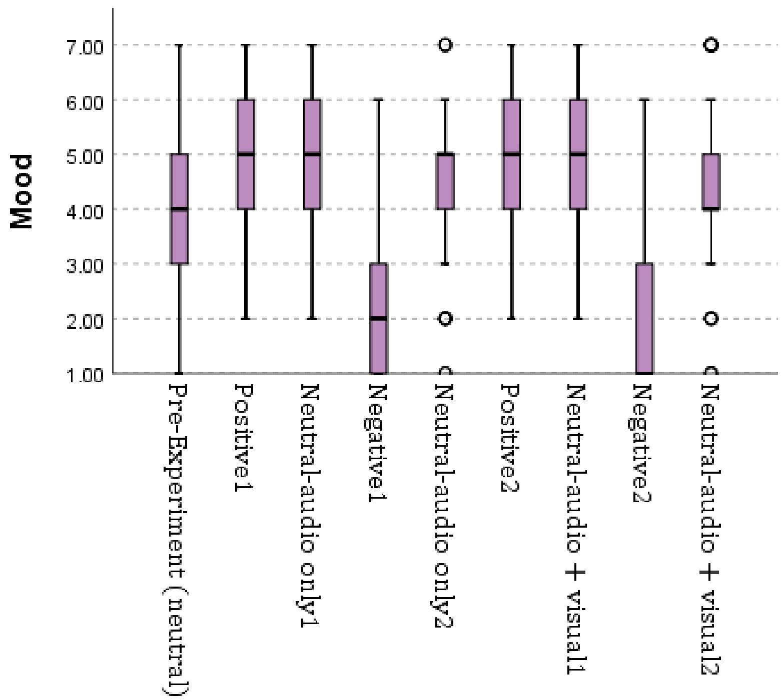

Figure 20. Mood regulation

Table 17: Summary of independent−sample Kruskal Wallis test for mood regulation

Total N	702
Test Statistic	209.484
Degrees of Freedom	8

Asymptotic Sig.(2-sided test)	0.000

The table below (table 18), shows which groups differed from each other. The pairwise comparison was used for conducting post hoc tests on a Kruskal Wallis test. We can see from the table below that there is a statistically significant difference in Negative2-Neutral-audio only2 ($p = 0.000$), as well as between the Negative2-Neutral-audio + visual2 ($p = 0.000$), Negative2-Neutral-audio + visual1 ($p = 0.000$), Negative2-Neutral-audio only1 ($p = 0.000$), Negative2-Positive1 ($p = 0.000$), Negative2-Positive2 ($p = 0.000$), Negative1- Neutral ($p = 0.000$), Negative1-Neutral-audio only2 ($p = 0.019$), Negative1-Neutral-audio + visual2 ($p = 0.012$), Negative1-Neutral-audio + visual1 ($p = 0.010$), Negative1-Neutral-audio only1 ($p = 0.001$), Negative1-Positive1 ($p = 0.000$), Negative1-Positive2 ($p = 0.000$), Neutral-Neutral-audio only2 ($p = 0.000$), Neutral-Neutral-audio + visual2 ($p = 0.000$), Neutral-Neutral-audio + visual1 ($p = 0.000$), Neutral-Neutral-audio only1 ($p = 0.000$), Neutral-Positive1 ($p = 0.000$), Neutral-audio + visual2-Positive2 ($p = 0.037$), Neutral-audio + visual1-Positive2 ($p = 0.041$).

However, there were no differences between the neutral groups (Neutral-audio only2-Neutral-audio + visual2, Neutral-audio only2-Neutral-audio + visual1, Neutral-audio only2-Neutral-audio only1, Neutral-audio + visual2-Neutral-audio + visual1, Neutral-audio + visual2-Neutral-audio only1), positive groups (positive 1-positive 2), positive and neutral groups (Neutral-audio only1-Positive1, Neutral-audio only1-Positive2, Neutral-audio only2-Positive1, Neutral-audio only2-Positive2, Neutral-audio + visual1-Positive1), and negative groups (Negative1-Negative2).

Table 18: Summary of pairwise comparison for mood regulation

Sample1－Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.
Negative2－Negative1	26.756	31.992	0.836	0.403
Negative2－Neutral	172.974	31.992	5.407	0.000
Negative2－Neutral－audio only2	247.974	31.992	7.751	0.000
Negative2－Neutral－audio + visual2	−253.679	31.992	−7.929	0.000
Negative2－Neutral－audio + visual1	254.962	31.992	7.969	0.000
Negative2－Neutral－audio only1	271.705	31.992	8.493	0.000
Negative2－Positive1	293.872	31.992	9.186	0.000
Negative2－Positive2	320.423	31.992	10.016	0.000
Negative1－Neutral	146.218	31.992	4.570	0.000
Negative1－Neutral－audio only2	−221.218	31.992	−6.915	0.000
Negative1－Neutral－audio + visual2	−226.923	31.992	−7.093	0.000
Negative1－Neutral－audio + visual1	−228.205	31.992	−7.133	0.000

Negative1−Neutral−audio only1	244.949	31.992	7.657	0.000
Negative1−Positive1	267.115	31.992	8.349	0.000
Negative1−Positive2	−293.667	31.992	−9.179	0.000
Neutral−Neutral−audio only2	−75.000	31.992	−2.344	0.019
Neutral−Neutral−audio + visual2	−80.705	31.992	−2.523	0.012
Neutral−Neutral−audio + visual1	−81.987	31.992	−2.563	0.010
Neutral−Neutral−audio only1	−98.731	31.992	−3.086	0.002
Neutral−Positive1	−120.897	31.992	−3.779	0.000
Neutral−Positive2	−147.449	31.992	−4.609	0.000
Neutral−audio only2−Neutral−audio + visual2	−5.705	31.992	−0.178	0.858
Neutral−audio only2−Neutral−audio + visual1	−6.987	31.992	−0.218	0.827
Neutral−audio only2−Neutral−audio only1	23.731	31.992	0.742	0.458

Neutral−audio only2−Positive1	45.897	31.992	1.435	0.151
Neutral−audio only2−Positive2	−72.449	31.992	−2.265	0.024
Neutral−audio + visual2−Neutral−audio + visual1	1.282	31.992	0.040	0.968
Neutral−audio + visual2−Neutral−audio only1	18.026	31.992	0.563	0.573
Neutral−audio + visual2−Positive1	40.192	31.992	1.256	0.209
Neutral−audio + visual2−Positive2	66.744	31.992	2.086	0.037
Neutral−audio + visual1−Neutral−audio only1	16.744	31.992	0.523	0.601
Neutral−audio + visual1−Positive1	38.910	31.992	1.216	0.224
Neutral−audio + visual1−Positive2	65.462	31.992	2.046	0.041
Neutral−audio only1−Positive1	22.167	31.992	0.693	0.488

Neutral−audio only1−Positive2	−48.718	31.992	−1.523	0.128
Positive1−Positive2	−26.551	31.992	−0.830	0.407

ANOVA was additionally used to compare the results of the ANOVA with those verified by the nonparametric test. The result of one−way ANOVA is F=39.697, p=.000 as shown in figure 19. As a result, there is a statistically significant difference between groups because the p value is less than 0.05.

Table 19. ANOVA Table

	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Between	784.353	8	98.044	39.697	.000
Groups	1711.590	693	2.470		
Total	2495.943	701			

From the results so far, we know that there are statistically significant differences between the groups as a whole. The table below (table 20), multiple comparisons, shows which groups differed from each other. The Scheffe test is used for conducting post hoc tests on a one−way ANOVA. We can see from the table below that there is a statistically significant difference in neutral and positive 1 group (p = 0.023), as well as between the neutral and negative 1 group (p = 0.000), the neutral and positive 2 group (p = 0.001), neutral and negative 2 group (p = 0.000), positive 1 and negative 1 group (p = 0.000), positive 1 and negative 2 group (p = 0.000), neutral−audio only 1 and negative 1 (p = 0.000), neutral−audio only 1 and negative 2 (p = 0.000), negative 1 and neutral−audio only 2 (p

= 0.000), negative 1 and positive 2 (p = 0.000), negative 1 and neutral–audio + visual 1 (p = 0.000), negative 1 and neutral–audio + visual2 (p = 0.000), neutral–audio only 2 and negative 2 (p = 0.000), positive 2 and negative 2 (p = 0.000), neutral–audio + visual1 and negative 2 (p = 0.000), negative 2 and neutral–audio only 2 (p = 0.000), negative 2 and positive 2 (p = 0.000), negative 2 and neutral–audio + visual 1 (p = 0.000), negative 2 and neutral–audio + visual2 (p = 0.000).

However, there were no differences between the neutral groups (neutral–neutral audio only 1, neutral–neutral audio only 2, neutral–neutral audio + visual 1, neutral–neutral audio + visual 2), positive groups (positive 1–positive 2), positive and neutral groups (positive 1–neutral, positive 1–neutral audio only 1, positive 1–neutral audio only 2, positive 1–neutral–neutral audio + visual 1, positive 1–neutral audio + visual 2, positive 2–neutral, positive 1–neutral audio only 1, positive 2–neutral audio only 2, positive 2–neutral–neutral audio + visual 1, positive 2–neutral audio + visual 2), and negative groups (negative1–negative2).

Table 20. Multiple Comparison Table

Sample 1	Sample2	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Neutral	Positive1	-1.06410	.25165	.023	–2.0585	-.0697
	Neutral–audio only1	-.80769	.25165	.247	–1.8021	.1867
	Negative 1	1.50000	.25165	.000	.5056	2.4944
	Neutral–	-.69231	.2516	.478	–	.3021

	audio only2		5		1.6867	
	Positive2	−1.29487	.25165	.001	−2.2893	−.3005
	Neutral−audio + visual1	−.69231	.25165	.478	−1.6867	.3021
	Negative 2	1.79487	.25165	.000	.8005	2.7893
	Neutral−audio + visual2	−.79487	.25165	.269	−1.7893	.1995
Positive1	Neutral	1.06410	.25165	.023	.0697	2.0585
	Neutral−audio only1	.25641	.25165	.998	−.7380	1.2508
	Negative 1	2.56410	.25165	.000	1.5697	3.5585
	Neutral−audio only2	.37179	.25165	.975	−.6226	1.3662
	Positive2	−.23077	.25165	.999	−1.2252	.7636
	Neutral−audio + visual1	.37179	.25165	.975	−.6226	1.3662
	Negative 2	2.85897	.25165	.000	1.8646	3.8534
	Neutral−audio + visual2	.26923	.25165	.997	−.7252	1.2636
Neutral−audio	Neutral	.80769	.25165	.247	−.1867	1.8021

only1	Positive1	-.25641	.25165	.998	-1.2508	.7380
	Negative 1	2.30769	.25165	.000	1.3133	3.3021
	Neutral-audio only2	.11538	.25165	1.000	-.8790	1.1098
	Positive2	-.48718	.25165	.879	-1.4816	.5072
	Neutral-audio + visual1	.11538	.25165	1.000	-.8790	1.1098
	Negative 2	2.60256	.25165	.000	1.6082	3.5970
	Neutral-audio + visual2	.01282	.25165	1.000	-.9816	1.0072
Negative 1	Neutral	-1.50000	.25165	.000	-2.4944	-.5056
	Positive1	-2.56410	.25165	.000	-3.5585	-1.5697
	Neutral-audio only1	-2.30769	.25165	.000	-3.3021	-1.3133
	Neutral-audio only2	-2.19231	.25165	.000	-3.1867	-1.1979
	Positive2	-2.79487	.25165	.000	-3.7893	-1.8005
	Neutral-audio + visual1	-2.19231	.25165	.000	-3.1867	-1.1979
	Negative 2	.29487	.25165	.995	-.6995	1.2893

	Neutral–audio + visual2	−2.29487	.25165	.000	−3.2893	−1.3005
Neutral–audio only2	Neutral	.69231	.25165	.478	−.3021	1.6867
	Positive1	−.37179	.25165	.975	−1.3662	.6226
	Neutral–audio only1	−.11538	.25165	1.000	−1.1098	.8790
	Negative1	2.19231	.25165	.000	1.1979	3.1867
	Positive2	−.60256	.25165	.677	−1.5970	.3918
	Neutral–audio + visual1	.00000	.25165	1.000	−.9944	.9944
	Negative2	2.48718	.25165	.000	1.4928	3.4816
	Neutral–audio + visual2	−.10256	.25165	1.000	−1.0970	.8918
Positive2	Neutral	1.29487	.25165	.001	.3005	2.2893
	Positive1	.23077	.25165	.999	−.7636	1.2252
	Neutral–audio only1	.48718	.25165	.879	−.5072	1.4816
	Negative1	2.79487	.25165	.000	1.8005	3.7893
	Neutral–audio only2	.60256	.25165	.677	−.3918	1.5970

	Neutral–audio + visual1	.60256	.25165	.677	-.3918	1.5970
	Negative 2	3.08974	.25165	.000	2.0954	4.0841
	Neutral–audio + visual2	.50000	.25165	.861	-.4944	1.4944
Neutral–audio + visual1	Neutral	.69231	.25165	.478	-.3021	1.6867
	Positive1	-.37179	.25165	.975	-1.3662	.6226
	Neutral–audio only1	-.11538	.25165	1.000	-1.1098	.8790
	Negative 1	2.19231	.25165	.000	1.1979	3.1867
	Neutral–audio only2	.00000	.25165	1.000	-.9944	.9944
	Positive2	-.60256	.25165	.677	-1.5970	.3918
	Negative 2	2.48718	.25165	.000	1.4928	3.4816
	Neutral–audio + visual2	-.10256	.25165	1.000	-1.0970	.8918
Negative 2	Neutral	-1.79487	.25165	.000	-2.7893	-.8005
	Positive1	-2.85897	.25165	.000	-3.8534	-1.8646
	Neutral–audio only1	-2.60256	.25165	.000	-3.5970	-1.6082

	Negative 1	-.29487	.25165	.995	-1.2893	.6995
	Neutral-audio only2	-2.48718	.25165	.000	-3.4816	-1.4928
	Positive2	-3.08974	.25165	.000	-4.0841	-2.0954
	Neutral-audio + visual1	-2.48718	.25165	.000	-3.4816	-1.4928
	Neutral-audio + visual2	-2.58974	.25165	.000	-3.5841	-1.5954
Neutral-audio + visual2	Neutral	.79487	.25165	.269	-.1995	1.7893
	Positive1	-.26923	.25165	.997	-1.2636	.7252
	Neutral-audio only1	-.01282	.25165	1.000	-1.0072	.9816
	Negative 1	2.29487	.25165	.000	1.3005	3.2893
	Neutral-audio only2	.10256	.25165	1.000	-.8918	1.0970
	Positive2	-.50000	.25165	.861	-1.4944	.4944
	Neutral-audio + visual1	.10256	.25165	1.000	-.8918	1.0970
	Negative 2	2.58974	.25165	.000	1.5954	3.5841

3.3.3 Image Classification

Figure 19 shows the result of image classification. We used Orange Data Analysis to find the F1 score of low, neutral, and high labeled images. For all the images, SVM showed the highest F1 score among the three models. For low−labeled and high−labeled images, the F1 score was lower than for neutral−labeled images.

Table 21. Results of image classification

Label	Model	F1 score
Low	SVM	0.764
	Random Forest	0.756
	Neural Network	0.744
Neutral	SVM	0.932
	Random Forest	0.895
	Neural Network	0.893
High	SVM	0.784
	Random Forest	0.712
	Neural Network	0.741

Chapter 4 Discussion

This study aims to investigate the differences in reaction time based on different moods and provide a corresponding infotainment system to make the driver neutralize conditions. In general, the results revealed that the participant's moods affect by different infotainments. Providing a positive infotainment system turned in a positive mood, and providing negative infotainment confirmed that participants turned into a negative mood. In addition, providing neutralized infotainment showed that participants' minds changed from positive or negative to neutral. Furthermore, we could see the difference in reaction time according to the participants' mood regulation. Participants boasted the fastest reaction time in a neutralized mood, followed by a positive and negative mood.

4.1 Mood Regulation

The result of mood regulation revealed a significant difference between neutralizer groups and positive and negative groups. In addition, the results of ANOVA with that of the nonparametric test were similar. As for the variables, there was no difference between neutralizers, positive and negative. The reason is that when providing a neutralizer, users' minds tended to stabilize equally. There was no difference when exposed to different neutralizers because the neutralizer had the same purpose: to stabilize the human mind. Therefore, it can be seen that the neutralizer successfully influenced the participants. In addition, it is crucial to provide infotainment according to the driver's situation because there is expected to be a slight difference between infotainment that only provides auditory and infotainment that provides auditory and vision at the same time. Since the results of comparing positive stimuli were also provided to positively change the participants' mood, the fact that there was no significant difference between positive stimuli is a convincing result. The same is true when comparing negative stimuli.

Significant differences were found when comparing neutralizer-positive and neutralizer-negative. Therefore, participants' emotions can be controlled depending on the kind of infotainment provided. Therefore, providing the correct information will also be effective for drivers.

4.2 Reaction Time

In terms of reaction time, results from the analysis revealed that there is a significant difference between the variances. As for the variables, some of the groups did not show many differences. The reason is that the differences in reaction time among each group were so minor that it was hard to see the difference. In addition, it took much work to perform an accurate comparative analysis because the number of recruiters needed to be more significant. However, there was a significant difference between the Neutral-Negative groups because people showed significant differences in reaction time in stabilized states where they reacted faster than when exposed to negative stimuli.

4.3 Image Classification

Regarding image classification, the F1 score for neutral-labeled images showed higher scores than low and high-labeled images. This is because images labeled low and high had relatively small data compared to images labeled neutral.

Chapter 5 Conclusion

The main aim of this study is to determine the reaction time according to the driver's mood regulation and provide a Driver's Emotion Neutralizing Infotainment System (DENIS). The mood was measured using a questionnaire to acquire in-depth data, and reaction time was measured by watching the participants respond time to the alert sound. As the experiment intended, participants showed positive mood when given positive stimuli, negative mood when negative stimuli, and neutralized mood when a neutralizer was provided. Moreover, it was confirmed that the stimuli affected the participants' emotions and emotions affected the reaction time. In summary, when providing neutralizer infotainment, participants did not feel much difference between using audio only and audio + visual information. In other words, the infotainment to control a person's mood to a neutral state has similar effects, using audio alone and audio + visual information simultaneously. Participants forget their previous feelings when a neutralizer is provided and focus on a new stimulus. Moreover, neutralized mood exhibits a shorter reaction time than positive or negative moods.

5.1 Limitation, Contribution, and Future Directions

Auditory or visual stimulation, which acts as a neutralizer, plays a sufficient role in calming emotions. While each neutralizer played for 100 seconds, the isolation effect that isolated the subject from positive or negative stimuli cannot be ignored. The neutralizer's role is significant because subjects left alone for the same period as the neutralizer playback time without additional stimuli may be unable to constantly remember the stimuli had previously acquired and move away from them. This is the same as failing to control emotions. On the other hand, the neutralizer plays as regeneration rather than focusing on the stimuli previously accepted by the subject. Allowing one to focus instead on the new stimuli rather than leaving an emotionally stimulated subject can provide an effective neutralizer.

In addition, since the experimental environment was not an actual vehicle driving environment, it would be better for future studies to conduct this experiment while experiencing the actual driving experience. Stimuli is a convincing result. The same is true when comparing negative stimuli.

Lastly, since the participants were not many people to experiment with, 13 people, better results are expected if more people are tested. If the amount of data is increased to match the data imbalance concerning image classification, the f1 score is expected to increase further.

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초　　록

자율 주행이 점차 높은 단계로 상용화 되면서 사람이 차량 내에서 인포테인먼트를 시청할 가능성과 여유가 늘어났다. 그에 따라 사용자의 감정 기복은 영향을 받을 수밖에 없는데 감정의 활성화 정도에 따라 사용자의 리액션 타임에 차이가 있을 것으로 예상된다. 이것이 중요한 이유는 자율주행 단계가 5레벨 미만인 경우 운전자는 Take Over Request 로부터 자유로울 수 없기 때문이며 위험 상황에서 보다 안전하기 위해서는 보다 빠른 반응 속도, 혹은 인지 능력을 요구한다. 따라서 본 연구를 통해 사용자의 감정 상태에 따른 인지력/순발력 차이를 확인해 보고, 사용자를 지속적으로 모니터링 해 사용자의 감정 상태가 변화함을 감지하면 그에 맞는 인포테인먼트를 제공하는 초기 프로토타입을 개발해 보았다.

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