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Drivers' comprehension of traffic information on graphical route information panels

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ABSTRACT

The concept of using signs to display graphical traffic information is now becoming increasingly popular. The main objective of this study was to design and undertake laboratory research to examine whether the content of traffic information displayed on graphical route information panel (GRIP) could be readily understood. Six kinds of GRIP signs that composed of three changeable information contents (road color only, road color with journey time, and road color with traffic speed) and two different road network types (triangle and tetragon) were proposed and tested in the experiment. Results showed that GRIP with road color only had the greatest optimum route choice percentage and the fastest response time compared to the other contents. On the contrary, GRIP with traffic speed had the slowest response time and the least optimum route choice percentage. Participants took less response time and greater optimum route choice percentage for triangle road network than for tetragon road network. Further, changeable information content interacted with road network type on response time and optimum route choice percentage. The road network type had little effect on response time and optimum route choice percentage under road color only, whereas under road color with journey time and road color with traffic speed, response times increased and optimum route choice percentage decreased significantly as road network complexity increased. Considering drivers' comprehension and response, using road color only to present traffic condition on GRIP could be an applicable solution. Road color with traffic speed presented on GRIP was not recommended. Road color with journey time can be used for a simple road network. However, it was not suggested for a complex road network. The findings of this study could assist in displaying suitable traffic information on GRIP and in improving efficient driving for motorists.

1. Introduction

Since the introduction of advanced variable display technologies in traffic system, a large variety of different types of dynamic systems have been developed. Variable message sign (VMS) is a one which has recently been widely installed on traffic arteries in many countries. VMS are programmable traffic control devices that display dynamic message composed mainly of text about road information. It is critical in informing motorists of various situations, especially in high volume traffic and congested zones. However, the amount of text which can be displayed on VMS is limited. A VMS cannot always present all relevant information to motorists at a certain location. The multitude of different routes existing in a road network would require directing different route recommendations at drivers with various destinations. Using signs to display graphical information may be a possible solution for this problem (Alkim et al., 2000). Graphical route information panel (GRIP) is one of the recent developments. Unlike conventional VMS, a GRIP is not restricted to text. It allows any kind of text, graphical representation and combinations thereof to be displayed. These features offer the opportunity to display route maps, text combined with symbols, the position of traffic congestion, travel time for each route, or any other representation the designer may wish (Matthijs and Brookhuis, 2008). GRIP has been operated in Japan for some time (Takeda et al., 1999). The concept is also now becoming increasingly popular in many countries such as Germany (Richards et al., 2005), the UK (Atkins, 2003), China (Gan et al., 2006), and Taiwan (TANFB, 2008).

One picture is worth a thousand words. By displaying part of a road network, including the location of congestion, an overview of the current traffic situation can be given. The potential of the human mind to absorb graphical information is a distinct advantage for a GRIP over a VMS which can display text message only. A GRIP can display information regarding different routes simultaneously. Because the road network is displayed, including the locations of congestion, motorists receive information on all possible routes, regardless of their destination. This can be important when the network is complex or when congestion occurs on

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several locations within the network. GRIP also serves a larger group of motorists, and particularly motorists who are not familiar with the roadways will have fewer problems. They will not need to know what the descriptive terms on text VMS stand for (Alkim et al., 2000).

Due to the short history of GRIP application, the researches of driver comprehension on GRIP are limited. Richards et al. (2005) investigated driver comprehension of information that may be contained in such signs with a view to establishing prototype design guidelines. A key objective of the concept study was to design and undertake laboratory research to examine whether the content of traffic information messages displayed by the GCDP could be readily understood. Although no single best sign design was identified, the research found that some design types were clearly more successful than others. The study commissioned by the Highways Agency of the UK recommended that the graphical panels are proposed for three route choices as they were more easily understood than text based signs. For two route choices, however, text panels are proposed (Atkins, 2003). Gan et al. (2009) proposed a macroscopic simulation approach to investigate control benefits of GRIP. Simulation on a hypothetical freeway network indicated that GRIP have a positive potential of reducing re-current congestions and facilitate more efficient use of road infrastructures.

With the advantages of GRIP, there are also disadvantages. Research has not shown our intake limit of graphical information, and how complex the GRIP can be for the motorist while negotiating an everyday road situation. A network that is displayed graphically must be simple and recognizable. The critical factor for information designing on GRIP is to find the right balance between recognition and simplicity (Alkim et al., 2000). As Dudek (2004) denoted in his review of variable message signs, displaying well-designed message on VMS is key to effectively managing traffic and maintaining credibility with motorists. To be effective, a VMS must communicate a meaningful message that can be read and understood by motorists within a very short time period. If a GRIP is to be read and believed by motorists, the content of the message must provide information relative to the wants of the motorist.

Color is an important characteristic of visual stimuli that may affect visual performance. It can be an effective means to improve human-computer communication (Pastoor, 1990). Results of the Munich research on GCDP indicated that use only two colors (red for congested and black for not congested) was preferable as it limited sign complexity (Schönfeld et al., 2000). It was found that the meaning of the color yellow is vague; in contrast to red and green which are well understand. Richards et al. (2005) found that an increase in the number of colors present does increase comprehension, a degree of confusion as to the meaning of the colors can arise. Lai (2010) also found that participants responded slower for three-color scheme than for one- and two-color scheme on the text messages of variable message signs. However, the Driver Time system in Australia (Kloot, 1999), which uses roadside signs with color strips to measure the level of congestion between roadway sections has used a three color scheme of green (light traffic), yellow (moderate congestion) and red (heavy congestion) (Richards et al., 2005). Atkins (2003) adopted the color red to represent heavy congestion or slow speed and yellow to represent light congestions, black to denote free following conditions. In general, the use of colors can increase the efficiency of graphics but can also increase the complexity if too many colors are used. The meaning of colors has to be understood intuitively and in a similar way by all drivers (Tsavachidis et al., 2000).

As the color coded display of level of service information for the relevant networks, journey time is another form of an effect on travel element. Journey time is very useful to motorists because it gives them some indication as to potential arrival time to their destination. Journey time information may be displayed if journey times can be measured or calculated using the electronic sensor equipment on the freeway. Also, journey times can be displayed during the peak and off-peak periods and has the added advantage that a message will be displayed on the changeable message sign more frequently rather than having the sign blank in the absence of incident (Dudek, 2004). Atkins (2003) recommended that GCDP display travel time information to enable motorists to make better informed route choices. Traffic speed is also an important piece of traffic data. It complements other traffic data in reflecting the performance of the road network and warning of possible traffic incidents on the roads. For motorists, speed information reflects the driving experience. It is easily understood, unlike other traffic data such as traffic volume and density which are more difficult for them to relate to. However, little available literatures have been done on the different information displayed on GRIP, and therefore it is worthwhile to consider the information displayed on GRIP and evaluate the effect of motorists' comprehension of them.

Besides all aforementioned attributes, road network complexity is one another critical indicator for designing of GRIP. Road network complexity refers to the number of the graphical and informational elements displayed. These depend on network coverage and the category and number of information displayed. Tsavachidis et al. (2000) indicated that there are no generic rules regarding the maximum complexity of a graphical network display, complexity being in itself a rather generic attribute. As accounting for all traffic related requirements would have required very complex displays, compromise designs had to be found in a heuristic approach. Motorists must time-share their attention to the roadway, to traffic, and to reading signs. Motorists cannot always devote full attention to reading a GRIP while moving. One must consider that the information displayed needs to be understood by a motorist without causing excessive workload (Dingus and Hulse, 1993). The amount of information in the total message is a critical consideration in designing of GRIP messages.

Inappropriate design of information in format, content or degree of complexity, can adversely affect the drivers' acceptance of the system. Furthermore, safety risks exist when the drivers' attention is distracted too much (Tsavachidis et al., 2000). The need to identify and define elements for graphic displays becomes critical (Ullman et al., 2008). In summary, the intent of this study was to design and undertake laboratory research to examine whether the content of traffic information displayed on GRIP could be readily understood.

2. Methods

2.1. Experiment design

This study focused on examining drivers' comprehension of traffic information displayed on graphical route information panel. The content of changeable information and type of road network were treated as independent variables. There were three levels of content of changeable information: road color only, road color with journey time, and road color with traffic speed. Triangle and tetragon road network were conducted for the type of road network. They were used to represent simple and complex road network separately in this study. The two types of road network are all widely seen on the freeway system in Taiwan. Table 1 shows illustrations of GRIP used in the experiment under combinations of changeable information content and road network type. A within-participants design was conducted for the two independent variables. Six treatment groups represented the combinations of the two within-participants factors.

Three different traffic conditions for each type of road network were designed to generate dissimilar response for a participant. Participants were asked to choose the fastest route to a given des-

Table 1
Illustrations of GRIP under combinations of changeable information content and road network type. Number in parenthesis indicates the amount of information units for each GRIP.

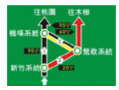
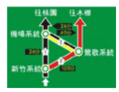
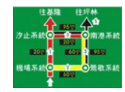
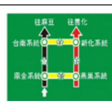
Content of changeable information	Type of road network			
	Triangle (information units)		Tetragon (information units)	
Road color only		(12)		(17)
Road color with journey time		(16)		(23)
Road color with traffic speed		(16)		(23)

Table 2
Examples of GRIP for three different traffic conditions with optimum route choice and associated response mode.

GRIP for three different traffic conditions		Optimum route choice	Associated response mode
		Driving straight	Press right pedal
		Turn left	Turn the wheel to left
		Turn right	Turn the wheel to right

tination. Distinct response modes were used to match the optimum route choice for different traffic conditions. Table 2 shows examples of the GRIP for three different traffic conditions with optimum route choice and associated response modes. Each participant went through a total of 18 randomized GRIP presentations (that is, 3 changeable information × 2 road network type × 3 different traffic GRIPs) in each test.

2.2. Material

The stimuli used in this study were composed of a sequence of computer-generated GRIP merged with a real drivers' view video. The driving videos were taken with a Sony VDCRTRV70 digital video camcorder mounted on a tripod and leveled at driver's eye height inside a 2006 Toyota Camry traveling at 100 km/h through a three-lane segment of National Freeway No. 3 in central Taiwan at about 2:00 p.m. on a sunny day in September 2008. The GRIP sign used green for the background color, red for heavy congestion road section, yellow for light congestion section, and black for normal conditions. The color coded level of service traffic information for the road network was in accordance with the definition of real-time traffic information of Taiwan Area National Freeway Bureau (TANFB, 2008). Average traffic speed under 40 km/h is regarded as heavy congestion, 40–80 km/h as light congestion, and above 80 km/h as normal condition. To make a fair comparison, the distance between two nodes on road network was assumed and designed to be equal. Journey time was calculated from the distance divided by traffic speed.

Each GRIP sign had varying levels of complexity, which could be subjectively classified in terms of information units (Dudek and Ullman, 2002). The information unit refers to each separate data item given in a message which a motorist could use to make a decision (Dudek and Huchingson, 1986; Dudek, 1992). For example, the GRIP sign for triangle road network with road color only shown in Table 1 contains 2 destinations, 3 interchange nodes, 3 road routes, and 4 road colors. Hence, the sign consisted of 12 information units. The amount of information units for each GRIP under combination of changeable information content and road network type is showed in Table 1.

The GRIP stimuli were introduced to appear on the central lane in a random but controlled manner. It would initially appear at the far end of the video as a small dot as seen in actual driving. The time interval allowed for each GRIP presentation was 20 s. Fig. 1 is an example of the GRIP for tetragon network merged with the scene of the driving environment.

2.3. Participants

32 university students (16 female and 16 male) who were between 20 and 29 years old ($M = 24.5$, $SD = 2.2$) participated in the experiment. All had 0.8 corrected visual acuity or better and normal color vision. Each participant had a valid driver's license and driving experience on freeway for 1 year at least. They were paid for their participation.

2.4. Apparatus and conditions of workplace

A Topcon Screenscope SS-3 was used to test participants' visual acuity and color vision. An Intel Pentium 3.0 GHz PC with 2 GB RAM was used to process the experimental task program for the participants. A Microsoft side winder force feedback wheel, replacing the steering wheel, was installed in front of the driver's seat of a

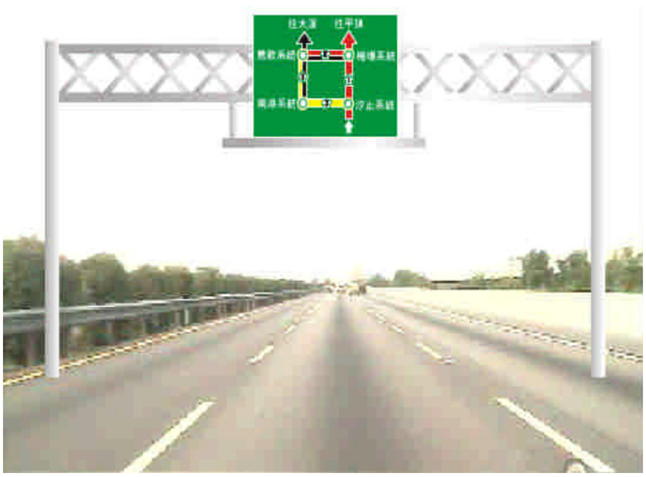


Fig. 1. An example of the GRIP for tetragon network merged with the scene of the driving environment.

refitted used car in the ergonomic laboratory. Computer-generated GRIP merged with a driver's view video was projected onto a screen (149 cm wide × 200 cm high) in front of the test vehicle through a MITSUBISHI XL9U projector. The distance between participant and screen was 350 cm. The illumination was about 300 lx which tested at participant's seat and 500 lx at screen. Fig. 2 shows the experimental task configuration.

2.5. Task and procedure

A test participant, sitting in the driver's seat of a refitted used car, would see the driving video on the screen with GRIP stimuli appearing on central road lane gradually increasing in size. Before the presentation of GRIP stimuli, an instruction message related to a given destination would appear with 5 s duration. Participants were asked to choose the fastest route from the source to a given destination. It is assumed that a motorist would ultimately choose the route to reach a given destination on the road network as quickly as possible. Each participant was instructed to respond by turning the steering wheel with his or her hand or by pressing the pedal with foot according to the associated response mode shown in Table 2 to signify her or his route choice for a specific GRIP message during each trial. After a response was made, the GRIP stimuli disappeared, and a random time lapse between 0 and 15 s was introduced to avoid the expectation of stimulus presentation. Then the next instruction and stimuli appeared. The computer recorded the participants' response mode and compared it to the associated mode. If the response mode was consistent with the associated mode, the response was regarded as optimum route choice. Participants' route choices and response times were recorded by the computer automatically.

Before starting the experiment, each participant was briefed on the purpose, task and procedures of the experiment. They were also asked to read an instruction about the meaning of each GRIP sign to make sure that they did understand the meaning of the sign. A warm up session was then performed to familiarize participants with GRIP information and response task. With the participants' consent, the actual experiment began. The complete experiment took about half an hour. To prevent visual fatigue, participants were asked not to do any reading tasks for an hour before the experiment.

2.6. Dependent measures and data analysis

The dependent measures collected in this experiment were response time and optimum route choice percentage. Response time was the time between the start of presentation of a GRIP stimuli and the moment of a participant's response to the information of the GRIP. Optimum route choice percentage was 100 times the number of optimum responses divided by the total number of responses. The optimum response is the fastest route choice among all alternatives on a GRIP.

Repeated measures analysis of variances (ANOVA) was conducted for each of the two dependent measures. The factors that were significant were further analyzed using the Bonferroni multiple comparison procedures to discuss the differences among the factor levels. Before the analysis of variance, the Kolmogorov–Smirnov test was conducted to examine the normality of the dependent variables. Because of the characteristics of the optimum route choice percentage, the arcsine transformation of this measure was conducted and then ANOVA was used (Kutner et al., 2005). All results are reported at significance level of 0.05. If the effect was significant, the *p*-value is provided. The statistical analyses were performed using the Statistical Package for the Social Science (SPSS).

3. Results

3.1. Response time

The distribution of response time for each treatment was found to follow a normal distribution by using the Kolmogorov–Smirnov test. Results of the analysis of variances for response time indicated that content of changeable information was significant ($F(2, 62) = 17.732$, $p < 0.001$). Post hoc pair-wise comparisons using the Bonferroni procedures indicated that participants had significantly less response time for road color only (15.085 s) than for road color with journey time (16.238 s) and road color with traffic speed (16.337 s). No difference was observed between road color with

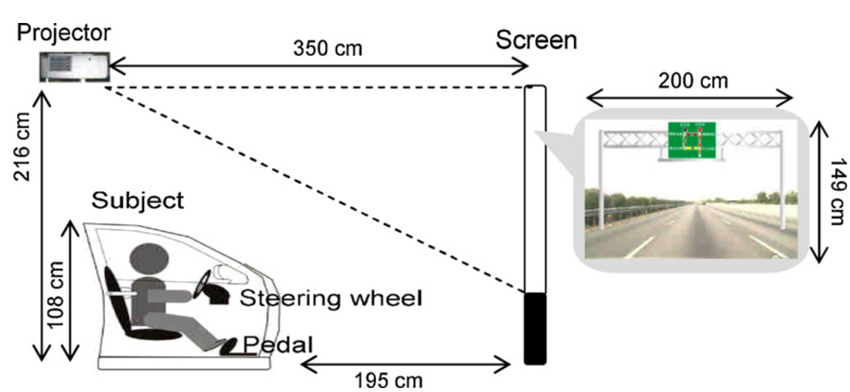


Fig. 2. The experimental task configuration.

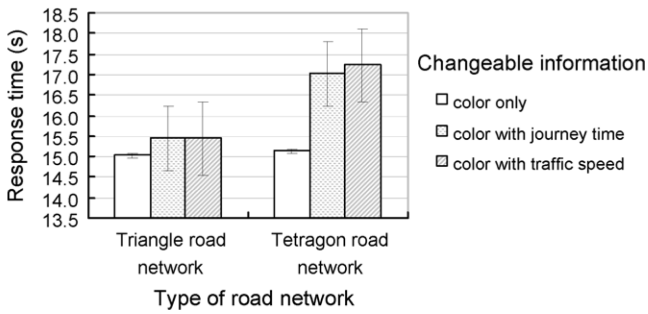


Fig. 3. Mean response times (with standard error bar) by changeable information content under each type of road network.

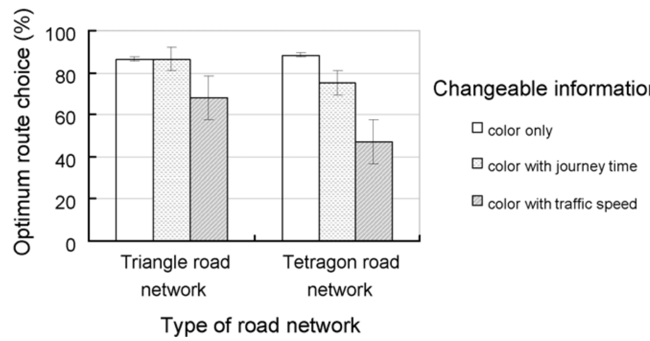


Fig. 4. Mean optimum route choice percentages (with standard error bar) by changeable information content under each type of road network.

traffic speed and road color with journey time. The type of road network was also significant ($F(1, 31) = 59.74$, $p < 0.001$). Participants responded more quickly for triangle network (15.308 s) than for tetragon network (16.465 s).

The interaction of content of changeable information and type of road network was significant for response time ($F(2, 62) = 11.430$, $p < 0.001$). Fig. 3 showed that response times under combination of road network type and changeable information content. The simple effects for each level of the two dependent variables were separately analyzed. The results indicated no significant difference for the changeable information content when the road network type was triangle. However, there were significant differences for changeable information content when the road network type was tetragon ($F(2, 31) = 19.008$, $p < 0.001$). Response time for road color only (15.138 s) was shorter than those for road color with journey time (17.025 s) and road color with traffic speed (17.231 s). The simple effect analysis also indicated that response times for the road type were significant when the information was color with journey time ($F(1, 31) = 54.676$, $p < 0.001$) and road color with traffic speed ($F(1, 31) = 36.145$, $p < 0.001$). Response time for triangle road type was shorter than for tetragon road type when the information content were color with journey time and color with traffic speed. There was no significant difference for the road network type when the information content was road color only.

3.2. Optimum route choice percentage

Analysis of variances showed that content of changeable information had significant difference on optimum route choice percentage ($F(2, 62) = 36.327$, $p < 0.001$). Multiple comparisons using the Bonferroni procedures demonstrated that participants had the greatest optimum route choice percentage for road color only (87.58%), with that of road color with journey time the next (80.73%) and road color with traffic speed the least (57.29%). There was also significant difference for road network type ($F(1, 31) = 10.493$, $p < 0.01$). Participants responded more correctly for triangle road network (80.2%) than for tetragon road network (70.1%).

A significant interaction between content of changeable information and type of road network was observed for optimum route choice percentage ($F(2, 62) = 5.857$, $p < 0.01$) as shown in Fig. 4. Analysis of the simple effect indicated that there was significant effect for the changeable information content under each road network type. Optimum route choice percentage for road color with traffic speed (67.71%) was less than road color only (86.46%) and road color with journey time (86.46%) when the road network type was triangle ($F(2, 62) = 14.291$, $p < 0.01$). When the road network type was tetragon ($F(2, 62) = 37.440$, $p < 0.001$), optimum route choice percentages for road color only was the greatest (88.54%), with that of road color with journey time the next (75%), and road color with traffic speed the least (46.87%). The results also indicated that optimum route choice percentage for the road type were significant when the information content was color with journey time ($F(1, 31) = 4.189$, $p < 0.05$) and color with traffic speed ($F(1, 31) = 20.1$, $p < 0.01$). Optimum route choice percentage for triangle road type was more than for tetragon road type. There was no significant difference for the road network type when the information content was color only.

4. Discussion

The main objective of this study was to examine drivers' comprehension of traffic information on graphical route information panels. Results showed that content of changeable information significantly affected participants' response time and optimum route choice percentage. GRIP with road color only had the most optimum route choice percentage and the fastest response time compared to the other contents of changeable information. On the contrary, GRIP with traffic speed had the least optimum route choice percentage and the slowest response time.

Comprehension and information units for changeable information on GRIP may explain some of these effects found. Comprehension is a critical step of the six information-processing steps that should result in a change of attitude for traveler (McGuire, 1968). Legibility and comprehensibility are the key cognitive ergonomic guidelines which could influence the comprehension of the travel information (Matthijs and Brookhuis, 2008). Legibility determines how easy a sign can be read. Comprehensibility refers to how easily the traveler can understand the displayed information. Key questions concerning comprehensibility include whether the message is meaningful, correctly understand, interpreted unambiguously, and whether the driver responds to it cognitively in the intended manner (Lay, 2004). The colors used as traffic signs have their own specific meaning in transport. For example, red is the "danger" color, yellow is often used as the "warning" color, and green is used to indicate "safety" or "things are in order" (Lai, 2008). In this study, road color only for content of changeable information had the fastest response time and the most optimum route choice percentage. It implied the use of color only to indicate position and severity of congestion can enhances the legibility and comprehensibility of GRIP. The color immediate makes clear that there is a deviation from a normal situation. Participants could comprehend the meaning with color code only intuitively and respond right away. However, legibility for the text with road color with journey time and road color with traffic speed is less than for the road color only. In addition to the comprehension, the amount of information units could contribute to the effects. According to Table 1, an increase in the message and complexity presented on GRIP would increase the amounts of information units. The mean information unit for road color only (14.5 units) was less than for road color with journey time (19.5 units) and road color with traffic speed

(19.5 units). Participants should need further calculation and interpretation of the GRIP information for road color with journey time and road color with traffic speed to decide their route choice.

Furthermore, results of this study confirmed the argumentation by Matthijs and Brookhuis (2008). They argued that social psychological principles and processes may also have an effect during information-processing steps of travel information. According to the elaboration likelihood model (Petty and Cacippo, 1986), travel information can be processed via central or peripheral route. The central route is accommodated by providing relevant information on journey time and traffic speed in the present study. In order to accomplish a change in behavior the driver should have the possibility to take time to calculate and translate, i.e., to elaborate on this information and subsequently make a choice. The peripheral route may be supported by providing the information on road color only that can be processed quickly during traffic conditions. For example, using the color red on a GRIP to indicate location and severity of congestion indicating that other routes may be better to travel, or using the black to indicate that a route is not congested and as a result is advised to travel.

The results also showed that participants had faster response time for triangle road network than for tetragon road network. Significantly more optimum route choice decisions were taken for the less complex network. The results are consistent with the previous research findings of Tsavachidis et al. (2000) and Richards et al. (2005). Their study found that the less complex motorway designs of travel information were well understood and could be considered an applicable solution. Many studies found that complicated figures degraded human performance (Curry et al., 1998; Dewar, 1999). Road network complexity and amount of information units could explain the effects. The main indicator for network complexity is the number of the graphical and informational elements displayed. There are basic difference in the type of road network and number of information units, which clearly influence the comprehension and response for the information of GRIP. The basic principle of information theory points out that choice reaction is a linear function of stimulus information (Hyman, 1953). Assuming that the information on a sign can be read and understood, it is likely that a sign with a greater quantity of information will result in more drivers reacting to the information. In this study, the amount of information units for the triangle road network is less than for the tetragon road network for each level of content of changeable information (see Table 1). Participants should interpret and respond to the information for the triangle road network more quickly and correctly.

However, the most important finding of this study was that there were significant interactions between changeable information content and road network type on participants' response time and optimum route choice percentage. With respect to response time, there was no significant difference for the changeable information contents when the road network type was triangle. When the road network type was tetragon, response time for road color only was shorter than those for road color with traffic speed and road color with journey time (see Fig. 3). With respect to optimum route choice percentage, road color with traffic speed was less than road color only and road color with journey time when road network type was triangle. When the road network type was tetragon, road color only was the greatest, with that of journey time the next, and traffic speed the least (see Fig. 4). The interaction also indicated that complexity of the road type has an effect when the content includes color with traffic speed or color with journey time on response time and optimum choice percentage but not solely road color. Both response time and optimum choice percentage for triangle road type were better than for tetragon road type when the information contents were color with journey time and color with traffic speed.

The interaction results confirm the expectations of Alkim et al. (2000). They expected that the effects of congestion information on GRIP will be limited under complex conditions. The category and number of information displayed could be the main factors for the effects (Tsavachidis et al., 2000). As can be seen from Table 1, the information units are systematically increased from road color only through road color with journey time and traffic speed under each road network type. Response time increased greatly for GRIP signs with 23 information units which represent road color with journey time and road color with traffic speed under tetragon road network (see Fig. 3). Optimum route choice percentage also decreased rapidly for GRIP with 23 information units (see Fig. 4). On the contrary, the information unit for road color only under tetragon network is 17. The difference of information units (6 units) could be the factor that resulted in the superiority for participants to comprehend and respond under the use of road color only. However, when the road type was triangle, there was less difference of information unit (4 units) between road color and color with journey time and color with traffic speed, the superiority for road color only was not significant. Here the implication is that the superior effects of road color only could not be found if the differences of information units between GRIP signs are not larger enough. In summary, using color code only for traffic condition has superior effects for more complex road network. Road color with journey time and road color with traffic speed were not suited for complicated GRIP signs. When the road network was simple, road color only or road color with journey time was recommended except road color with traffic speed.

The research will promote a better understanding about the design of traffic information displayed on GRIP in the human/intelligent transportation system interface issues. However, there are a few limitations to the current study. Firstly, this study was conducted in a laboratory setting. Participants were asked to respond to a pre-recorder driving video without interaction with real traffic. The circumstance allowed the test participants to put their best effort in the GRIP task, where in real-world driving, frequently drivers must pay attention to more than one task. Secondly, the present study did not ask participants to report their reactions and perceptions to the different types of information. It is difficult to infer how participants reacted to the different GRIPs. The issue which needs to be investigated in the future research. Thirdly, the response time used in the study is not the same as the reading time which the time that it actually takes a driver to read a GRIP message. It is more than the available reading time to a motorist in the study. Another limitations worth noting include: (a) the use of college students that are not representative of the general population, (b) there are possible effects of language and culture in how participants responded, and (c) a short testing period that may produce different results than when participants have the opportunity for extensive practice. The application of the results should be taken with care because the limitations.

5. Conclusions

This study examined drivers' comprehension of traffic information on graphical route information panels. The main effects showed that GRIP with road color only had the greatest optimum route choice percentage and the fastest response time compared to the other contents. Participants took less response time and greater optimum route choice percentage for triangle road network than for tetragon road network. Changeable information content interacted with road network type on response time and optimum road choice percentage. Overall the results indicated that the less complex designs for GRIP were well understood and could be considered an applicable solution. It should be expected that the effectiveness of traffic information on GRIP will be limited under complex conditions. Considering drivers' comprehension and response, a road network that is displayed graphically must be simple as well as recognizable. Using road color only to present traffic condition on GRIP may be a suitable method. Road color with traffic speed had the greatest response time and the least optimum route choice percentage. It was not recommended to display traffic speed on a GRIP. Road color with journey time can be used for a simple road network. However, it was not suggested for a complex road network.

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