Journal of Information Systems Engineering and Management
2025, 10(32s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Variable Message Signs (VMS) for Road Safety: The Combination of Message Framing and Colour Priming and on the Effectiveness of Seat Belt Usage Campaign

Ardita Puspa Maulida [1], Samantha Jamson [2], Martha Leni Siregar [3*], Alifia Nisrina R [4]

[1] *Department of Civil and Environmental Engineering, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia. Email: ardita.puspa@ui.ac.id*

[2] *Scholar, Department of Transport, Faculty of Environment, University of Leeds, Leeds, United Kingdom. Email: s.l.jamson@its.leeds.ac.uk*

[3] *Scholar, Department of Civil and Environmental Engineering, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia. Email: leni@eng.ui.ac.id*

[4] *Department of Civil and Environmental Engineering, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia. Email: alifia.nisrina@ui.ac.id*

ARTICLE INFO

Received: 31 Dec 2024

Revised: 20 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

Utilising Variable Message Signs (VMS) for road safety campaigns, beyond their primary role of displaying traffic conditions, can contribute significantly to achieving Sustainable Development Goals (SDG) 11: Sustainable Cities and Communities. A notably high percentage of driver fatalities occur due to the failure to wear a seat belt, which prompted this study to investigate the effectiveness of VMS in Leeds. This research, which had not previously been conducted, explored the impact of pairing message framing and colour priming to encourage seat belt use. This study was conducted using an online questionnaire-based experiment, with four groups of participants based on the combination of positive vs. negative framing and red vs. blue priming. The results revealed that knowledge significantly influenced message recall and contradictory combinations like negative framing with red were found effective. This combination enhanced recall and heightened participants' perceived efficacy regarding seat belt use, potentially reducing severe injuries and fatalities, aligning with the goals of SDG 11.

Keywords: Colour Priming, Message Framing, SDG, VMS.

INTRODUCTION

Although VMS primarily acts as a messaging platform connecting road users and transport authorities by delivering live updates on traffic and road situations, it may also serve to promote road safety campaigns, ensuring it remains effectively used when no urgent traffic updates are needed. In 2022, one in five car occupant deaths in Great Britain involved individuals who were not wearing seatbelts, highlighting seat belt use as a crucial road safety issue that needs to be emphasised [1].

Two approaches for designing communications that shape how individuals interpret and react to information are message framing and colour priming. Message framing emphasises a narrative with either a positive tone or negative tone, while colour priming involves using specific colours to create particular associations. Because of their different emotional impacts, red and blue are commonly compared in study; blue, which is cooler, usually has to do with tranquilly, while red, which is warmer, is regularly linked to awareness. Previous studies have shown that these approaches are commonly combined in domains such as advertisement and public health promotion [2], [3].

Approximately 45 VMS in Leeds, managed by Leeds City Council (LCC), have yet to be assessed for their effectiveness in conveying safety campaign messages. To adress these gaps, this research which has purpose to assess the impact of road safety campaign through VMS in Leeds, established the subsequent research questions:

1. Despite differences in design (the combination), do factors such as socio-demographics, travel habits, attitudes towards VMS, and understanding of UK seat belt regulations affect road users' ability to remember the content displayed on VMS?
2. What is the relationship, and how does the pairings of colour priming and message framing approaches benefit in recollecting buckle up campaign on VMS?
3. What is the impact of combining colour priming and message framing in the seat belt campaign via VMS on road users' immediate reactions, perceived efficacy, and behavioural intentions?

LITERATURE REVIEW

Several elements can affect driver reaction to VMS messages, including the message's substance and presentation style [4]. Framing involves a strategic design of information presentation to enable individuals to grasp, analyse, and classify the data [5], [6]. Priming involves a technique of employing a stimulant to influence later responses [7].

Chaurand, et al. [8] revealed that positively framed messages were more effective in decreasing speed than negatively framed messages. They recommended employing positively framed messages for preventative programs, especially in the absence of significant risk factors. Conversely, using messages which contain humorous or unpleasant feelings (such melancholy, anxiety, or menace) that aim to arouse emotions is the most efficient method of altering behaviour [9].

When performing Critical Race Theory (CRT) reading task, Matthews [10] discovered that the inappropriate application of colour can result in diminished performance and a heightened incidence of visual discomfort. Colour is an effective way of communicating ideas to the brain of a person, and it is regularly found to significantly enhance memory function [11]. Despite the fact that this study is predominantly focused on business and wellness, multiple research studies have additionally shown the effectiveness of colour priming in influencing behavioural changes. However, it remains infrequently employed in road safety. For instance, numerous restaurants implement red hues due to their conviction that they can stimulate customers' appetites [12]. The different characteristics of red and blue are frequently used as a basis for research contrast, as red has long wavelengths and blue has short wavelengths [13], [14].

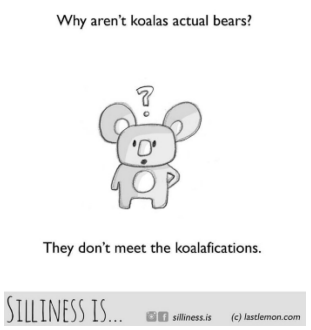
Approach or avoidance motivation can help to indirectly link message frames with colours [3]. For example, the participants' behavioural desire to apply sunscreen were raised by the use of a booklet featuring blue colour paired with a positive message [14]. Because red is linked to fear and goes better with negative messaging, this pairing substantially increased the intention of participants to get the HPV vaccine [15]. Previous research on pairing these two techniques is primarily located in the disciplines of wellness and commercials, as has been stated. However, to the greatest extent of the writer's understanding, nothing of this kind has been conducted in the field of road safety. Consequently, to improve upon this underexplored aspect in the existing studies, the purpose of this research is to examine the efficacy of these pairings in VMS messages, with a particular emphasis on their influence on recall and the behavioural intentions of road users.

METHODOLOGY

This research involved conducting an online test utilising a questionnaire to gather data. 222 respondents were categorised into four teams according to the pairings of colours (red vs. blue) and message frames (positive vs. negative) in a between-subjects design. Consequently, there were four distinct questionnaires which were: red-positive, red-negative, blue-positive, and blue-negative. Parts 1–5 of each questionnaire had the same questions, while parts 6 and 7 had different queries. The primary questionnaire included a total of 41 questions, excluding distraction items depicted in Table .

Table 1: Example of the Distraction

Trivia Question	Where does koala come from? a. India b. Canada c. Australia

Humorous Pun	

The details of each part are outlined below:

1. Part 1 - Characteristics of the respondents

Enquiries regarding age, gender, and ownership of a driving licence;

2. Part 2 - Aspects of travel

Enquiries about regular choices for travel, typical daily journeys, and regular journey duration;

3. Part 3 - Perceptions of VMS

Respondents rated their attention to various types of messages displayed on VMS which scaled 1 (never) – 7 (always). The types of messages included information regarding incident, weather-related occurrence, road diversion, road work, and safety driving;

4. Part 4 – Familiarity with the UK seat belt regulations

To measure participants' understanding of the regulations as well as awareness of punishments associated with seat belt usage in the UK;

5. Part 5 - Seat belt wearing habits

Seat belt wearing habits are measured using a scale based on seven Likert points. Respondents who answered 'seven,' signifying consistent seat belt use, were subsequently asked about their motivations for this behavior. Individuals who infrequently utilised seat belts were surveyed regarding their main obstacles to compliance and potential motivators for increased usage.

6. Part 6 – Memory test

Depending on the pairing type, this part is different for positive-red, positive-blue, negative- red, and negative-blue messages. The pairs demonstrated the message styles that were seen in a brief clip within the test. Following each of the 4 clips containing messages, 4 queries were posed, as shown in *Table* arranged by group type. The chosen text colours were displayed on a black background in the clips, which were intended to replicate VMS. The concept complied to the rules set forth by Leeds City Council (LCC), which stipulated that there must be no more than 4 rows each panel and no more than 15 characters each line.

While the positively framed contents were adapted from the existing VMS style of LCC and result from a research carried out in Virginia, the negatively framed contents made use of data on statistics from the Department for Transport [9], [16]. Meanwhile Table presents a distraction introduced between the messages and the questions to replicate a real driving environment.

7. Part 7 – Intent-to-act test

This part re-displayed four previous messages, again based on the pairing set, which were presented simultaneously on a single screen. Subsequently, participants were presented with a series of further enquiries to evaluate their behaviour:

a. Immediate Response: Participants were queried regarding their level of fear associated with not buckling up. The answer option utilised a 7-point Likert scale, with responses that ranged from 1 (not at all) – 7 (extremely).

b. Perceived Efficacy: Participants' perceived efficacy of buckling up was assessed by enquiring the likelihood of sustaining major injury would be affected by buckling up. It was evaluated using a 7-point Likert scale, from "decrease dramatically" (-3) to "increase dramatically" (3), and a midpoint of 0 indicating "remain unchanged".

c. Behavioural Intentions: Respondents' behavioural intentions were evaluated by asking the future action to buckle up. The assessment utilised a 7-point Likert scale, with responses 1 (never) – 7 (always).

Table 2: Experiment Message Designs

The Experiment Messages	Questions	The Experiment Messages	Questions
Negative-Red		**Negative-Blue**	
	What is the number of deaths involving unbelted passengers?*		*
	30% of those who died unbelted are**		**
	What is the number of drivers deaths involving unbelted passengers?***		***
	Who experience four weekly injuries in traffic accidents due to the absence of seatbelt use?****		****
Positive-Red		**Positive-Blue**	
	how expensive could it be to not buckle up?*****		*****
	Where could we survive by wearing a seatbelt?******		******
	Who could you be able to meet if you wear your seatbelt?*******		*******
	Who needs to be buckled up for a safer tomorrow?********		********

JISC Online Surveys was employed to create the four question sheet designs. Subsequently, QR codes were implemented for each question sheet to enhance accessibility. Posters which featured links and barcodes, were made for each question sheet design and subsequently disseminated through private outreach methods and social media, including LinkedIn and Twitter. Ordinal logistic regression was utilised to solve research questions 1 and 2, while one-way ANOVA was applied to investigate research question 3.

RESULTS

Factors Affecting Message Recall among Road Users

To investigate the influence of several factors, which includes characteristics of the respondents (age, gender, ownership of a driving licence), aspects of travel, perceptions of VMS, and familiarity with the UK seat belt regulations, on message recollection ability, an ordinal logistic regression was applied. Against which these elements

were observed, the recollection test point—which varied from zero to four accurate answers—was the dependent variable for this study.

The findings in Table 3 demonstrated that 'knowledge' significantly influenced message recollection. The results indicate that respondents with a richer grasp of buckling up regulations in the UK, reflected by greater results, are about 1.43 times more probable to recollect the information. Conversely, the other variables exhibited no significant impact on the dependent variable ($p > 0.05$).

Table 3: Parameter Estimates

	B	**S.E.**	**Wald**	**df**	**Sig.**	**EXP(B)**	**95% C.I. for EXP(B)**	
							Lower	**Upper**
Attitude	-0.084	0.095	0.774	1	0.324	0.92	-0.27	0.103
Knowledge	0.355	0.092	14.782	1	**<.001***	**1.43**	0.174	0.537
Age								
18-24	0.384	0.609	0.399	1	0.528	1.47	-0.809	1.577
25-34	0.356	0.54	0.435	1	0.509	1.43	-0.702	1.414
35-44	0.736	0.59	1.556	1	0.212	2.09	-0.42	1.892
≥45								
Gender								
Male	0.736	0.866	0.722	1	0.396	2.09	-0.962	2.433
Female	0.49	0.867	0.319	1	0.572	1.63	-1.209	2.188
Non-binary								
Driving License								
0-9	-0.059	0.457	0.017	1	0.898	0.94	-0.953	0.836
10-19	-0.119	0.465	0.066	1	0.798	0.89	-1.031	0.792
≥20	0.102	0.542	0.035	1	0.851	1.11	-0.961	1.165
Do not have								
Travel as								
Car driver	-0.513	0.347	2.183	1	0.14	0.6	-1.194	0.168
Car passenger	-0.26	0.387	0.451	1	0.502	0.77	-1.017	0.498
cyclist	-0.735	0.513	2.053	1	0.152	0.48	-1.742	0.271
Pedestrian	-0.068	0.418	0.026	1	0.871	0.93	-0.886	0.751
PT passenger								
Average Trip								
1-2	0.308	0.566	0.297	1	0.586	1.36	-0.8	1.417
3-4	-0.285	0.622	0.209	1	0.648	0.75	-1.504	0.935
>4								
Travel time								
<20	0.728	0.429	2.876	1	0.09	2.07	-0.113	1.57
20-40	0.462	0.355	1.698	1	0.193	1.59	-0.233	1.157
40-60	0.267	0.447	0.356	1	0.551	1.3	-0.61	1.144
>60								

The Pairing of Message Framing and Color Priming Approaches Benefits Message Recollection

The predictors or independent variables used to answer the second research question were the pairings involving negatively framed message with red text, positively framed message with red text, negatively framed message with blue text, and positively framed message with blue text. The impact of the pairings on the ability to recollect messages was assessed by evaluating them against the message recollect test result (score 0 - 4), which acted as the dependent variable. An ordinal logistic regression analysis was employed for this purpose.

Table 4: Parameter Estimates

	B	S.E.	Wald	df	Sig.	Odds Ratio	95% C.I. for EXP(B)	
							Lower	Upper
Red_Negative	0.061	0.334	0.034	1	0.854	1.063	-0.594	0.717
Red_Positive	1.163	0.331	12.323	1	<.001*	3.199	0.514	1.812
Blue_Negative	0.076	0.334	0.052	1	0.82	1.079	-0.579	0.731
Blue_Positive	0[a]			0				

Link function: Logit.

This parameter is set to zero because it is redundant

H0 = The dependent variable is significantly influenced.

H1 = The dependent variable is not significantly influenced.

The pairing of blue-positive messages acts as the baseline or reference category as illustrated in Table 4. The results demonstrated that the red-positive combination significantly influenced message recollection, with a likelihood of 3.199 times greater than that of the blue-positive group. It is further supported by the subsequent result. A parameter estimate is deemed statistically significant when its confidence interval (CI) excludes or does not intersect zero (0) which is satisfied by the positive-red group, signifying a significant impact on message recollection. Conversely, the other combinations did not significantly affect message recall.

The Impact of Combining Colour Priming and Message Framing on the Immediate Reactions, Perceived Efficacy, and Behavioural Intentions of Road Users

To explore the last research question, colour priming (red or blue) and message framing (positive or negative) were utilised as independent variables. Respondents' behaviour was examined as the dependent variable, divided into immediate effect, perceived efficacy, and behavioural intention. To analyse the variations in respondents' behaviour as influenced by the specific pairings, a one-way ANOVA test was conducted. The findings are outlined below.

Immediate Effect

Table 5: ANOVA test for Immadiate Effect

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.953	3	1.651	.674	.569

H0= The 4 groups in the pairing exhibit no differences

H1= The 4 groups in the pairing exhibit a difference.

The ANOVA results presented in Table 5 indicate insignificant differences in respondents' immediate effects among the combinations ($F(3,218) = 0.674$, $p = 0.569$). In conclusion, the evidence does not indicate a distinction in respondents' immediate reactions across the variations.

Perceived Efficacy

Table 6: ANOVA for Perceived Efficacy

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	93.802	3	31.267	5.152	.002

H0= The 4 groups in the combination exhibit no differences

H1= The 4 groups in the combination exhibit a difference

Utilising one-way ANOVA, the combinations were employed as independent variables or predictors, were evaluated against perceived efficacy. The ANOVA results in Table 6 indicated a statistically significant disparity in the perceived efficacy of participants across the combinations ($F(3,218) = 5.152$, $p = 0.002$). This indicates that the interaction between colour priming and message framing notably affected respondents' perceptions of seat belt efficacy. A post hoc test was performed to ascertain which specific groups exhibit substantial differences.

Table 7: Tukey Test for Perceived Efficecy

(I) Pairing	(J) Pairing	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Blue_Negative	Red_Negative	-1.260	.493	.054	-2.54	.02
	Red_Positive	.348	.475	.885	-.88	1.58
	Blue_Positive	-.917	.465	.201	-2.12	.29
Red_Negative	Red_Positive	1.608*	.475	.005	.38	2.84
	Blue_Negative	1.260	.493	.054	-.02	2.54
	Blue_Positive	.343	.465	.882	-.86	1.55
Blue_Positive	Red_Negative	-.342	.465	.882	-1.55	.86
	Red_Positive	1.265*	.447	.026	.11	2.42
	Blue_Negative	.918	.465	.201	-.29	2.12
Red_Positive	Red_Negative	-1.608*	.475	.005	-2.84	-.38
	Blue_Negative	-.343	.475	.885	-1.58	.88
	Blue_Positive	-1.265*	.447	.026	-2.42	-.11

H0 = The averages of the two pairings under comparison are identical.

H1 = The averages of the two pairings under comparison differ.

Tukey's HSD test was utilised for post hoc comparisons to analyse pairwise group differences and identify significant variations. Table 7 shows significant disparity ($p<0.05$) among group averages. The average test score for the red-negative group ($M = 0.78$) was notably greater than that of the red-positive group ($M = -0.83$), with a average disparity of 1.608 ($p = 0.005$). This suggests that respondents in the red-negative group believed buckling up would considerably increase the likelihood of getting serious injury, while those in the red-positive group held the contrary view. The blue-positive group ($M = 0.44$) exhibited a significant difference from the red-positive group ($M = -0.83$), resulting in an average disparity of 1.265 ($p = 0.026$). This suggests that respondents in the blue-positive group perceived that buckling up would elevate the likelihood of major injury, whereas those in the red-positive group believed it would reduce that likelihood.

Behavioural Intention

Table 8: ANOVA for Behaviour Intention

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.180	3	1.727	.969	.408

H0= The 4 groups in the combination exhibit no differences

H1= The 4 groups in the combination exhibit a difference

Table 8 presents the ANOVA test results ($F(3,218) = 0.969$, $p = 0.408$), indicating a lack of statistically significant evidence for differences in behavioural intention across the various pairings of colour priming and message framing among respondents.

DISCUSSION

Factors Affecting Message Recall among Road Users

The analysis demonstrated that 'knowledge' significantly contributed to the prediction of message recall ability. Participants possessing a higher level of knowledge regarding UK seat belt regulations, indicated by elevated test scores, demonstrated a 1.43-time increase in the likelihood of recollecting the VMS content they saw.

This result is consistent with prior studies indicating that people tend to recollect information that relates to existing knowledge more effectively than entirely novel news [17], [18], [19], [20]. For example, Hemmer, et al. [21] demonstrated in their experiment that general prior knowledge regarding gender-related height differences affected the ability to recollect individual heights. A research examining recollection ability between novel stimuli (artificial shapes) and naturalistic stimuli (fruits and vegetables) found that the greater familiarility naturalistic stimuli were recollected with greater precision than the shapes [18]. Previous research indicates that participants demonstrated enhanced recollection of information after viewing a segment of a video one day prior to the recollect test [22]. Similarly, in a research by Bransford and Johnson [23], respondents showed enhanced recollection for familiar essays in comparison to unfamiliar ones.

Conversely, some studies indicate that prior knowledge negatively impacts memory performance, demonstrating that information accompanied by prior knowledge results in greater recall errors compared to information without prior knowledge. Individuals may mistakenly recall seeing books in an office when none were present, influenced by their expectation that offices generally contain books [24]. Likewise, Underwood [25] discovered that preexisting information could lead to errors in recollecting terms associatively connected to previously presented terms.

The results presented in this study are consistent with the evidence from previous studies, which indicates that message recollection is substantially influenced by knowledge [26], [27], [28], [29]. Multiple research investigations indicate a significant relationship among driver education and better understanding of safe driving practices, a decline in unsafe driving behaviours, and a reduction in collisions and traffic violations [30], [31], [32]. Consequently, providing comprehensive traffic and driving education to road users continues to be important.

The Pairing of Message Framing and Color Priming Approaches Benefits Message Recollection

The statistical analysis indicated that positive-red messages significantly enhanced message recall. This pairing resulted in the highest recall rate, reaching 38%. Compared to positive-framed messages combined with blue-colored text, this combination had a 3.199-time higher recall rate (coefficient of 1.163).

In contrast to the conventional belief that negative emotions are more effective, this discovery is consistent with prior research, which indicates that respondents are more likely to remember messages better when they are associated with pleasant emotions [33], [34], [35].

According to a research by Gerend and Sias [15], the colour red was useful in drawing attention to their immunisation campaign. Although their results showed that the negatively-framed messages combined with red worked best, they noted that while red is commonly used as a warning symbol in some health-related contexts, it may not always arouse feelings of danger. According to Mehta and Zhu [36] individuals who were exposed to red were able to recall more accurate items than those who were exposed to blue, suggesting that red could improve recall task performance. Red

is the best colour to use in coloured VMS, according to another study, especially when showing crowded traffic times [37].

The results of this study deviate from previous research that has consistently shown the efficacy of the negative-red combination when these two approaches are combined. In order to generate interest in their vaccination campaign utilising pamphlets, Gerend and Sias [15] who were the initial researchers to pair the concepts of message framing with colour priming, found that negative-red pairings worked best.

The findings of this study show that the positive-red combination improved message recall more significantly. There are a number of reasons for this discrepancy. First, compared to other studies that focused mostly on male college students, the demographic makeup of the sample in this study was very different. On the other hand, a greater range of ages and genders were represented in this study. Second, unlike previous studies that used offline testing using pamphlets and binders, this study used an online questionnaire-based experimental design. Direct guidance was an option for the offline trials, which might have affected the internal validity of their findings.

Third, a different interpretation could be found in the particular context surrounding the use of the messages. Message recollection from reading a seat belt campaign conveyed by VMS was explicitly explored in this study, contrasting with earlier studies that mainly concentrated on health-related behaviours using pamphlets. The effectiveness of the message combinations may be impacted by differences in the effect of recall that are shown in various circumstances [38]. This offers a fresh viewpoint for future research and implies the need for more studies to examine the many restrictions and variances that can affect message recall. Despite these variations, the result emphasises the need for more research in this field and offers more proof of how crucial it is to take into account the unique circumstances of every road safety campaign when creating successful communication plans.

The Impact of Combining Colour Priming and Message Framing on the Immediate Reactions, Perceived Efficacy, and Behavioural Intentions of Road Users

The results showed that only perceived efficacy (the second behaviour evaluated) showed significant differences in the effects of combining colour priming and message framing. In particular, there were significant disparity between the pairings of red-positive and blue-positive (mean difference = 1.265, p = 0.026) and red-negative and red-positive (average disparity = 1.608, p = 0.005).

According to replies to the query "How would the chances of getting severe injury change when wearing a seat belt?" red-negative and red-positive pairings showed a substantial difference in perceived efficacy (see Table 18). The idea of buckling up would significantly reduce the risk of serious injury was more successfully enhanced by the positive-red combination. There was also a significant disparity between the pairings of positively framed messages with red colour and positively framed messages with blue colour in the way the positively framed messages with red colour group fostered this perception compared to the positively framed messages with blue colour group.

The effectiveness of the pairing of positively framed messages with red colour defies common belief that red, a colour usually connected to danger, activates risk aversion, vigilance, or avoidance motivation, which is more in line with negative framing [39], [40], [41]. Despite the contradiction, this research shows a new result that points to the possible effectiveness of pairing colour and contradicting message, especially when it comes to positive frame with red colour. This presents the opportunity for additional research to explore the ways in which apparently pairing opposed elements can continue to work in a mutual benefit in particular scenarios, such as road safety campaign.

The finding that pairing of positively framed message with red increases the perceived efficacy of buckling up is in contrast to prior research, despite the fact that these research findings also exhibit inconsistencies. One study, for instance, discovered that short-wavelength hues, such blue or purple, in conjunction with positive-framed messaging were more successful in encouraging sunscreen application behaviour [14]. Jiang, et al. [3] found that a negative message presented on a red background effectively enhanced non-intenders' coping appraisal regarding oral health. As a result, these inconsistencies could indicate that the effects of colour priming, and message framing are context dependent.

It is crucial to point out that self-reported measures of affect, efficacy, and behavioural intention were used in this study. Respondents may not consistently provide honest responses in surveys due to the influence of experimenter bias. This research evaluated behavioural intentions instead of actual driving behaviour. The respondent's absence of engagement in active driving or realistic driving surroundings during the testing period may have led to a reduced

connection to the messages, making it more challenging for them to relate to the risks of unbuckled up, as they were not immersed in real driving scenarios. Earlier studies have demonstrated a correlation between intentions and actual behaviour; however, forthcoming road safety research should specifically investigate real behaviour [42], [43]. This limitation emphasises the importance of conducting additional research in this field.

CONCLUSION

The results of this research demonstrate that the 'knowledge' variable had a significant influence on message recollection, revealing a positive association. The pairings of positively framed message with red significantly impacted on message recollection. Upon analysis of behavioural intentions, notable differences emerged solely from the interaction between message framing and colour priming regarding 'perceived efficacy'. Notable distinctions were observed between the pairings of negatively framed messages with red and positively framed messages with red, in addition to the differences between the pairings of positively framed messages with red and positively framed messages with blue. Respondents in the positively framed messages with red group reported a more significant decrease in the perceived risk of serious injury associated with buckle up than those in the negatively framed messages with red and positively framed messages with blue groups.

Although the findings run contrary to previous research, which frequently indicates that pairings of positively framed messages with blue or negatively framed messages with red work best, this research introduces a new finding. It implies that contrary pairings, such as positive framing used in conjunction with red, may be effective. This suggests that there is potential for further research into the potential synergy of these apparently opposing elements in specific contexts, such as road safety campaigns.

Leeds City Council may wish to implement this strategy for seat belt use campaigns via VMS in light of these observations. This method has the potential to improve recall, influence perceived efficacy, and ultimately contribute to the reduction of fatalities and severe injuries associated with seat belt non-use, which is consistent with the objectives of SDG 11, which are to establish sustainable cities and communities.

Acknowledgements

We thank Ardita Puspa Maulida, Samantha Jamson, Martha Leni Sinaga, and Alifia Nisrina for their contributions to this research. Special thanks to Universitas Indonesia and University of Leeds for their assistance and the Ministry of Transportation Republic of Indonesia for the financial support.

Funding Statement

This research was funded by a collaboration program between the Universitas Indonesia and the Ministry of Transportation's Human Resources in implementing the double degree program. In this collaboration, UI through the Department of Civil and Environmental Engineering, Faculty of Engineering, provides a post-graduate program in Civil Engineering for specialization in transportation. As for the foreign universities that will be addressed, the University of Leeds through the Institute for Transport Studies (ITS) which provides master's programs in various fields of transportation expertise.

Conflict of Interest

The authors declare that there is no conflict of interest.

REFERENCES

[1] Department for Transport. "Seatbelt and mobile phone use surveys: 2023." GOV.UK. https://www.gov.uk/government/statistics/seatbelt-and-mobile-phone-use-surveys-2023#:~:text=97.6%25%20of%20drivers%20were%20observed,compared%20with%2095.7%25%20for%20Scotland) (accessed 6th August, 2024).

[2] C. Hughes, "Seeing Colors: The Impact of Color Priming on Brand Perception," 2020. [Online]. Available: https://jayscholar.etown.edu/cgi/viewcontent.cgi?article=1009&context=busstu.

[3] T. Jiang, Q. Guo, X. Wu, and Y. Chi, "Combining gain-loss frame and background color to increase the effectiveness of online oral health messages: Differences among decision stages," International Journal of Medical Informatics, vol. 168, p. 104902, 2022/12/01/ 2022, doi: https://doi.org/10.1016/j.ijmedinf.2022.104902.

[4] V. Kwigizile et al., "Quantifying Effectiveness and Impacts of Digital Message Signs on Traffic Flow," (in English), Tech Report 2022. [Online]. Available: https://rosap.ntl.bts.gov/view/dot/62965.
[5] E. Goffman, Frame analysis: An essay on the organization of experience (Frame analysis: An essay on the organization of experience.). Cambridge, MA, US: Harvard University Press, 1974, pp. ix, 586-ix, 586.
[6] R. Entman, "Framing: Toward Clarification of A Fractured Paradigm," The Journal of Communication, vol. 43, pp. 51-58, 12/01 1993, doi: 10.1111/j.1460-2466.1993.tb01304.x.
[7] C. Hughes, "Seeing Colors: The Impact of Color Priming on Brand Perception," Business and the Elizabethtown College Honors Program, 2020.
[8] N. Chaurand, F. Bossart, and P. Delhomme, "A naturalistic study of the impact of message framing on highway speeding," Transportation Research Part F: Traffic Psychology and Behaviour, vol. 35, pp. 37-44, 2015/11/01/ 2015, doi: https://doi.org/10.1016/j.trf.2015.09.001.
[9] T. Shealy, P. Kryschtal, K. Franczek, and B. J. Katz, "Driver Response to Dynamic Message Sign Safety Campaign Messages," (in English), Tech Report 2020. [Online]. Available: https://rosap.ntl.bts.gov/view/dot/54604.
[10] M. L. Matthews, "The influence of colour on CRT reading performance and subjective comfort under operational conditions," (in eng), Appl Ergon, vol. 18, no. 4, pp. 323-8, Dec 1987, doi: 10.1016/0003-6870(87)90140-2.
[11] F. Wichmann, L. Sharpe, and K. Gegenfurtner, "The Contributions of Color to Recognition Memory for Natural Scenes," Journal of experimental psychology. Learning, memory, and cognition, vol. 28, pp. 509-20, 06/01 2002, doi: 10.1037//0278-7393.28.3.509.
[12] S. Singh, "Impact of color on marketing," Management Decision, vol. 44, pp. 783-789, 07/01 2006, doi: 10.1108/00251740610673332.
[13] A. E. Saïd, "Examining the relationships between online store atmospheric color, flow experience and consumer behavior," Journal of Retailing and Consumer Services, vol. 37, pp. 43-55, 2017/07/01/ 2017, doi: https://doi.org/10.1016/j.jretconser.2017.03.007.
[14] R. P. Voss Jr, R. Corser, M. McCormick, and J. D. Jasper, "Influencing health decision-making: A study of colour and message framing," Psychology & Health, vol. 33, no. 7, pp. 941-954, 2018/07/03 2018, doi: 10.1080/08870446.2018.1453509.
[15] M. A. Gerend and T. Sias, "Message framing and color priming: How subtle threat cues affect persuasion," Journal of Experimental Social Psychology, vol. 45, no. 4, pp. 999-1002, 2009/07/01/ 2009, doi: https://doi.org/10.1016/j.jesp.2009.04.002.
[16] Department for Transport, "Reported road casualties Great Britain, annual report: 2022," Department for Transport, 2023. [Online]. Available: https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-annual-report-2022/reported-road-casualties-great-britain-annual-report-2022
[17] T. Konkle and A. Oliva, "Normative representation of objects and scenes: Evidence from predictable biases in visual perception and memory," Journal of Vision, vol. 7, no. 9, pp. 1049-1049, 2007, doi: 10.1167/7.9.1049.
[18] P. Hemmer and M. Steyvers, "Integrating episodic memories and prior knowledge at multiple levels of abstraction," (in eng), Psychon Bull Rev, vol. 16, no. 1, pp. 80-7, Feb 2009, doi: 10.3758/pbr.16.1.80.
[19] J. Huttenlocher, L. V. Hedges, and S. Duncan, "Categories and particulars: prototype effects in estimating spatial location," (in eng), Psychol Rev, vol. 98, no. 3, pp. 352-76, Jul 1991, doi: 10.1037/0033-295x.98.3.352.
[20] F. C. Bartlett, Remembering: A study in experimental and social psychology (Remembering: A study in experimental and social psychology.). New York, NY, US: Cambridge University Press, 1932, pp. xix, 317-xix, 317.
[21] P. Hemmer, J. Shi, and M. Steyvers, "The Influence of Prior Knowledge on Recall for Height," 01/01 2010.
[22] M. T. Van Kesteren, G. Fernández, D. G. Norris, and E. J. Hermans, "Persistent schema-dependent hippocampal-neocortical connectivity during memory encoding and postencoding rest in humans," Proceedings of the National Academy of Sciences, vol. 107, no. 16, pp. 7550-7555, 2010.
[23] J. D. Bransford and M. K. Johnson, "Contextual prerequisites for understanding: Some investigations of comprehension and recall," Journal of Verbal Learning and Verbal Behavior, vol. 11, no. 6, pp. 717-726, 1972/12/01/ 1972, doi: https://doi.org/10.1016/S0022-5371(72)80006-9.
[24] W. F. Brewer and J. C. Treyens, "Role of schemata in memory for places," Cognitive Psychology, vol. 13, no. 2, pp. 207-230, 1981/04/01/ 1981, doi: https://doi.org/10.1016/0010-0285(81)90008-6.

[25] B. J. Underwood, "False recognition produced by implicit verbal responses," Journal of Experimental Psychology, vol. 70, no. 1, pp. 122-129, 1965, doi: 10.1037/h0022014.
[26] M. R. DeWitt, J. B. Knight, J. L. Hicks, and B. H. Ball, "The effects of prior knowledge on the encoding of episodic contextual details," Psychonomic Bulletin & Review, vol. 19, pp. 251-257, 2012.
[27] N. Hennies, M. A. L. Ralph, M. Kempkes, J. N. Cousins, and P. A. Lewis, "Sleep spindle density predicts the effect of prior knowledge on memory consolidation," Journal of Neuroscience, vol. 36, no. 13, pp. 3799-3810, 2016.
[28] M. T. Van Kesteren, M. Rijpkema, D. J. Ruiter, R. G. Morris, and G. Fernández, "Building on prior knowledge: schema-dependent encoding processes relate to academic performance," Journal of Cognitive Neuroscience, vol. 26, no. 10, pp. 2250-2261, 2014.
[29] K. R. Brandt, L. M. Cooper, and S. A. Dewhurst, "Expertise and recollective experience: recognition memory for familiar and unfamiliar academic subjects," Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, vol. 19, no. 9, pp. 1113-1125, 2005.
[30] D. Mayhew et al., "Evaluation of beginner driver education programs: Studies in Manitoba and Oregon," 2014.
[31] D. F. Shell, I. M. Newman, A. L. Córdova-Cazar, and J. M. Heese, "Driver education and teen crashes and traffic violations in the first two years of driving in a graduated licensing system," Accident Analysis & Prevention, vol. 82, pp. 45-52, 2015.
[32] D. Maulina, E. S. Siregar, T. A. Rachma, S. A. Nashria, and D. Y. Irwanda, "How effective is training for improving traffic sign comprehension? Examining the interaction between training and sign type among motorcyclists," IATSS Research, vol. 46, no. 4, pp. 614-622, 2022/12/01/ 2022, doi: https://doi.org/10.1016/j.iatssr.2022.11.002.
[33] R. F. Soames Job, "Effective and ineffective use of fear in health promotion campaigns," (in eng), Am J Public Health, vol. 78, no. 2, pp. 163-7, Feb 1988, doi: 10.2105/ajph.78.2.163.
[34] M. R. Robberson and R. W. Rogers, "Beyond fear appeals: Negative and positive persuasive appeals to health and self-esteem," Journal of Applied Social Psychology, vol. 18, no. 3, Pt 1, pp. 277-287, 1988, doi: 10.1111/j.1559-1816.1988.tb00017.x.
[35] E. Kassens-Noor, P. T. Savolainen, T. J. Gates, M. Cai, and T. Deaminada, "Communicating safety with drivers via dynamic message signs," Transportation Research Part F: Traffic Psychology and Behaviour, vol. 81, pp. 417-430, 2021/08/01/ 2021, doi: https://doi.org/10.1016/j.trf.2021.06.010.
[36] R. Mehta and R. J. Zhu, "Blue or Red? Exploring the Effect of Color on Cognitive Task Performances," Science (New York, N.Y.), vol. 323, pp. 1226-9, 03/01 2009, doi: 10.1126/science.1169144.
[37] K. Kersavage, S. I. Guler, and M. Pietrucha, "Analysis of Colored Variable Message Signs for Visibility and Comprehensibility," Transportation Research Record, vol. 2674, no. 1, pp. 125-134, 2020, doi: 10.1177/0361198119900127.
[38] B. Wang, S. Q. Liu, J. Kandampully, and M. Bujisic, "How Color Affects the Effectiveness of Taste- versus Health-Focused Restaurant Advertising Messages," Journal of Advertising, vol. 49, no. 5, pp. 557-574, 2020/10/19 2020, doi: 10.1080/00913367.2020.1809575.
[39] A. J. Elliot, M. A. Maier, A. C. Moller, R. Friedman, and J. Meinhardt, "Color and psychological functioning: the effect of red on performance attainment," (in eng), J Exp Psychol Gen, vol. 136, no. 1, pp. 154-68, Feb 2007, doi: 10.1037/0096-3445.136.1.154.
[40] T. Mann, D. Sherman, and J. Updegraff, "Dispositional motivations and message framing: a test of the congruency hypothesis in college students," (in eng), Health Psychol, vol. 23, no. 3, pp. 330-4, May 2004, doi: 10.1037/0278-6133.23.3.330.
[41] R. Friedman and J. Förster, "Effects of Motivational Cues on Perceptual Asymmetry: Implications for Creativity and Analytical Problem Solving," Journal of personality and social psychology, vol. 88, pp. 263-75, 02/01 2005, doi: 10.1037/0022-3514.88.2.263.
[42] C. J. Armitage and M. Conner, "Efficacy of the Theory of Planned Behaviour: a meta-analytic review," (in eng), Br J Soc Psychol, vol. 40, no. Pt 4, pp. 471-99, Dec 2001, doi: 10.1348/014466601164939.
[43] T. L. Webb and P. Sheeran, "Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence," (in eng), Psychol Bull, vol. 132, no. 2, pp. 249-68, Mar 2006, doi: 10.1037/0033-2909.132.2.249.