Can greyscale phone screens reduce mobile use while driving and walking? An exploratory experimental study

Rahmillah, Fety Ilma; Tariq, Amina; Kaye, Sherrie Anne; King, Mark; Oviedo-Trespalacios, Oscar

DOI
10.1016/j.trf.2025.05.029

Publication date
2025

Document Version
Final published version

Published in
Transportation Research Part F: Traffic Psychology and Behaviour

Transportation Research Part F: Psychology and Behaviour 114 (2025) 498–512

Contents lists available at ScienceDirect

Transportation Research Part F: Psychology and Behaviour

journal homepage: www.elsevier.com/locate/trf

Can greyscale phone screens reduce mobile use while driving and walking? An exploratory experimental study

Fety Ilma Rahmillah [a,b,*], Amina Tariq [a], Sherrie-Anne Kaye [b], Mark King [b], Oscar Oviedo-Trespalacios [c]

[a] *Queensland University of Technology (QUT), School of Public Health and Social Work, Brisbane, Australia*
[b] *Queensland University of Technology (QUT), MAIC - QUT Road Safety Research Collaboration, Brisbane, Australia*
[c] *Delft University of Technology, Faculty of Technology, Policy and Management, Section of Safety and Security Science, the Netherlands*

A R T I C L E I N F O

Keywords:
Misuse of Technology
Smartphone
Apps
Mixed Methods
Distraction
Road Safety

A B S T R A C T

Mobile phone distraction is a critical global road safety issue, contributing to crashes and subsequent injuries and fatalities. This issue has led to calls for effective interventions. Based on neuropsychological research indicating that colour stimuli play a significant role in driving phone engagement, one potential strategy to reduce road user phone use while on the road is activating greyscale on phones. By removing colour, the sensory reward associated with phone use may be diminished, potentially reducing usage. However, this approach has yet to be empirically tested. As such, the aim of this study is to investigate how greyscale influences phone use behaviours while driving and walking. Participants were asked to switch their phone interface from colour to greyscale for a duration of 2-weeks. A mixed-methods approach, including surveys and interviews, was employed to gather insights from participants regarding their perceptions of greyscale on their phone use behaviour while driving and walking. The quantitative results showed that greyscale decreased the frequency of participants glancing at their phone screens in a cradle while driving. However, using the greyscale feature did not lead to significant changes in the frequency of participants picking up the phone and looking at the screen while driving, nor did it increase participants' use of other devices such as the in-vehicle infotainment system, smartwatches, or voice commands. Additionally, greyscale significantly reduced the probability of pedestrians using handsfree phones while walking, although greyscale did not influence the likelihood of looking at the screen of a handheld phone. The qualitative results revealed that the greyscale had a complex impact on road users' phone behaviour. Greyscale altered how they used their phones, made them less appealing and enjoyable, and added complexity to phone use. However, some participants found work-around, though not everyone adopted them. Overall, the findings suggest that while greyscale effectively reduced some phone-related behaviours over a 2-week period, its impact on phone use behaviours while driving or walking was limited in scope, with mixed effectiveness across different contexts and with some users finding work-around.

1. Introduction

Global smartphone network subscriptions are projected to surpass 7.7 billion by 2028 (Statista, 2023a). In Australia, smartphone

* Corresponding author.
E-mail address: fetyilma.rahmillah@hdr.qut.edu.au (F.I. Rahmillah).

https://doi.org/10.1016/j.trf.2025.05.029
Received 3 December 2024; Received in revised form 7 April 2025; Accepted 27 May 2025
Available online 14 June 2025
1369-8478/

ownership has consistently risen and is projected to reach 87 % by 2026 (Statista, 2023b). Concerningly, reports suggest that excessive involvement with mobile phones often leads to maladaptive and risky behaviours, such as mobile phone use while driving (Oviedo-Trespalacios et al., 2019a; Rahmillah et al., 2023a). Mobile phone distraction has been recognised as a significant challenge for road safety worldwide, impacting all road users (Rahmillah et al., 2023a).

In Australia, for example, nearly 61 % of drivers (n = 484) report using their phones while driving, despite the risk of high penalties (Oviedo-Trespalacios et al., 2017). The use of mobile phones is also a concern among vulnerable road users, such as pedestrians (Yadav & Velaga, 2022; Davis, Pugliese, & Barton, 2019). For instance, a self-report study shows that over 80 % of 968 pedestrians are distracted by handheld phone use, such as text messaging or using social media, while walking (O'Hern et al., 2020). Another self-report study shows that some pedestrians use their phones to text while crossing roads (Lennon et al., 2017). Given the prevalence of mobile phone use on our roads, it is important to investigate countermeasures to reduce mobile phone use while driving and walking.

A potential explanation for the high rates of phone use on the road is that individuals may struggle to self-regulate their use. Studies exploring the potential for addiction-like behaviours with mobile phones have found that individuals classified as problem phone users exhibit a higher frequency of both handheld and handsfree mobile phone use while driving compared to casual, habitual, or regular users (e.g., Oviedo-Trespalacios et al., 2019a). Another study reveals that higher levels of smartphone addiction significantly and positively correlate with an increased likelihood of falls, collisions, or traffic injuries (Kim et al., 2017). Further, a systematic review concludes that phone use on the road is a manifestation of maladaptive mobile phone use (Rahmillah et al., 2023a). Arguably, reducing general phone use could also be an approach to reduce phone use on the road, given the accumulated evidence.

Reducing phone use can be addressed as a design issue. Recent efforts have focused on modifying mobile phone interfaces to make phone use less appealing. A review by Rahmillah et al. (2023b) of 13 apps aimed at reducing phone use shows their potential, with effectiveness ranging from low to high. The findings from this review suggest that altering the phone's interface to greyscale can be a cost-free and promising strategy for reducing phone use (Rahmillah et al., 2023b). Research has shown that greyscale can reduce phone use by up to 38 min per day (Holte & Ferraro, 2023). Greyscale changes the phone display to black and white, reducing its visual appeal and making the phone less engaging, thus discouraging overuse (Holte & Ferraro, 2023).

Theoretically, greyscale is a good strategy to reduce phone use because it decreases visual stimulation from the phones and makes apps and content less appealing and engaging (Holte & Ferraro, 2023). This reduction in sensory appeal may lower the urge for habitual or impulsive phone checks (Holte et al., 2023). However, there is limited research on how effective greyscale is in everyday life and its potential to prevent phone use in safety–critical situations, like while driving or walking. This study aims to explore whether using greyscale can help reduce phone use among drivers and pedestrians.

To investigate the impact of greyscale on phone use behaviours among drivers and pedestrians, this innovative study employs a mixed-methods design. The primary objective is to measure how greyscale influences phone use during driving and walking, while also exploring participants' perceptions and experiences after using greyscale over a two-week period. The study is among the first to offer real-world insights into interactions with greyscale in the context of distracted driving and walking. These hypotheses are outlined in the following Table 1.

In addition to testing these hypotheses, the study explores participants' experiences after using greyscale. Through interviews, the study aims to capture how participants perceive the impact of greyscale on their phone use, especially in safety–critical situations such as driving or walking. By combining quantitative and qualitative data, this study aims to provide a well-rounded understanding of the effectiveness of greyscale in reducing phone use in safety–critical contexts.

2. Methods

2.1. Study design

Participants were invited to switch their phone interface from colour to greyscale (black and white) for 2 weeks. Greyscale refers to a range of shades of grey without any visible colour, and when selected it applies to all apps on the phone but does not impact brightness or the interfaces with connected devices (e.g., Apple Watch, web WhatsApp). Phones can function normally, but visual cues relying on colour, such as the WhatsApp blue "read" tick, appear grey, which may cause confusion about whether a message has been read (Bell, 2024). Data were collected across this period in the form of two surveys (baseline and end of week 2) and one interview at

Table 1
Hypotheses.

Context	Hypothesis
Phone use while driving	**H1**: Greyscale use reduces the likelihood of looking at the screen of a handheld phone while driving.
	H2: Greyscale use reduces the likelihood of looking at the screen of a phone placed in a cradle while driving.
	H3: Greyscale use reduces the likelihood of interacting with the in-vehicle information system (IVIS) to use a phone while driving.
	H4: Greyscale use reduces the likelihood of interacting with a phone via a smartwatch while driving.
	H5: Greyscale use reduces the likelihood of using voice commands to control a phone handsfree while driving.
	H6: Greyscale use reduces the likelihood of talking or using voice commands to control a handheld phone while driving.
Phone use while walking	**H7**: Greyscale use reduces the likelihood of looking at the screen of a handheld phone while walking.
	H8: Greyscale use reduces the likelihood of using a phone handsfree while walking.
	H9: Greyscale use reduces the likelihood of interacting with a phone via a smartwatch while walking.

end of the period. Due to the limited existing research on the topic, an explanatory mixed-methods design was chosen to gather comprehensive, detailed information and address the research questions thoroughly (Creswell & Creswell, 2018). This study adopted a design similar to that used in the mixed-methods study by Oviedo-Trespalacios et al. (2020), which investigated mobile phone apps designed to prevent phone use while driving. That study involved a real-world deployment during driving for one week and relied on count data, mean values, and user reflections (i.e., diary study) to evaluate behavioural change and usability. In contrast, our participants applied greyscale continuously over a 2-week period, enabling more naturalistic patterns of use and facilitating assessment of how sustained exposure may influence phone use behaviour. The study initially collected and analysed quantitative data, followed by qualitative data collection to further clarify the quantitative findings (Creswell & Creswell, 2018).

2.2. Participants

Participants were recruited using a convenience sampling approach via online platforms and social media, targeting individuals who met eligibility criteria (i.e., used an iPhone as a primary device, held a provisional or international driver license, and drove at least one hour per week). iPhone users were specifically selected to ensure data consistency. The sample comprised of 61 participants, with 36 females (59.02 %) and 25 males (40.98 %), ranging in age from 18 to 45 years ($M = 31.74$; $SD = 6.04$). The sample size is relatively small and was subject to recruitment challenges, but it closely approximated the calculated requirement of 66 participants based on G*Power estimation. Olson et al. (2022) recruited 51 participants (80 % power to detect small-to-medium effects; $d = 0.36$) from the general public for a 2-week intervention that combined greyscale with other strategies (participants could choose particular strategies). That broader recruitment approach made the recruitment easier than this study which used full greyscale for 2 weeks and limited it to drivers and pedestrians who were also iPhone users. Exclusion criteria included a diagnosis of colour blindness or regular application of greyscale on their phones in the past seven days.

Participants were informed about the possible risks like altered experiences with greyscale, reduced brightness, slower processing, and potential navigational challenges from missing colour cues. The participant information sheet also noted that the survey asked about behaviours like phone use while driving but recorded no identifying details, protecting against legal or reputational harm. Clear instructions and debriefings further ensured ethical transparency and minimised bias. Eligible participants consented prior to starting the first survey.

Data collection occurred between February and September 2023. Participants self-reported an average phone usage of 6.9 h ($SD = 3.89$ h), with an average of 42.49 % of phone usage attributed to work-related activities. On average, participants reported driving 201.32 km per week ($SD = 298.17$ km), with 53.59 % of their overall driving time spent driving on motorways. In the past 3 years, 27.87 % of participants reported involvement in a crash as a driver, irrespective of fault, while 39.34 % had incurred demerit points or

Table 2
Demographics.

Demographics	N = 61	Percentage (%)
Employment/study status		
Employed full-time	27	41.54
Self-employed	5	7.69
Student part-time	4	6.15
Employed part-time	14	21.54
Unemployed	1	1.54
Student full-time	13	21.31
Casual employment (seasonal work)	1	1.54
Education level		
Bachelor degree	32	52.46
Postgraduate degree or higher	20	38.46
Some colleges but no degree	4	6.56
High school degree or equivalent	2	3.28
Other	3	4.92
Driver licence		
Valid international driver licence	16	26.23
Open/full licence	33	54.1
Provisional/probationary licence	12	19.67
Car type		
Automatic	52	85.25
Manual	9	14.75
Hours of driving		
Less than 5 h per week	20	32.79
6–10 h per week	19	31.15
11–20 h per week	15	24.59
21–30 h per week	6	9.84
More than 30 h per week	1	1.64
Purpose of driving		
Mostly for work	9	14.75
Mostly personal (including for education)	13	21.31
Mixture of work and personal	39	63.93

fines for traffic offences (excluding parking violations). Notably, 21.31 % of these offences were related to mobile phone use while driving. Additionally, 44.26 % of participants reported being in a car involved in a near miss (sudden braking or swerving) caused by someone using their mobile phone while driving, including instances of glancing at their phones, within the past year. Table 2 provides further details of the demographics of participants. Participants were recruited through paid University Facebook advertising, the Psychology Research Management System (SONA), mailing lists, and recruitment flyers.

2.3. Data collection

The research project received ethical approval from the Human Research Ethics Committee from the university (Approval number: 6154). Participants were invited to switch their phone interfaces from colour to greyscale (black and white) for a 2-week and completed the following as part of the study.

(1) A survey questionnaire completed at two time points.

At the start of the study, participants answered the screening and demographic questionnaire (e.g., age, education, hours of driving, driver license type) administered via Qualtrics. Then, participants were asked to complete the mobile phone use while driving and walking questionnaire prior to using greyscale (week 0) and after using greyscale (at the end of week 2). In the middle of weeks 1 and 2, a reminder text message was sent to participants to keep their phones in greyscale.

(2) A semi-structured interview.

Each participant interview took 15–20 min and was conducted by FIR through video conference. It was undertaken after participants had used greyscale for 2 weeks. The interview was audio recorded to capture information. The interview guide was based on the Technology Acceptance Model (TAM), which explores user interactions with technology (Davis, 1989). Participants received an AUD $40 e-gift voucher to acknowledge their contribution to the study.

2.4. Measures

2.4.1. Survey questionnaire

Besides the demographics, the survey questions captured participants' mobile phone use while driving and walking.

Mobile phone use while driving.

For mobile phone use while driving, participants were asked: In the past one week, have you: (Q1) Looked at the screen of a handheld phone while driving; (Q2) Looked at the screen of a phone in a cradle while driving; (Q3) Looked at the in-vehicle information system (IVIS) to use your phone while driving; (Q4) Used a smartwatch to interact with your phone while driving; (Q5) Used voice commands (e.g., Bluetooth) to control your phone handsfree while driving; (Q6) Talked or used voice commands (e.g., Siri) to control your phone handheld while driving? If yes, what was the reason?: (a) Communicated with another person; (b) Used social media (e.g., like, comment, post, read, watch videos); (c) Used entertainment or relaxation apps (e.g., listen to music); (d) Used apps or function to help you drive (e.g., GPS); or (e) Checked your phone for no specific reason. All questions offered a Yes/No response options.

Mobile phone use while walking.

For mobile phone use while walking, participants were asked: In the past one week, have you: (Q7) Looked at the screen of a handheld phone while walking; (Q8) Used a handsfree phone through (e.g., earphones); (Q9) Used a smartwatch to interact with your phone while walking? If yes, what was the reason?: (a) Communicated with another person; (b) Used social media (e.g., like, comment, post, read, watch videos); (c) Used entertainment or relaxation apps (e.g., listen to music); (d) Used apps of function to help you walk (e.g., GPS); or (e) Checked your phone for no specific reason. Each question had a Yes/No response options.

Table 3
Phone use behaviour while driving.

In the past one week, have you …	Week	No	Yes	p	Yes, when …		
					Vehicle was moving	Vehicle was stopped at red traffic light	Both
Q1. Looked at the screen of a handheld phone while driving	W0	28	33	0.629	5	9	19
	W2	25	36		8	15	13
Q2. Looked at the screen of a phone in a cradle while driving	W0	16	45	0.049*	9	11	25
	W2	26	35		12	9	14
Q3. Looked at the in-vehicle information system (IVIS) to use your phone while driving	W0	30	31	1	7	7	17
	W2	31	30		11	5	14
Q4. Used a smartwatch to interact with your phone while driving	W0	37	24	0.648	5	6	13
	W2	36	25		7	5	13
Q5. Used voice commands (e.g., Bluetooth) to control your phone handsfree while driving	W0	28	33	0.332	10	6	17
	W2	33	28		14	4	10
Q6. Talked or used voice commands (e.g., Siri) to control your phone handheld while driving	W0	28	33	0.388	14	5	14
	W2	32	29		13	3	13

2.4.2. Semi-Structured interviews

A semi-structured interview guide was used to guide participant interviews. Participants were asked questions about their experiences of using greyscale while driving and walking. Questions included, "Tell me about your experience of applying greyscale while driving/walking?; Can you think of any potential problems or concerns that you might have in using greyscale feature while driving/walking?; Has the way you used the phone changed after applying greyscale while driving/walking?; How useful did you find greyscale to use while driving/walking?; What do you like/dislike about using greyscale while driving/walking?".

2.5. Data analysis

2.5.1. Quantitative

Pearson correlation coefficients were calculated using SPSS to examine the relationships between sociodemographic variables (i.e., gender, experience of crash related to phone use, hours of driving) and phone use behaviours while driving (Q1-Q6) and while walking (Q7-Q9). To examine any variations in self-reported phone use behaviour across time (W0 and W2), the McNemar test was employed. The analysis consisted of two parts: the first part of the analysis comprised six items assessing phone use behaviour while driving (refer to Table 3), while the second included three items focusing on phone use behaviour while walking (refer to Table 5). The reasons for phone use behaviour both while driving and walking were presented in descriptive form (Tables 4 and 6) for example use the phone to communicate with another person, use social media, use entertainment or relaxation apps, use apps or function to help drive, or to check phone without a specific reason.

2.5.2. Interview

The first author (FIR) recorded and transcribed all interviews, and the transcripts were subsequently imported into NVivo 11 (Jackson et al., 2019). The data were analysed following the six-phase thematic analysis outlined by Braun and Clarke (2022). Initially, FIR read and re-read the transcripts to become familiar with the data. Key features relevant to the research question were then systematically coded and grouped into several themes. The research team (FIR, AT, SK, OO-T, and MK) regularly reviewed and refined the themes by re-examining the data, merging themes where necessary, and assigning descriptive labels that encapsulated their essence. Any discrepancies were deliberated among the researchers until 90 % of agreement was achieved.

3. Results

Participants engaged in a 2-week greyscale intervention (n = 61) with an average greyscale use of 88 % in the first week and 86 % in the second week. First, potential correlations between sociodemographic variables and phone use behaviour while driving and walking were examined. Second, analysis was conducted on greyscale's effect on phone use behaviour while driving and walking by comparing before and after the 2-week of intervention. Last, thematic analysis was undertaken to examine participants' experience of using greyscale interventions.

3.1. Correlations

Seventeen variable pairs demonstrated moderate to strong statistically significant correlations ($r \geq 0.4$), highlighting patterns across different types of phone use while driving and walking (See Appendix 1). The strongest correlation was observed between the

Table 4
Reasons for phone use behaviour while driving.

In the past one week, have you …		Communicated with another person			Used social media			Used entertainment or relaxation apps			Used apps or function to help you drive (e.g., GPS)			Checked your phone for no specific reason		
		M*	S*	Both	M*	S*	Both	M*	S*	Both	M*	S*	Both	M*	S*	Both
Q1. Looked at the screen of a handheld phone while driving	W0	3	5	13	3	3	12	4	2	15	2	3	15	0	1	3
	W2	2	5	10	4	2	6	7	8	10	4	9	13	1	2	2
Q2. Looked at the screen of a phone in a cradle while driving	W0	2	5	10	3	2	11	2	3	18	6	6	24	0	4	5
	W2	7	1	7	3	3	2	3	4	8	5	7	13	2	1	3
Q3. Looked at the in-vehicle information system (IVIS) to use your phone while driving	W0	3	3	9	3	3	7	0	2	17	4	6	15	3	0	5
	W2	3	0	9	5	2	5	8	3	12	4	2	12	2	1	5
Q4. Used a smartwatch to interact with your phone while driving	W0	2	4	8	3	2	8	2	2	11	2	4	11	2	2	5
	W2	1	3	7	3	2	5	5	3	8	3	3	9	1	3	4
Q5. Used voice commands (e.g., Bluetooth) to control your phone handsfree while driving	W0	5	4	12	1	4	9	7	4	13	2	4	10	0	2	4
	W2	6	0	7	3	1	3	10	2	6	4	3	7	1	1	4
Q6. Talked or used voice commands (e.g., Siri) to control your phone handheld while driving	W0	7	3	12	0	3	10	8	5	13	2	2	10	0	0	5
	W2	7	2	9	6	2	7	7	1	7	4	1	10	0	1	5

*M: When vehicle was moving; *S: When vehicle was stopped at red traffic light.

Table 5
Phone use behaviour while walking.

In the past one week, have you …	Week	No	Yes	p	Yes, when …		
					Walking	Waiting for the walk signal at traffic lights	Both
Q7. Looked at the screen of a handheld phone while walking	W0	12	49	0.804	14	3	32
	W2	10	51		26	3	21
Q8. Used a handsfree phone through (e.g., earphones) while walking	W0	14	47	0.035*	22	2	23
	W2	23	38		18	2	18
Q9. Used a smartwatch to interact with your phone while walking	W0	33	28	0.804	9	3	16
	W2	35	26		11	2	13

use of voice commands to control handsfree (Q5) and handheld phone use while driving (Q6) at W0 and W2 ($r_{W0} = 0.738$; $r_{W2} = 0.609$). Several correlations reflected consistency across W0 and W2, such as looking at the screen of a handheld phone use while driving ($r_{Q1} = 0.436$), handsfree phone use while driving ($r_{Q5} = 0.402$), talking or using voice assistants to control a handheld phone while driving ($r_{Q6} = 0.626$), and handsfree phone use while walking ($r_{Q8} = 0.400$). Cross-contextual correlations were also found; for example, smartwatch use while driving (Q4) was associated with smartwatch use while walking at W0 (Q9) ($r = 0.538$), at W2 ($r = 0.455$), and across weeks ($r = 0.424$). Habitual device use was also found while driving including the use of a smartwatch (Q4) and voice commands to control a handheld phone while driving (Q6) at W2 ($r = 0.587$), the use of IVIS (Q3) and a smartwatch while driving (Q4) at W2 ($r = 0.581$), the use of IVIS (Q3) and voice commands to control a handheld phone while driving (Q6) at W2 ($r = 0.499$). This habitual device use was also found across context such as voice control via handheld phone (e.g., Siri) while driving (Q6) was associated with the use of earphones while walking at W2 (Q8) ($r = 0.472$), the use of voice commands to control handsfree phone while driving (Q5) and handsfree phone use while walking (Q8) at W0 ($r = 0.417$). Habitual device use was also associated with the use of voice commands to control handsfree (Q5) and handheld phones while driving (Q6) across weeks ($r = 0.560$ and $r = 0.407$). Additionally, smartwatch interaction while driving was moderately associated with crash-related phone use ($r = 0.431$), pointing to a potential link between wearable technology use and distraction related incidents.

3.2. Mobile phone use while driving

The McNemar test conducted on six items related to phone use behaviour while driving (refer to Table 3) revealed a statistically significant decrease in one behaviour: “In the past one week, have you looked at the screen of a phone in a cradle while driving” (Q2), following a greyscale intervention ($p < 0.05$). Specifically, the number of participants who reported using their phones while the vehicle was in motion or when the vehicle was stopped at red traffic lights reduced from 25 to 14. This decline was also visible in the suggested reasons for looking at the screen of a handheld phone while driving such as to use entertainment/relaxation apps or to use apps or functions to help them drive (Fig. 1). The remaining five behaviours did not show any significant changes between baseline and after 2-week intervention (Q1, Q3-Q6).

3.3. Mobile phone use while walking

The McNemar test on three items of phone use behaviour while walking (Table 6) found that one behaviour showed significant changes ($p < 0.05$) after the intervention, “In the past one week, have you used a handsfree phone through (e.g., earphones) while walking” (Q8). Specifically, the number of participants who reported using their phones handsfree while walking and both (while walking and waiting for the walk signal at traffic lights) reduced (22 to 18 and 23 to 18, respectively) (Table 7). The decline was also shown in the reasons for using a handsfree phone through (e.g., earphones) while walking such as to communicate with another person, use social media, use entertainment/relaxation apps, or use apps or function to help to walk (Fig. 2). However, greyscale did not show a significant effect on the other two behaviours (Q7 and Q9).

3.4. Participants’ experience of using greyscale intervention

To gain further insights into the experience of using greyscale, participants ($n = 54$) were interviewed after participating in the intervention; four participants declined to be interviewed, while another three participants did not respond to interview requests. The primary objective of these interviews was to further understand the effect of greyscale on drivers and pedestrians’ mobile phone behaviour. From the coded data, five key themes emerged. Four themes were common to both drivers (D) and pedestrians (P): (1) greyscale changed phone use behaviour, (2) greyscale made phone use less attractive and enjoyable, (3) greyscale increased the complexity of using the phone, and (4) work-around to overcome greyscale challenges. A fifth theme, specific to drivers, was identified: (5) no effect for participants using IVIS. For a visual representation of these findings, refer to Fig. 3.

3.4.1. Theme 1: Greyscale changed phone use behaviour

This theme captured the changes in phone use behaviour experienced by both drivers and pedestrians when utilising greyscale on their phones. Some participants reported an increase in distraction due to the difficulty of operating their phone in greyscale while driving, which led them to not use their handheld phone while driving.

Table 6
Reasons of phone use behaviour while walking.

In the past one week, have you …	Week	Communicated with another person			Used social media			Used entertainment/ relaxation apps			Used apps or function to help you walk (e.g., GPS)			Checked your phone for no specific reason		
		Walk	Wait*	Both	Walk	Wait	Both	Walk	Wait	Both	Walk	Wait	Both	Walk	Wait	Both
Q7. Looked at the screen of a handheld phone while walking	W0	9	1	31	9	2	25	9	2	27	5	1	21	1	0	12
	W2	11	3	16	17	3	13	14	1	20	9	0	15	4	1	6
Q8. Used a handsfree phone through (e.g., earphones)	W0	9	1	31	9	2	25	9	2	27	5	1	21	1	0	12
	W2	6	1	12	7	1	9	14	1	15	2	1	10	0	1	5
Q9. Used a smartwatch to interact with your phone	W0	5	0	14	0	2	10	2	3	13	3	1	11	1	3	4
	W2	4	1	8	8	2	5	4	1	11	3	1	7	1	1	2

* Waiting for the walk signal at traffic lights.

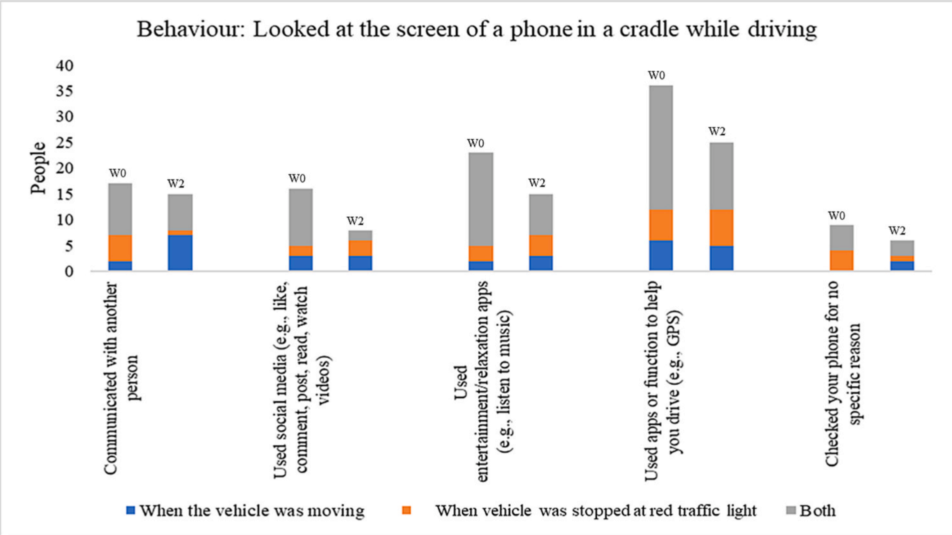

Fig. 1. Looked at the screen of a phone in a cradle while driving.

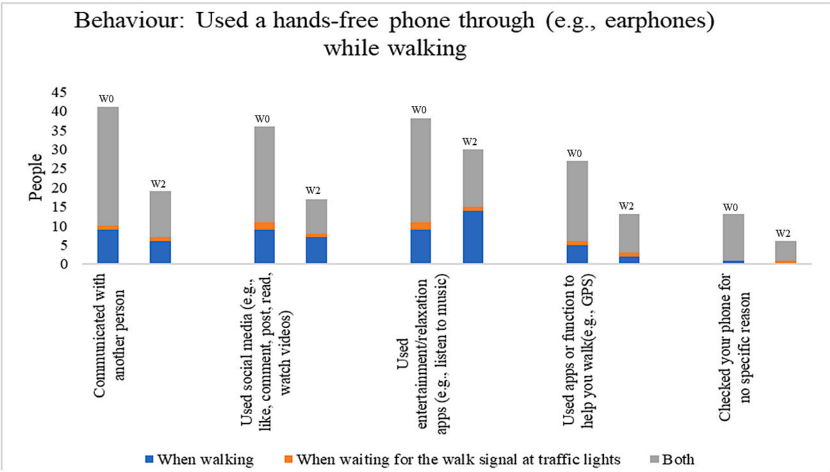

Fig. 2. Used a handsfree phone through (e.g., earphones) while walking.

"Sometimes when I am in the traffic lights, I want to open [the phone] to see what's going on, is there someone texting me or someone contacting me through WhatsApp? But I don't feel like I want to use it anymore [after greyscale] because it is not possible". (F, 41)

"[Before using greyscale] Normally I do press my phone a lot even while driving. I am addicted to my phone, I play with music, I chat with people sometimes while driving. It is kind of awkward for me sometimes, I can't concentrate. [After using greyscale] It's impossible to do that while in greyscale and driving". (M, 31)

Similarly, and in the context of walking, a few participants reported less multitasking with handheld phones, as activities like checking social media, replying to emails, taking photos, and recording videos became more challenging with greyscale. Even though some participants still reported using their phone while walking, the time they reported using the phone reduced when in greyscale.

> *"I don't take as many photos and* videos *[as I used to be when walking] in greyscale phone". (F, 31)*
> *"I would still pick up my phone and look at my phone for no reason, but I was less likely to scroll or post on Instagram or anything which I would normally do whilst walking". (F, 34)*

In addition, a few participants reporting preferring to leave their phones in their pockets or at home, perceiving phones as less useful while walking. Specifically, some opted to disengage from their phones, until they returned home.

> *"Yeah, I do, but not as much when I'm using colour. So, I just let go off the phone and maybe when I get home, I can deal with it". (M, 26)*
> *"I didn't like using my phone in greyscale mode. I didn't scroll as much as when I have that colour mode on my phone. It's just a reflex for me, tend to just leave my phone when I want to walk outside". (F, 42)*

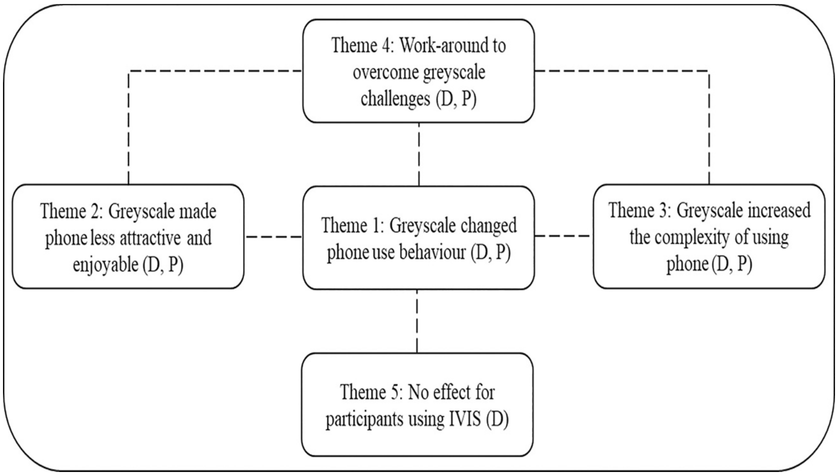

Fig. 3. Effect of greyscale on phone use behaviour of drivers (D) and pedestrians (P).

3.4.2. Theme 2: Greyscale made phone less attractive and enjoyable

Greyscale reduced the visual appeal of mobile phones with its unattractive monochrome display. Absence of vibrant colours made phone use less enjoyable, promoting greater focus on the environment and reducing risky behaviour, both on the road and while walking.

Greyscale possibly acted as a deterrent against phone usage while driving or walking, as participants reported feeling less inclined to interact with their mobile phones due to the unattractive greyscale display. Many participants noted that the absence of vibrant colours reduced distractions and made the phone less visually captivating.

> *"When I see the phone in greyscale, I feel like being reminded that I shouldn't use it while driving. The phone is not appealing, so there's no need to use it. I use my phone on social media mostly, just go to check out stuffs, and when driving these stuffs distract me. So, after using greyscale over time, it doesn't allow me to use it, so I feel less distracted". (M, 33)*
> *"Sometimes I want to open [the phone] to see what's going on when I am [driving] in the traffic lights. But I don't feel the urge to look at it anymore as it doesn't attractive". (F, 41)*

Some participants reported greyscale also reduced the appeal of checking social media both while driving and walking, as vibrant colours were absent, discouraging risky behaviour like phone use at red lights. This effect extends to walking, where some individuals reported that they were more inclined to immerse themselves in their surroundings rather than focus on their screens.

> *"If you're the kind of person who is checking social media at a red light when you are driving, it is not going to be as enjoyable with greyscale on. So, you're less likely to do it because the reward-to-risk ratio is impacted". (F, 33)*
> *"Yeah, a lot less, I think mostly because social media needs a lot of colour to make it very attractive and enjoyable. Once it was in greyscale, it didn't feel as enjoyable. So, less time, yeah". (F, 31)*

3.4.3. Theme 3: Greyscale increased the complexity of using the phone while driving/walking

A key theme that emerged from discussion with participants was around how greyscale increased the complexity of using the phone. This was reflected across several subthemes such as: greyscale increased visual distraction and increased time to process information (e.g., read navigation app) both while driving and walking. In addition, greyscale increased potential risk while driving.

Increased visual distraction.

Some participants perceived that greyscale increased visual distraction, predominantly in relation to navigation apps. Participants reported that the lack of colour on the navigation app made it particularly hard to discern crucial information, like traffic signals and road directions, leading to confusion, difficulties in concentration, and potential wrong decisions about which way to travel. In navigation apps, each colour represents a different meaning about traffic conditions. For example, green means no traffic delays, orange means there is a medium amount of traffic, and red means there are traffic delays. Participants reported their struggles with reading the navigation app while driving, as evidenced by the following remarks.

> *"The GPS is very hard to use as everything is black and white, and I can't see the blue line or where is the next turns. I end up squinting and looking at a little bit harder. Even the streets are grey, so I don't know if it's turning right at this street, that street, or the other street". (F, 29)*
> *"It is frustrating, and I have experience going the wrong way as I cannot differentiate the shade in greyscale". (M, 28)*

However, the visual distraction was not confined to the use of the navigation app but also applied to other common features and applications used on the phone as expressed by participants.

> *"Greyscale in the phone makes me really confused as I cannot see clearly when my phone is on the handler while I'm driving or even stopping at traffic. Usually I can easily operate, like choose feature, connect to Bluetooth, set the music, or call someone". (M, 31)*
> *"[I usually] listen to music, podcasts and* audio *books, while driving. No, not really [do it again]. Because it's hard to figure out some things while driving [in greyscale]. I felt like it's safer not to be distracted while driving". (M, 33)*

Increased time to process information

Some participants perceived that using greyscale on their phones increased the time it took to perform tasks such as accessing navigation, searching for apps, or changing music while driving or walking. In contrast, colour-coded apps allowed users to understand and complete these tasks more quickly. Some of the quotes are presented here.

> *"I don't notice have to concentrate on what I am doing on the phone a bit more. So, instead of looking for a colour when I want to find an app, I have to actually think about what I am doing, and it take me longer to do something. So, I end up spending more time if I pick my phone up, being on my phone while I am walking". (F, 33)*

> *"I Found that if I have to use maps while I'm driving and walking, I need more time to identify the GPS and work out the orientation of the maps and that sort of thing". (F, 40)*

Increased potential risk while driving.

Few participants perceived that greyscale increased potential risk while driving because it could prolong the time needed to access information on the phone, such as maps, compared to coloured displays, potentially diverting drivers' attention from the road for longer periods, thus increasing the likelihood of crashes. Additionally, using the phone, especially with greyscale, may diminish awareness of surroundings, increasing the risk of crashes as drivers struggle to read information on their screens.

> *"I don't think that [greyscale] would make it any safer. Let's say for instance, someone is making use of the maps when the phone is on coloured. For those brief moments that the person looking at their map, it can cause a crash. But then the situation changes into someone is making use of greyscale and then tries to look at the map and that might take longer than usual, the likelihood of crashing increases". (M, 28)*
> *"Well, I guess, any time you're on your phone, you're at more of a risk of having a crash because you're not as aware of your surroundings. And as I said, greyscale can sometimes make it a bit harder to see what's on your screen. If it is in colour, it shows red, meaning lots of traffic, whereas in greyscale you can't distinguish between red, orange and green. That's dangerous". (F, 28)*

3.4.4. Work-around to overcome greyscale challenges

As participants used greyscale on their phones, they reported devising work-around, which are strategies aimed at addressing deviations from the usual workflow, even though this strategy was not universally employed.

Some participants reported a change from using phone to preferring IVIS to overcome limitations of the greyscale. It is worth noting while some drivers already had IVIS before the greyscale intervention, a few participants still preferred using handheld phones while driving. However, with greyscale, these participants opted to use IVIS (including the in-car navigation device) instead. Some of the quotes expressed here represented a work-around using IVIS and the in-car navigation device instead of the phone.

> *"Before now, I use my phone while driving just to check on random stuff on the Internet. Now, I basically use IVIS, and don't have to touch my phone necessarily. So, from where I started and where I am now, I think there is a huge difference in my phone usage, I try as much as possible not to use my phone while driving for things that are not important". (F, 35)*
> *"Before using greyscale, I think I use a lot of Google Maps through my phone. Now, I use my cars navigation system instead of looking at the phone directly". (M, 27)*

A few participants found alternatives to using maps in greyscale such as relying on audio navigation instructions rather than viewing maps both while driving and walking.

> *"I don't think it's difficult to use GPS on greyscale. Most of the time these GPS use voice control, it will direct you to where you're going and on greyscale, you can just use it'". (M, 33)*
> *"So, I tend to just listen to the instruction instead of looking of the phone when the phone was navigating me somewhere. So, I didn't look at the greyscale screen while driving and walking". (F, 44)*

One participant commented upon their ability to differentiate between shades in navigation app. In addition, a few participants found a way to overcome glare on sunny days by adjusting the brightness of their phones whilst in greyscale, as expressed below:

> *"I worked out when using maps [while driving] that the darker was red, the lighter was yellow. It's fine. I adapted quickly [by differentiating] the different shades of grey and work out which ones represent what colours. It was just like watching black and white TV, I don't need to have my phone in colour to use it, or to read the map". (F, 36)*
> *"With the sunlight, I can't see so much except by increasing the brightness on the phone [while driving]". (M, 26)*
> *"For walking, I did sometimes have to adjust the brightness of the phone". (F, 28)*

3.4.5. No effect for participants using IVIS

While some participants reported a discernible effect of greyscale during both driving and walking activities, others noted no effect.

Some of participants reported not using a handheld phone while driving as they had IVIS or in-car navigation devices in their cars. So, when they were engaged in primary (e.g., accessing the navigation app) and secondary activities (e.g., receiving an incoming call, listening to music) these were carried out through IVIS or their in-car navigation devices. The greyscale intervention had no impact on these participants who used IVIS, as they did not physically handle or pick up their phones while driving. This was also mentioned as the reason they did not use the phone as a navigation tool as the IVIS or in-car navigation device provided a seamless navigation experience without distractions from smartphone notifications.

"I think no because I don't use my phone while driving. I have an infotainment system in my car. So, my phone connects to the system, and I use it for GPS and music and that's just the way my car works". (F, 28)

"I don't mind applying greyscale on the phone because I always use navigation from the car, not through the phone. There is major difference such as when you are using phone, you'll get distracted with so many things going on in the phone, but when you are using a normal satellite navigation, you'll never get distracted with notification like SMS or social media alerts". (M, 42)

4. Discussion

The effectiveness of greyscale in reducing certain behaviours.

The present study investigated the effects of a greyscale intervention on phone use behaviour among drivers and pedestrians following a 2-week intervention. The self-reported survey data revealed that only two out of nine hypotheses were supported. First, greyscale significantly reduced the likelihood of drivers glancing at their phone screens in a cradle while vehicle was moving and when it was stationary at traffic lights compared to baseline. Second, greyscale significantly reduced the likelihood of pedestrians using handsfree phones while walking and while waiting for the walk signal at traffic lights compared to baseline. These findings align with previous research, which also found that greyscale makes the phone screen less appealing (Holte et al., 2023). When looking at the types of content, it was found that the decrease in phone use behaviour, specifically looking at phones in a cradle while driving and using handsfree phones while walking was due to decreases in communicating with other people, using social media, using entertainment or relaxation apps, and using navigation apps to drive or walk. However, there were no other significant differences in behaviours under investigation.

In daily life, greyscale settings can reduce phone usage by diminishing the device's visual appeal and inducing boredom, thereby decreasing the likelihood of frequent phone interactions (Holte et al., 2023). Additionally, greyscale has been shown to enhance users' perceived control over their phone use and reduce perceptions of overuse (Dekker & Baumgartner, 2023). This evidence suggests that minimising visual distractions can support better self-regulation of phone usage. Similarly, our study found that greyscale may discourage drivers from multitasking with their phones while on the road. Some drivers reported that using greyscale helped them concentrate more on driving and less on their phone activities. The colourful phone screen typically displays notifications, messages, and updates, which can tempt drivers to check their devices while driving. By removing these enticing visual cues, greyscale may make it less tempting for drivers to engage in multitasking behaviours with their phones, thereby helping them maintain focus on the road.

The reduction in handsfree phone use while walking is significant, but is a somewhat counterintuitive finding. There are two potential explanations. First, according to the Technology Acceptance Model (Davis, 1989), individuals are more likely to engage with technology when they perceive it as useful and enjoyable. The reduced visual appeal of greyscale may have diminished participants' perceived usefulness of their phones, leading them to disengage from their phones. This aligns with interview results where some participants preferred to leave their phones in their pockets or at home, perceiving their phones no longer felt essential while walking. Second, prior research suggests that reducing visual stimulation can heighten awareness of one's surroundings and influence overall engagement with mobile devices (Strayer & Drews, 2007). It is suspected that the reduced visual appeal of greyscale may have led participants to limit all types of phone interactions, including handsfree use, as part of a broader shift in distraction awareness. In addition, some participants noted that they still experienced greyscale in connection with handsfree use when first setting up the phone or searching for music, even though they did not view the screen during handsfree music listening. This may be one reason why they reduce handsfree phone use. Moreover, it is important to recognise that visual-manual interactions and handsfree interactions often relate to each other. Drivers, for example, may first engage in visual-manual interactions-such as dialling a number before switching to handsfree use. Similarly, in everyday walking scenarios, participants may have initially relied on visual-manual inputs before transitioning to handsfree interaction (Oviedo-Trespalacios et al., 2016, 2020). As these two modes of interaction are interconnected yet influenced by different contextual and personal factors, altering one (such as reducing visual-manual appeal through greyscale) can indirectly affect the other. This interdependency may help explain the broader reduction in phone engagement across modalities.

In addition, social media engagement through handsfree or audio devices can occur via passive listening (e.g., notifications read aloud) and active interaction (e.g., responding via voice commands). Users may prefer passive engagement as it reduces visual distractions while keeping them informed (Hoy, 2018; Strayer & Drews, 2007). Alternatively, some users may use voice assistants (e.g., Google Assistant, Siri, Alexa) to enable active responses (e.g., responding to messages or composing posts). However, privacy concerns, speech errors, and effortful dictation often discourage frequent use (Luger & Sellen, 2016; Pradhan et al., 2018). Additionally, greyscale may reduce phone engagement overall, leading some to disengage entirely.

Another key finding was that no significant changes were observed in the use of IVIS following greyscale intervention. This suggested that participants did not shift their phone interaction preferences toward IVIS in response to the visual disruption caused by greyscale. In other word, greyscale did not inadvertently introduce new distractions through compensatory behaviours. Those who already relied on IVIS continued to do so, likely because of the perceived convenience and relative safety of this feature (Oviedo-Trespalacios et al., 2019b). In this study, half of the participants employed IVIS for phone interaction while driving, and this behaviour remained unchanged by greyscale intervention. This finding suggested that while greyscale may reduce screen-based distractions, it may not alter broader patterns of phone engagement, particularly among those who are already multi-device users (Stiegemeier et al., 2022). Supporting this, the correlation showed that IVIS use was moderately associated with other forms of interaction, including handheld voice control and smartwatch use while walking.

Although IVIS use remined stable after greyscale intervention, there remains a concern that activating greyscale could prompt individuals to rely on IVIS more extensively while driving. This is plausible given that IVIS provides a centralised interface within the vehicle for accessing various functions such as navigation, entertainment, and communication (Oviedo-Trespalacios et al., 2019b). Further, and unlike hand-held phone use, using IVIS while driving is not an illegal behaviour in Australia. With greyscale limiting the visual appeal of phones, individuals may opt to use IVIS features for tasks like navigation, listening to music, and phone calls even though IVIS can still lead to driver distraction (Ebel et al., 2023). However, the interviews showed that few participants still reported using phones for navigation even though they have IVIS or an in-car navigation device. This preference aligned with a previous study which stated that mobile phones were often preferred over IVIS as it was easier to use, and people were already familiar with phones rather than emerging technologies such as IVIS (Oviedo-Trespalacios et al., 2019b). In addition, the adoption of IVIS is influenced by several points including perceived usefulness, perceived ease of use, safety, trust, and anxiety (Stiegemeier et al., 2022). A key issue to remember is that IVIS remain an important source of distraction that we cannot ignore due to the potential of result in road crashes (Wang et al., 2024). These findings highlighted the importance of evaluating the unintended consequences of interventions, as they can result in equal harms—in this case, shifting from one distraction to another, or even creating worse situations.

As voice technology continues to advance, it becomes increasingly accessible for drivers and pedestrians to engage in voice-enabled activities, such as making calls, sending messages, listening to music, and accessing information handsfree without needing to touch or look at their phone screens, which is arguably safer and less cognitively demanding (Larsen et al., 2020; Oviedo-Trespalacios et al., 2019b). In this study, however, no changes in the use of voice control commands (e.g., Siri, Bluetooth) were identified following the greyscale intervention. This finding was supported by the correlation results, which revealed moderate to strong association between use of handsfree, voice-based, and wearable devices. For example, handsfree use and handheld voice assistant use were strongly correlated and handheld phone use while driving at W0 and at W2 had remained moderately correlated over time. This finding indicates that participants using greyscale did not shift their preferences toward voice interventions, which is positive because it means no additional distractions were introduced. Instead, those who relied on voice commands continued to do so, likely due to the inherent safety benefits they offer. Regarding smartwatch usage, 40 % of participants reported using smartwatches to interact with their phones while driving, and none indicated that this behaviour was affected by the greyscale intervention. It is important to highlight that experimental research has suggested smartwatches can be more distracting than both phones and voice commands (Brodeur et al., 2021). Overall, this suggests that greyscale's impact is localised, specifically influencing screen-based phone use while leaving other smartphone functions, such as audio-based interactions, unaffected. Consequently, it is essential to revise our metrics for phone use from focusing on specific tasks to encompassing all potential forms of distraction. By doing so, we can more accurately assess and mitigate the various ways in which technology may contribute to driver distraction, ensuring that safety interventions address the root causes rather than merely substituting one form of distraction for another.

Our study also highlighted the impact of participants' age regarding preferences for using various common apps while driving and walking. A previous study found that most young drivers (aged 16–17; N = 153) were unwilling to give up navigation (59 %) and music apps (43 %) while driving (Delgado et al., 2018). Participants in our study were not predominantly young drivers (M = 31.74; SD = 6.04). This demographic difference may partly explain the observed variations in phone use behaviour. Furthermore, participants' tendency to look at the greyscale screen of a handheld phone while driving was not significantly reduced, highlighting the complexity and variability of phone use behaviour across age groups while driving.

While both groups reported that greyscale made their phones less attractive and enjoyable, leading to reduced engagement in distracting activities, drivers uniquely highlighted their continued reliance on in-vehicle information systems (IVIS) as a result of the intervention. This reliance suggests that drivers may shift their attention from handheld phones to integrated vehicle technologies when the visual appeal of their phones is diminished. In contrast, pedestrians did not exhibit a similar shift, as their phone use behaviours were primarily focused on personal devices. Additionally, both groups experienced increased complexity in using their phones under greyscale settings, though the nature of these challenges varied based on their specific contexts, drivers dealing with navigation and vehicle controls, and pedestrians with activities like walking and multitasking in public spaces. Overall, the findings suggest that while greyscale can effectively reduce certain types of phone-related distractions, its impact varies between drivers and pedestrians, highlighting the need for comprehensive strategies that consider the diverse ways in which different user groups interact with their devices.

Participant awareness.

Participation in this distraction study itself may have influenced behaviour, a phenomenon known as the Hawthorne effect, where individuals modify their behaviours due to the awareness of being observed (Adair, 1984; Sedgwick, & Greenwood, 2015). Since this study was a pre-post design without a control group, some reductions in phone use might be partially attributed to participants' awareness of being in a study. The interviews indicated that greyscale played a significant role in discouraging phone engagement, with some participants viewing it as a behavioural cue that reminded them to reduce usage. Some participants explicitly mentioned that when the phone interface was in colour, they engaged with it unconsciously for longer periods, whereas greyscale interrupted this habitual use by serving as visual cue that discouraged engagement. This finding suggests the potential of greyscale to reduce the allure of colourful phone interfaces while driving and walking, contributing modestly to road safety. We recommend incorporating greyscale settings as part of a preventive strategy in driver safety programs to minimise phone-related distractions and promote safer driving habits, though further research is needed to clarify its broader impact.

Risk compensation

Risk compensation occurs when individuals adjust their behaviour in response to perceived changes in risk, often in ways that counteract the effectiveness of safety outcomes (Hedlund, 2000). Although greyscale reduced visual phone engagement, the correlation results suggested compensatory patterns across various contexts. In driving, handheld phone use at W0 was moderately correlated with handheld phone use at W2, indicating continued phone use despite the greyscale intervention. Additionally, handsfree use was strongly correlated with handheld voice assistant use in both weeks, suggesting participants who engaged with one device often used another. In walking, moderate correlations were found between smartwatch use and other audio-based behaviours, such as between smartwatch use and handsfree use. These patterns also reflect cross-context and multi-device use, where participants maintained or shifted engagement across tools rather than reducing it. While greyscale limited screen interaction, overall screen engagement appeared sustained, consistent with a risk compensation effect.

Behavioural adaptation

Behavioural adaptation typically follows a dynamic process involving initial disruption, short-term adjustment, and either long-term integration or reversion to prior habits (Lally et al., 2010; Orbell & Verplanken, 2010). The 2-week greyscale intervention likely followed a phased adaptation trajectory. Initially, participants may have experienced an awareness and adjustment phase, where the sudden shift to greyscale disrupted their habitual phone use, leading to an immediate but potentially superficial reduction in engagement, which aligns with short-term adaptation (Lally et al., 2010; Orbell & Verplanken, 2010). Research on behavioural interventions suggests that unless the change aligns with intrinsic motivation or external reinforcement, users may gradually return to their original habits once the intervention finish (Orbell & Verplanken, 2010). The 2-week intervention may not have been sufficient for long-term habit formation as behaviour change requires time with median around 66 days to form a habit (Lally et al., 2010).

5. Limitations and future research

This study has limitations that warrant consideration. Firstly, the 2-week intervention is relatively short and thus may have provided limited insight to the effect of greyscale on phone use behaviour among drivers and pedestrians. A longer duration might be necessary to assess how to sustain the influence of greyscale on engagement patterns over time and on phone use habits. Secondly, the convenience sampling strategy and small sample size raises concerns about the representativeness of the sample compared to the broader populations of drivers and pedestrians in Queensland. Future research should aim to employ probability-based sampling methods and larger, more diverse samples to enhance generalisability. Thirdly, other categories of road users such as motorcyclists, cyclists, scooter riders, and taxi drivers, may not have been adequately represented. Future research should aim for greater diversity among participants in terms of gender, age, road user type, and education. Fourth, the reliance on self-reported data, a limited number of items, and simplified response formats (e.g., binary options, count data, mean values), may have oversimplified the complexity of participant attitudes and behaviours. A more nuanced approach should be adopted in the future, such as using Likert scale items, expanding the breadth of measured constructs, and incorporating modelling techniques to account for individual variations. This will further add to the literature on user engagement and behavioural change.

Fifth, while greyscale appeared to reduce visually stimulating phone use, we did not isolate its effects from broader interface or environmental factors. In real-world evaluations of mobile phone apps to prevent phone use while driving, isolating the effect of a single design feature is challenging due to the influence of other confounding variables, such as usability and individual differences (Oviedo-Trespalacios et al., 2020; Chen & Schulz, 2016). In addition, it is nearly impossible to determine absolute causal effects due to the complexity of human-technology interaction (Chen & Schulz, 2016). Future research should investigate the specific impact of greyscale on user behaviour separately from broader interface design factors, for example through controlled experiments. Sixth, although some participants noted challenges in using greyscale, the current study did not quantitatively assess usability as a predictor of behavioural outcomes. Future research could explore whether the usability challenges of greyscale predict changes in phone use frequency or distraction-related behaviours. This study holds important practical implications, as greyscale feature can be applied to all mobile phones. However, enhancing the built-in greyscale feature is important to minimise distraction and better accommodate individual preferences. For instance, providing users with the option to disable particular apps in greyscale, such as a navigation app, could improve usability while maintaining the intended benefits in reducing MMPU.

6. Conclusion

In conclusion, this study revealed that activating greyscale phone settings can effectively reduce specific mobile phone-related behaviours, such as decreasing the likelihood of drivers glancing at phone screens in a cradle and limiting handsfree phone use among pedestrians while walking. However, the intervention did not significantly alter the frequency of handheld phone use while driving or prevent the substitution of phone use with alternative technologies like in-vehicle information systems (IVIS), smartwatches, and voice commands. Qualitative insights indicated that greyscale made phones less attractive and more complex to use, prompting some users to adopt work-around without reducing overall distraction levels. These findings underscore the critical need to evaluate the unintended consequences of such interventions, as they may simply shift distractions rather than mitigate them. Therefore, we recommend incorporating greyscale settings as part of a comprehensive, multifaceted strategy within driver safety programs that addresses all potential sources of distraction. Additionally, it is essential to revise assessment metrics to encompass all forms of distraction, ensuring that safety interventions effectively target the root causes of mobile phone-related distractions. By adopting a holistic approach, future efforts can more accurately assess and mitigate the various ways technology contributes to driver and pedestrian distraction, ultimately enhancing road safety and preventing the substitution of one form of distraction for another.

7. Declaration of generative AI in scientific writing

During the preparation of this work, the author(s) used Chat GPT 4 in order to improve the language. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

CRediT authorship contribution statement

Fety Ilma Rahmillah: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Amina Tariq:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Sherrie-Anne Kaye:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Mark King:** Writing – review & editing, Supervision, Conceptualization. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was funded by the Australian Research Council through OO-T's Discovery Early Career Researcher Award (DE200101079).

Data availability

Data will be made available on request.

References

Adair, J. G. (1984). The Hawthorne effect: A reconsideration of the methodological artifact. *Journal of Applied Psychology, 69*(2), 334.
Bell, A. (2024, September 30). *WhatsApp check marks explained.* Thinglabs. https://thinglabs.io/whatsapp-check-marks-explained. Accessed March 29, 2025.
Braun, V., & Clarke, V. (2022). *Thematic analysis*. American Psychological Association.
Brodeur, M., Ruer, P., Léger, P. M., & Senecal, S. (2021). Smartwatches are more distracting than mobile phones while driving: Results from an experimental study. *Accident Analysis & Prevention, 149*, Article 105846. https://doi.org/10.1016/j.aap.2020.105846
Chen, Y. R. R., & Schulz, P. J. (2016). The effect of information communication technology interventions on reducing social isolation in the elderly: A systematic review. *Journal of Medical Internet Research, 18*(1), e4596.
Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Los Angeles: Sage.
Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.
Davis, S. J., Pugliese, B. J., & Barton, B. K. (2019). The intersection of pedestrian safety and multimodal perception. *Transportation Research Part F: Traffic Psychology and Behaviour, 67*, 205–216. https://doi.org/10.1016/j.trf.2019.11.002
Dekker, C. A., & Baumgartner, S. E. (2023). Is life brighter when your phone is not?The efficacy of a grayscale smartphone intervention addressing digital well-being. *Mobile Media & Communication, 12*(3), 688–708.
Delgado, M. K., McDonald, C. C., Winston, F. K., Halpern, S. D., Buttenheim, A. M., & Setubal, C. (2018). Attitudes on technological, social, and behavioral economic strategies to reduce cellphone use among teens while driving. *Traffic Injury Prevention, 19*(6), 569–576.
Ebel, P., Lingenfelder, C., & Vogelsang, A. (2023). On the forces of driver distraction: Explainable predictions for the visual demand of in-vehicle touchscreen interactions. *Accident Analysis & Prevention, 183*, Article 106956.
Hedlund, J. (2000). Risky business: Safety regulations, risk compensation, and individual behavior. *Injury Prevention, 6*(2), 82–89.
Holte, A. J., & Ferraro, F. R. (2023). True colors: Greyscale setting reduces screen time in college students. *The Social Science Journal, 60*(2), 274–290. https://doi.org/10.1080/03623319.2020.1737461
Holte, A. J., Giesen, D. T., & Ferraro, F. R. (2023). Color me calm: Grayscale phone setting reduces anxiety and problematic smartphone use. *Current Psychology, 42*(8), 6778–6790. https://doi.org/10.1007/s12144-021-02020-y
Hoy, M. B. (2018). Alexa, Siri, Cortana, and more: An introduction to voice assistants. *Medical Reference Services Quarterly, 37*(1), 81–88.
Jackson, K., Bazeley, P., & Bazeley, P. (2019). *Qualitative data analysis with NVivo*. Sage.
Kim, H. J., Min, J. Y., Kim, H. J., & Min, K. B. (2017). Accident risk associated with smartphone addiction: A study on university students in Korea. *Journal of Behavioral Addictions, 6*(4), 699–707. https://doi.org/10.1556/2006.6.2017.070
Lally, P., Van Jaarsveld, C. H., Potts, H. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *European Journal of Social Psychology, 40*(6), 998–1009.
Larsen, H. H., Scheel, A. N., Bogers, T., & Larsen, B. (2020). Hands-free but not eyes-free: A usability evaluation of Siri while driving. In *In Proceedings of the 2020 Conference on Human Information Interaction and Retrieval* (pp. 63–72).
Lennon, A., Oviedo-Trespalacios, O., & Matthews, S. (2017). Pedestrian self-reported use of smart phones: Positive attitudes and high exposure influence intentions to cross the road while distracted. *Accident Analysis & Prevention, 98*, 338–347.
Luger, E., & Sellen, A. (2016). " Like having a really bad PA" The gulf between user expectation and experience of conversational agents. In *In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 5286–5297).
O'Hern, S., Stephens, A. N., Estgfaeller, N., Moore, V., & Koppel, S. (2020). Self-reported pedestrian behaviour in Australia. *Transportation Research Part F: Traffic Psychology and Behaviour, 75*, 134–144.
Orbell, S., & Verplanken, B. (2010). The automatic component of habit in health behavior: Habit as cue-contingent automaticity. *Health Psychology, 29*(4), 374.
Oviedo-Trespalacios, O., Haque, M. M., King, M., & Washington, S. (2016). Understanding the impacts of mobile phone distraction on driving performance: A systematic review. *Transportation Research Part C: Emerging Technologies, 72*, 360–380.
Oviedo-Trespalacios, O., King, M., Haque, M. M., & Washington, S. (2017). Risk factors of mobile phone use while driving in Queensland: Prevalence, attitudes, crash risk perception, and task-management strategies. *PLoS One, 12*(9), Article e0183361.

Oviedo-Trespalacios, O., Nandavar, S., Newton, J. D. A., Demant, D., & Phillips, J. G. (2019a). Problematic use of mobile phones in Australia… is it getting worse? *Frontiers in Psychiatry, 10*, Article 440510.

Oviedo-Trespalacios, O., Nandavar, S., & Haworth, N. (2019b). How do perceptions of risk and other psychological factors influence the use of in-vehicle information systems (IVIS)? *Transportation Research Part F: Traffic Psychology and Behaviour, 67*, 113–122. https://doi.org/10.1016/j.trf.2019.10.011

Oviedo-Trespalacios, O., Truelove, V., & King, M. (2020). "It is frustrating to not have control even though I know it's not legal!": A mixed-methods investigation on applications to prevent mobile phone use while driving. *Accident Analysis & Prevention, 137*, Article 105412.

Pradhan, A., Mehta, K., & Findlater, L. (2018). " Accessibility Came by Accident" Use of Voice-Controlled Intelligent Personal Assistants by People with Disabilities. In *In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp. 1–13).

Rahmillah, F. I., Tariq, A., King, M., & Oviedo-Trespalacios, O. (2023a). Is distraction on the road associated with maladaptive mobile phone use? A systematic review. *Accident Analysis & Prevention, 181*, Article 106900.

Rahmillah, F. I., Tariq, A., King, M., & Oviedo-Trespalacios, O. (2023b). Evaluating the Effectiveness of Apps Designed to Reduce Mobile Phone Use and Prevent Maladaptive Mobile Phone Use: Multimethod Study. *Journal of Medical Internet Research, 25*, Article e42541.

Sedgwick, P., & Greenwood, N. (2015). Understanding the Hawthorne effect. *Bmj, 351*.

Statista. Number of smartphone mobile network subscriptions worldwide from 2016 to 2022, with forecasts from 2023 to 2028(in millions). (2023a). Available online at: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/.

Statista. Smartphone penetration rate as share of the population (2023b). Available online at https://www.statista.com/statistics/321477/smartphone-user-penetration-in-australia/.

Stiegemeier, D., Bringeland, S., Kraus, J., & Baumann, M. (2022). "Do I really need it?": An explorative study of acceptance and usage of in-vehicle technology. *Transportation Research Part F: Traffic Psychology and Behaviour, 84*, 65–82.

Strayer, D. L., & Drews, F. A. (2007). Cell-phone–induced driver distraction. *Current Directions in Psychological Science, 16*(3), 128–131.

Wang, B., Xue, Q., Yang, X., Wan, X., Wang, Y., & Qian, C. (2024). Driving Distraction Evaluation Model of In-Vehicle Infotainment Systems Based on Driving Performance and Visual Characteristics. *Transportation Research Record, 03611981231224750*.

Yadav, A. K., & Velaga, N. R. (2022). A systematic review of observational studies investigating the influence of mobile phone distraction on road crossing behaviour of pedestrians. *Transportation Research Part F: Traffic Psychology and Behaviour, 91*, 236–259.

Lee, B., Lee, Y. J. N., Park, S., Kim, H., Lee, S. J., & Kim, J. (2014). Driver's distraction and understandability (EOU) change due to the level of abstractness and modality of GPS navigation information during driving. *Procedia Computer Science, 39*, 115–122.