http://www.press.ierek.com

ISSN (Print: 2357-0849, online: 2357-0857)

Environmental Science and Sustainable Development

DOI: 10.21625/essd.v8i3.954

What is the general population's perception of smart motorways in the UK?

Mr Luke Lynch[1], Dr Elisavet Andrikopoulou[2], Dr Nima Dadashzade[3]

[1]*MSc Information Systems, University of Sheffield, UK*

[2]*Senior Lecturer, School of Computing University of Portsmouth, UK*

[3]*Postdoctoral Research Fellow Intelligent Transport Cluster, University of Portsmouth, UK*

Abstract

Motorway users have various opinions about the types of smart motorways. Motorway utilization can be affected if road users have a negative perception of certain types of smart motorways, particularly on the topic of safety. There are three types of smart motorways that can be found in the UK. These are Controlled Smart Motorways (CSM), Dynamic Hard Shoulder (DHS), and All-Lane Running (ALR). This study focuses on the comparison of ALR and DHS smart motorways as ALR smart motorways are developed to replace and improve upon DHS smart motorways. The aim of this project is to understand how the general population perceives smart motorways in the UK. This aim will be achieved by answering a series of these research questions: (1) How does existing knowledge of smart motorways affect the perception of smart motorways; (2) How does age affect the perception of smart motorways; (3) How does car ownership affect the perception of smart motorways? Data were collected using an online survey disseminated to the UK adult population of vehicle and non-vehicle drivers via social media and advertisements. Descriptive statistics and cluster analysis were used to analyze the dataset and find similarity clusters. The primary research shows that ~57% of the survey respondents had never heard of or did not know the meaning of the 3 different types of smart motorways and only ~13% of respondents fully understand the different types. Car owners in both cluster analysis models show substantial variation in the results of the comfort / smart motorway choice variables. This research demonstrates that greater knowledge and awareness about smart motorways are required to improve the perception of smart motorways. It would seem that this is particularly true for all-lane running smart motorways which are both the newest and most physically different type of smart motorway with their removal of the hard shoulder.

Keywords

Controlled motorways; Dynamic motorways; All-Lane Running motorways; People's perception

1. Introduction

Motorway users have various opinions regarding the types of smart motorways. Motorway utilization can be affected if road users have a negative perception of certain types of smart motorways, particularly on the topic of safety. The three types of smart motorways in the UK are Controlled, Dynamic, and All-Lane Running. Based on the Department for Transport 2020 report their current length in the UK is Controlled Smart Motorways: 137 miles, Dynamic Smart Motorways: 66 miles, and All-Lane Running Smart Motorways 123 miles. The Transport Committee (2021) report encourages further rollout of the smart motorways but very little is known about their perception by the UK public.

A controlled smart motorway (CSM) consists of a minimum of three lanes with a permanent hard shoulder (Jallow et al., 2019); hence it always maintains a conventional emergency hard shoulder. This was the first smart motorway implemented in the UK and introduced overhead variable speed or lane indication boards, camera-based traffic monitoring, and vehicle speed recording. Unfortunately, the hard shoulder cannot be converted into a live lane for use at peak times (Highways England, 2016).

Dynamic hard shoulder (DHS) motorways have the ability to convert the hard shoulder into a live lane for use at peak times with the use of refuge areas (National Highways, 2021). These emergency refuge areas occur every 800-1,000 meters so that vehicle experiencing an issue has somewhere to pull over even when the hard shoulder is in use as a live lane (Transport Committee, 2021). Often the hard shoulder is used unpredictably to tackle congestion" (Transport Committee, 2021), introducing risk and discouraging drivers from using the extra hard shoulder lane (Callaghan et al., 2017).

All lane running (ALR) motorways have no hard shoulder with emergency refuge areas occurring up to 1.6 miles (or 2.5km) apart but typically occur every 1.2 miles (Transport Committee, 2021). They also include a radar-based stopped vehicle detection system that can identify a stationary vehicle in 20 seconds (Transport Committee, 2021). This is superior to camera-based identification as an operator is not required to identify a stopped vehicle which saves time and should improve road safety. This study focuses on the comparison of ALR and DHS smart motorways as ALR smart motorways are aiming to replace and improve upon DHS smart motorways. The aim of this project is to understand how the general population perceives smart motorways in the UK. This aim will be achieved by answering a series of these research questions:

- How does existing knowledge of smart motorways affect the perception of smart motorways?
- How does age affect the perception of smart motorways?
- How does car ownership affect the perception of smart motorways?

2. Methodology

A pragmatic research philosophy (Creswell & Plano-Clark, 2011) has been chosen for this project enabling the researchers to focus on selecting the best method to answer the research question.

Data were collected using an online survey disseminated to UK vehicle and non-vehicle drivers via social media and advertisements in the county of Hampshire, UK. This study was ethically approved by the University of Portsmouth FEC committee with an approval number 2021-101659.

Descriptive statistics were initially used to analyze the dataset and to describe relationships between certain variables in a sample or population (Kaur et al., 2018). Frequencies, mean and standard deviation were used.

Cluster analysis is a technique used to combine similar data into several clusters based on the similarity of the values of several variables to each other (Sinharay, 2010). In the context of this study, the data records generated by the survey are combined into groups called clusters based on their similarity to each other. Cluster analysis was used on all of the demographic questions as well as a select few other questions such as a Likert scale question: "I feel comfortable with using smart motorways" and the smart motorway choice question.

3. Results

The survey received 112 respondents in 3 weeks after which google forms was used to export the responses into an excel document. Excel was used to cleanse, format code, and initially analyze the data. Data coding was required to represent the text answers seen in the survey questions as numeric data. A data dictionary was created to convert the answers for each question into categorized numeric values (see Appendix A). This was the most efficient option as all of the questions in the survey are categorized (e.g., multiple choice or Likert scale). The Excel spreadsheet was used to produce the descriptive statistics and was then imported into SPSS for further analysis.

3.1. Descriptive statistics

This section provides an initial understanding of the factors which are relevant to the three research questions. A total of 112 complete responses were recorded, there was no incomplete response as the survey questions were all highlighted as "required".

Figure 1 shows the measures of frequency and Table 1 shows the measures of variation for the survey questions. Approximately 57% of respondents have never heard of or did not know the meaning of the 3 different types of smart

motorways and 13% of respondents fully understand the different types. This shows that the subject knowledge of our sample is low. 54% of the respondents are between 18 and 24 years of age with the other 46% being of older age groups. The majority of the respondents (73%) are car owners with enough remaining non-car owners to be able to complete meaning comparisons. There are more male (58.04%) than female (40.18%) respondents. Undergraduate level education (57.14%) is the most common with the General Certificate of Secondary Education (GCSE) level lowest at 3.57%. The most preferred smart motorway is dynamic (44.64%).

There are slightly more positive perspectives (43.75%) than negative (32.14%) when the respondents were asked about how comfortable they are with using smart motorways. The respondents were asked how safe they feel when using smart motorways and there were slightly more negative perspectives, i.e. not feeling safe (41.96%) than positive (38.39%). Although there is a slight difference looking closely at the mean and standard deviation, we can infer that the variability is limited.

Smart Motorway Knowledge	**Count**	**Percentage**
Never heard of them	33	29.46
Have heard of them but don't know what they mean	31	27.68
Have heard of them and have some idea of what they mean	33	29.46
Fully understand what they mean	15	13.39
Age Breakdown		
18-24	61	54.46
25-44	23	20.54
45-64	23	20.54
65+	5	4.46
Car Ownership Breakdown		
Yes	82	73.21
No	30	26.79
Gender Breakdown		
Female	45	40.18
Male	65	58.04
Non-binary	1	0.89
Prefer not to answer	1	0.89
Education Breakdown		
GCSE	4	3.57
A-level / BTEC	18	16.07
Undegraduate	64	57.14
Postgraduate	26	23.21
Smart Motorways Comfort Breakdown		
Strongly agree	22	19.64
Agree	27	24.11
Indifferent	21	18.75
Disagree	19	16.96
Strongly disagree	17	15.18
No opinion / Prefer not to answer	6	5.36
Smart Motorways Safety Breakdown		
Strongly agree	24	21.43
Agree	19	16.96
Indifferent	17	15.18
Disagree	29	25.89
Strongly disagree	18	16.07
No opinion / Prefer not to answer	5	4.46
Smart Motorway Choice Breakdown		
All-lane running smart motorway	25	22.32
Dynamic smart motorway	50	44.64
Equal	37	33.04

Figure 1 Frequencies of the entire sample

We calculated frequencies with cross-tabulation and we also calculated the mean and standard deviation for all the variables (Riffenburgh, 2012, pp. 30–37). Most of the variables have a good spread.

Table 1 Measures of Variation

Variables	Mean	Standard deviation
Smart Motorway Knowledge	2.27	1.03
Age Breakdown	1.75	0.93
Car Ownership Breakdown	1.27	0.44
Gender Breakdown	1.63	0.55
Education Breakdown	3	0.73
Smart Motorways Comfort Breakdown	3.15	1.52
Smart Motorways Safety Breakdown	3	1.51
Smart Motorway Choice Breakdown	2.11	0.73

3.2. Cluster Analysis

Two-step cluster analysis "identifies the groupings by running pre-clustering first and then by hierarchical methods" (Statistics Solutions, 2020). Usefully, it also "automatically selects the number of clusters" (Statistics Solutions, 2020). This approach was chosen due to versatility and ease of understanding compared to other approaches such as hierarchical or K-means clustering. The existing knowledge, age, and car ownership questions were included as part of the cluster analysis due to their direct relationship with the three research questions which measure how existing knowledge, age, and car ownership affect the perception of smart motorways.

The Two-step cluster analysis consists of the following categoric variables:

- "I feel comfortable with using smart motorways"
- Knowledge of smart motorways
- Car ownership
- Age

The predictor importance (IBM, 2021) of the four variables has been identified as the most important variable in making a prediction the "feel comfortable with using smart motorways" followed by the knowledge of smart motorways, car ownership, and age. This analysis produced 5 clusters with 13, 18, 19, 28, and 34 records as shown in Figure 2.

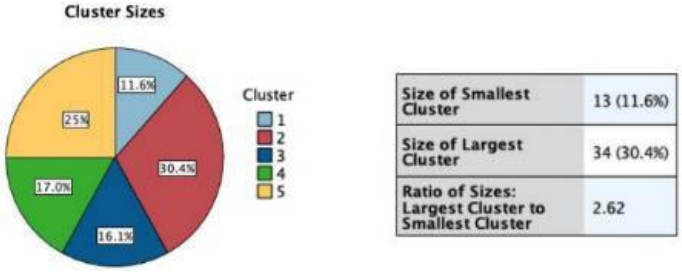


Figure 2 Clusters of Cluster Analysis 1

Knowledge of smart motorways and age comparison was chosen because cluster 5 contains knowledge of smart motorways modal value with 92% of the total cluster values for knowledge of smart motorways. The modal value for cluster 4 contains 63% of values with a cell distribution that is bell-shaped showing only 1 peak at the number 3. Figure 3 shows a small increase in knowledge on smart motorway types (2 to 3) may lead to a substantial decrease in feeling comfortable with using smart motorways (2 to 4), there is also a large difference in modal age which could be an influencing factor.

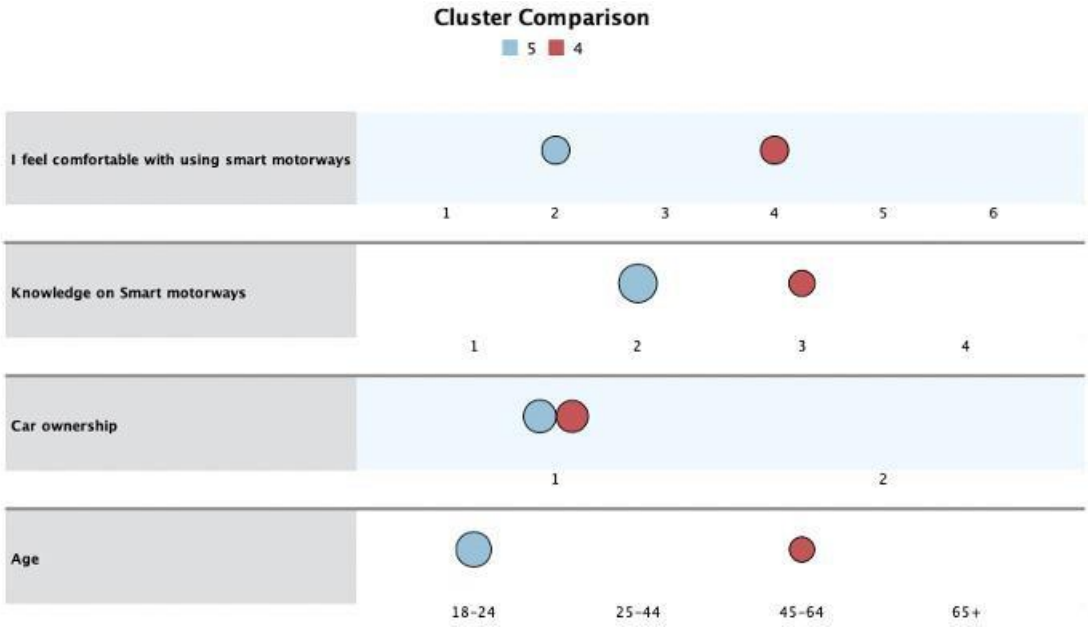


Figure 3 Lower Knowledge of Smart Motorways and Age

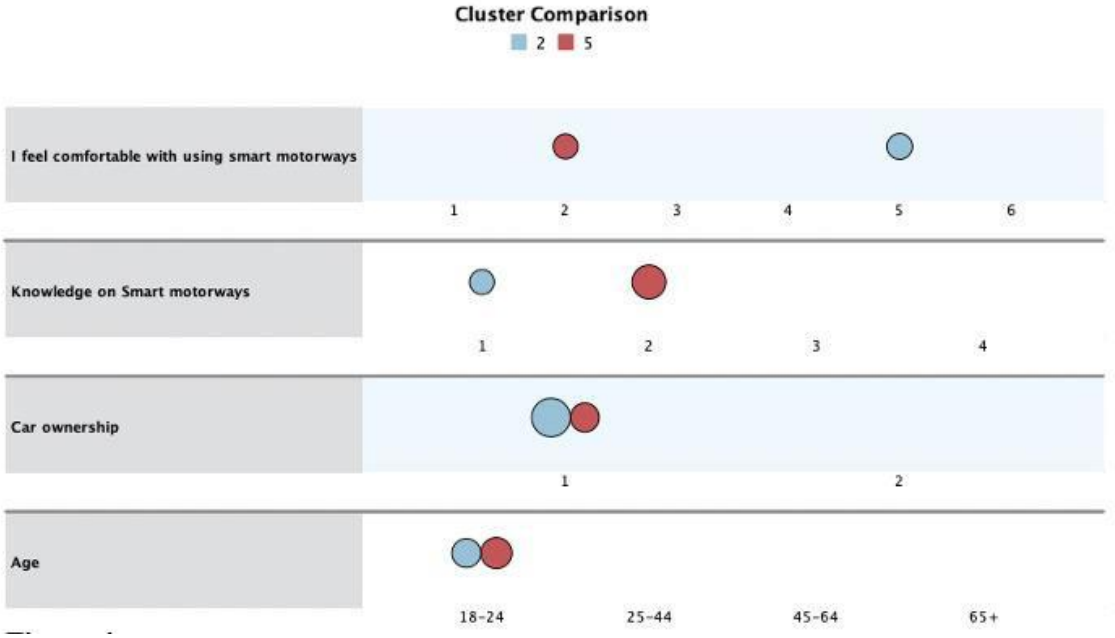


Figure 4 Higher Knowledge of Smart Motorways and Age

Figure 4 shows clusters 2 and 5 being compared as they contain values of the same modal age with a small increase in Knowledge of smart motorways (1 to 2) and similar car ownership figures to the first comparison. This comparison contrasts the first in that it shows a small increase in knowledge of smart motorway types may lead to a very large increase in feeling comfortable with using smart motorways (5 to 2).

Looking at the above 2 comparisons, it would seem age that this is a key factor in determining a vehicle owner's comfort with using smart motorways with road users of higher age on average being less comfortable with using smart motorways. However, as these comparisons do not investigate differences in car ownership, Figure 5 shows a comparison of Cluster 2 and 3 which was made due to the modal car ownership variable consisting of 100% car ownership and 100% non-car ownership respectively. This comparison shows that the clusters are very similar except when looking at car ownership and comfort with using smart motorways. The modal average shows that non-vehicle drivers are very uncomfortable with using smart motorways compared with vehicle drivers.

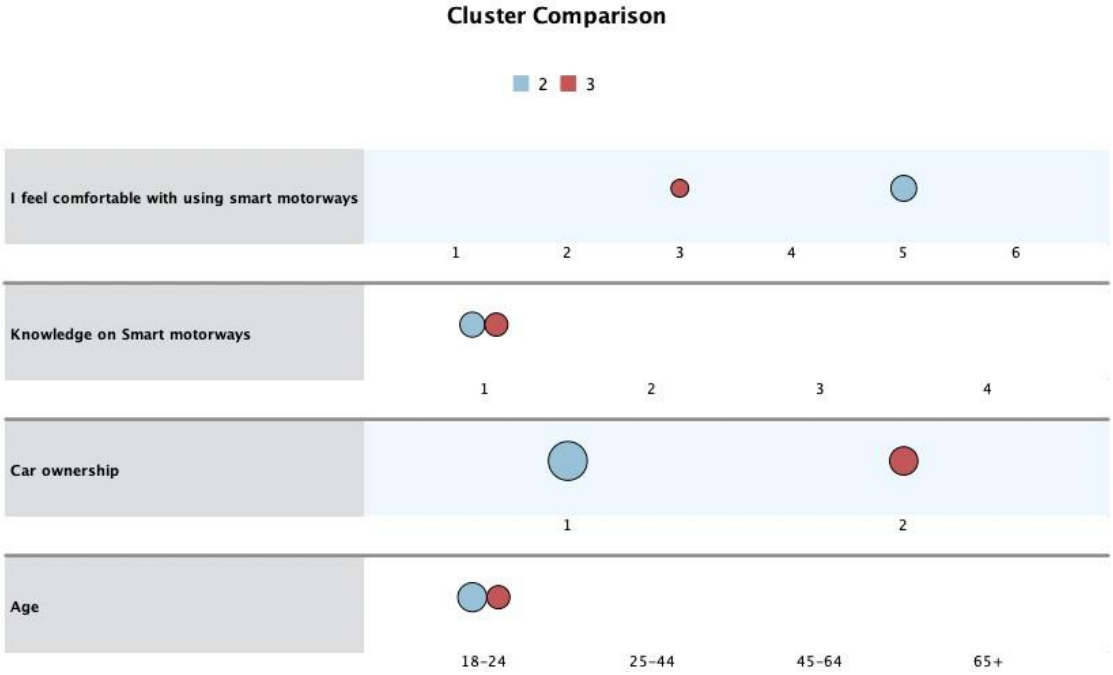


Figure 5 Car Ownership

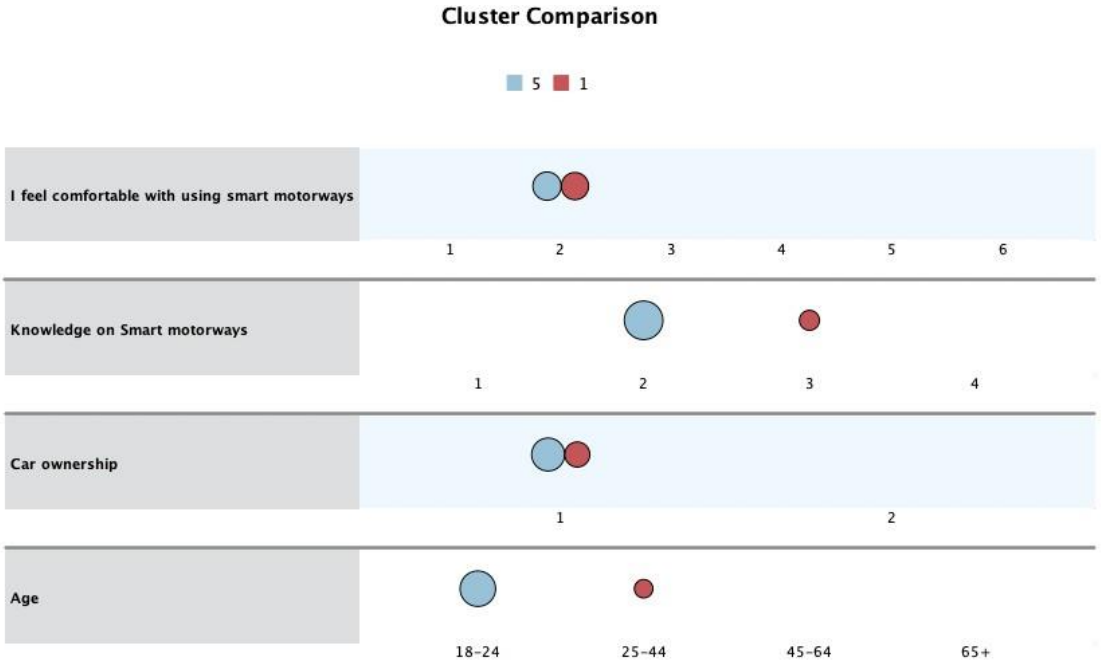


Figure 6 Comfort with Smart Motorways

Figure 6 shows clusters 1 and 5 which contain the respondents who are modally most comfortable with using smart motorways. A comparison between these clusters shows that they both have a model average of 2 or 3 for knowledge of smart motorways, tend to be of a younger demographic, and own cars.

A comparison between Clusters 2 and 4 in figure 7 shows similarities to the above comparison with the differences being both show car ownership and Cluster 2 is less comfortable with using smart motorways than cluster 3.

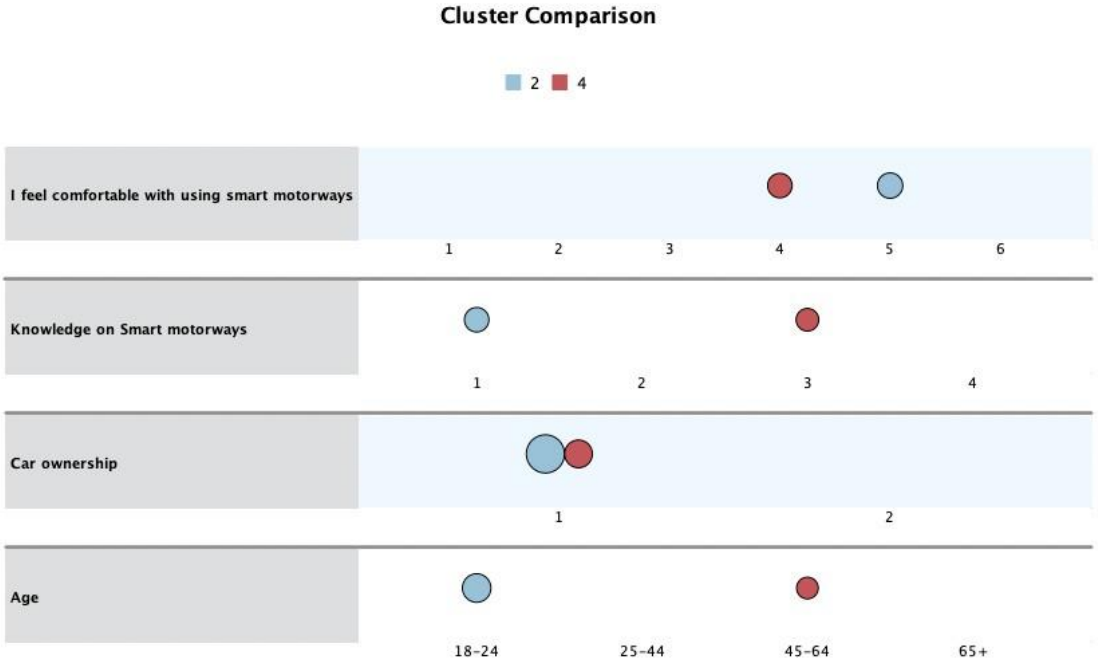


Figure 7 Car ownership and comfort driving the smart motorways

4. Discussion

How does existing knowledge of smart motorways affect the perception of smart motorways?

The primary research in this project shows that ~57% of the survey respondents had never heard of or did not know the meaning of the 3 different types of smart motorways and only ~13% of respondents fully understand the different types. This level of unawareness and knowledge surrounding the functionality of the roads being driven on is cause for concern and should be improved according to (Transport Committee, 2021), a stance which is shared by the Department for Transport and House of Commons reports (Department for Transport, 2020; Transport Committee, 2021), especially in the case of an emergency. The Department for Transport and House of Commons reports (Department for Transport, 2020; Transport Committee, 2021) suggest that an increased level of public knowledge about smart motorways will improve the public's perception of smart motorways. This is supported by the cluster analysis which shows that an increase in survey respondent knowledge led to an increase in comfort with using smart motorways when all other variables were the same.

How does age affect the perception of smart motorways?

No literature was found relating specifically to the effect of a person's age on their perception of smart motorways. This study provides evidence that road users of a higher age are on average significantly less comfortable with using smart motorways than road users of a lower age. It may be that individuals of a younger age are more accepting of the addition of technology to an originally non-technological environment such as a motorway. Older individuals may also have an existing positive experience with using conventional motorways and not see the need for smart motorways, which can limit their travel speed. Additional research will need to be carried out to understand the reasoning behind the effects of age on the perception of smart motorways specifically.

How does car ownership affect the perception of smart motorways?

No literature was found relating to the effect of a person's car ownership status on their perception of smart motorways. Car owners in both cluster analysis models show substantial variation in the results of the comfort / smart motorway choice variables. This is caused by the different clusters which make up car owners having different values for the age and knowledge of smart motorway variables. Non-car owners have a single cluster in both models so do not have these variations. Looking at the breakdown of the cell distribution for non-vehicle drivers' comfort with using smart motorways shows a large variation in results including over half of the total 6 (No opinion / Prefer not to answer) answers recorded in the whole survey. This data would suggest that respondents of this cluster have varying opinions of smart motorways which may have been caused by different experiences or information about smart motorways which they have encountered. As this cluster consists of non-vehicle owners, it may be that the respondents in this cluster have limited or no experience of driving on smart motorways which may be an explanation for the results seen.

5. Conclusion

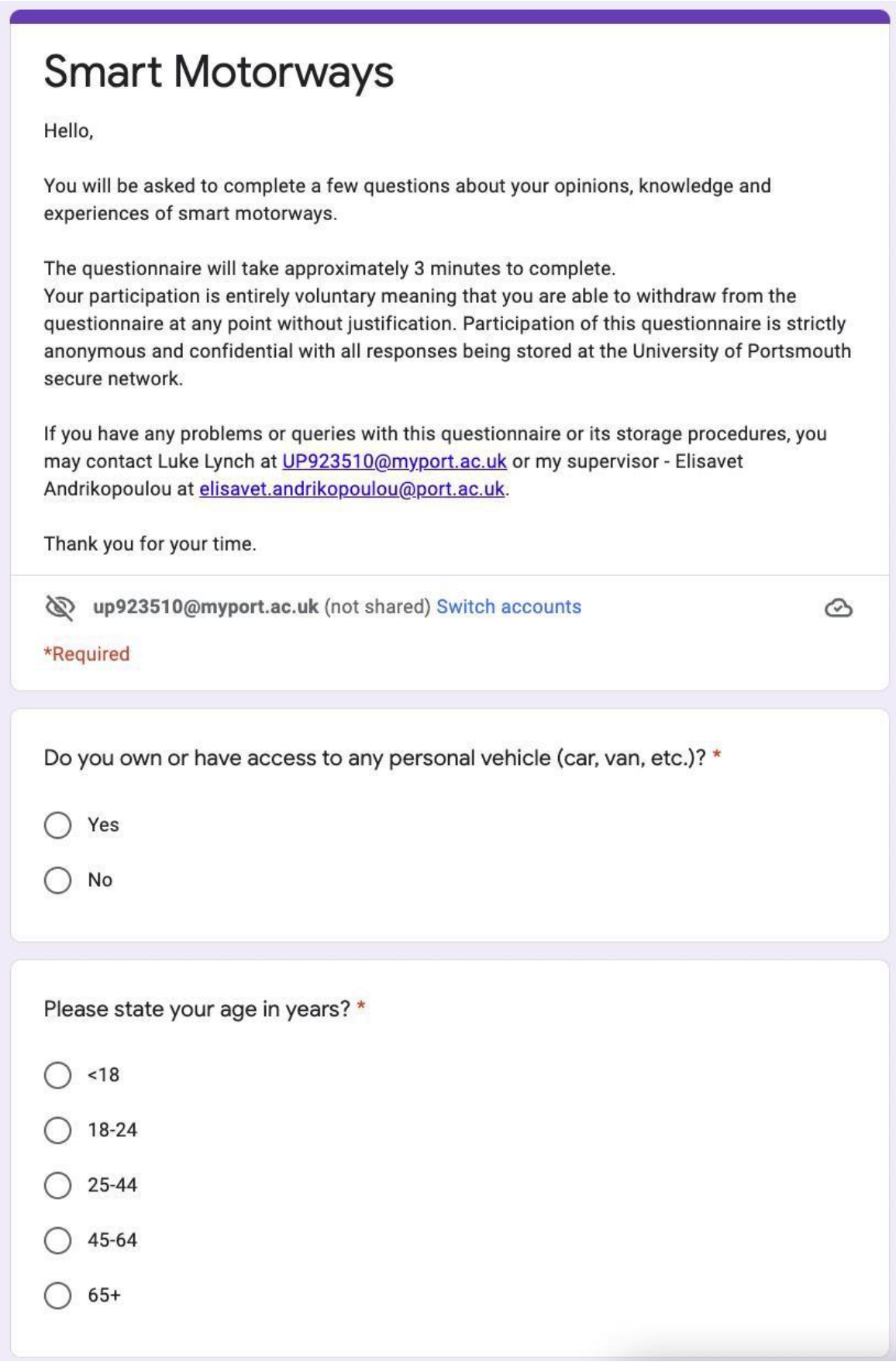
Overall, greater knowledge and awareness about smart motorways are required to improve the perception of smart motorways. It would seem that this is particularly true for all-lane running smart motorways which are both the newest and most physically different type of smart motorway with their removal of the hard shoulder. In concordance with the Transport Committee, (2021) suggestions**, a** greater understanding of how this type of smart motorway is used may also bring safety improvements, especially in the event of a vehicle breakdown. Controlled smart motorways should also be revisited for stretches of motorways which see lower usage due to the familiarity that road users have with them and the safety improvements that they bring over conventional motorways.

Appendix A. Coding dictionary

Age	Gender	Education	Car ownership	Knowledge on Smart motorways
1: 18-24	1: Female	1: GCSE	1: Yes	1: Never heard of them
2: 25-44	2: Male	2: A-level / BTEC	2: No	2: Have heard of them but don't know what they mean
3: 45-64	3: Non-binary	3: Undegraduate		3: Have heard of them and have some idea of what they mean
4 : 65+	4: Prefer not to answer	4: Postgraduate		4: Fully understand what they mean

Figure 8 Data dictionary

Appendix B. Online survey



Smart Motorways

Hello,

You will be asked to complete a few questions about your opinions, knowledge and experiences of smart motorways.

The questionnaire will take approximately 3 minutes to complete.
Your participation is entirely voluntary meaning that you are able to withdraw from the questionnaire at any point without justification. Participation of this questionnaire is strictly anonymous and confidential with all responses being stored at the University of Portsmouth secure network.

If you have any problems or queries with this questionnaire or its storage procedures, you may contact Luke Lynch at UP923510@myport.ac.uk or my supervisor - Elisavet Andrikopoulou at elisavet.andrikopoulou@port.ac.uk.

Thank you for your time.

up923510@myport.ac.uk (not shared) Switch accounts

*Required

Do you own or have access to any personal vehicle (car, van, etc.)? *

- Yes
- No

Please state your age in years? *

- <18
- 18-24
- 25-44
- 45-64
- 65+

Which gender best describes you? *

- ◯ Male
- ◯ Female
- ◯ Non-binary
- ◯ Prefer not to answer

Which education level best describes you? *

- ◯ GCSE
- ◯ A-level / BTEC
- ◯ Undegraduate
- ◯ Postgraduate

How familiar are you with the three types of UK Smart Motorways namely Controlled, Dynamic, and All Lane Running? *

- ◯ Never heard of them
- ◯ Have heard of them but don't know what they mean
- ◯ Have heard of them and have some idea of what they mean
- ◯ Fully understand what they mean

UK Smart Motorways

A smart motorway is a stretch of road where technology is used to regulate traffic flow and ease congestion. There are three main types (Leggett, 2022):

1. Controlled, which have a permanent hard shoulder, but use technology such as variable speed limits to adjust traffic flows.

2. Dynamic, where the hard shoulder can be opened up at peak times and used as an extra lane; when this happens, the speed limit is reduced to 60mph.

3. All-lane running, where the hard shoulder has been permanently removed to provide an extra lane; emergency refuge areas are provided at regular intervals for cars that get into trouble.

Controlled smart motorway (Dixon, n.d.)

Dynamic smart motorway (revtothelimit, 2021)

All-lane running smart motorway (Jones, 2019)

On a scale of 1 – 5, please state how strongly you agree or disagree with the following 7 statements. *

	1 - Strongly disagree	2 - Disagree	3 - Indifferent	4 - Agree	5 - Strongly agree	No opinion / Prefer not to answer
I am willing to use smart motorways if they can reduce travel time	○	○	○	○	○	○
I am willing to use smart motorways if they can reduce CO2 emissions	○	○	○	○	○	○
I feel comfortable with using smart motorways	○	○	○	○	○	○
I feel that it is safe to use smart motorways	○	○	○	○	○	○
I feel that I could confuse or misinterpret information provided by smart motorways (e.g., variable dynamic use of the hard shoulder lane)	○	○	○	○	○	○
I find it useful that technology is being incorporated into motorways	○	○	○	○	○	○

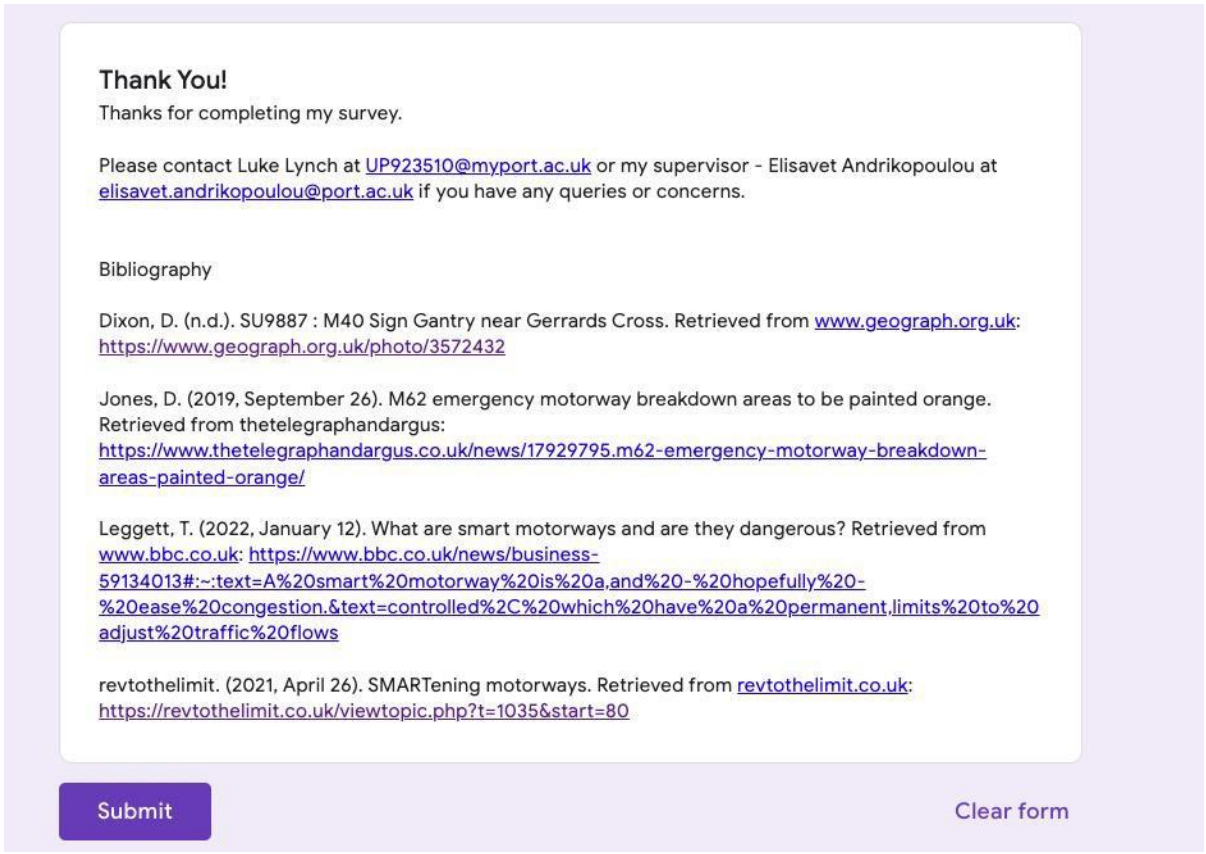
I do not mind using either conventional motorways or smart motorways	○	○	○	○	○	○

Please state which type of smart motorway you would choose in the following 4 areas *

	Dynamic smart motorway	Equal	All-lane running smart motorway
I feel the most comfortable travelling on	○	○	○
I feel will reduce travelling time the most	○	○	○
I feel is the easiest to use	○	○	○
I feel is the safest	○	○	○

Do you have any comments or suggestions?

Your answer



Ethics approval:

The authors were granted ethics approval by the ethics committee of Portsmouth University for the interviews and questionnaires that were conducted by the authors.

References

Sinharay, S. (2010). An overview of statistics in education. In *International Encyclopedia of Education* (pp. 1–11). Elsevier Ltd. https://doi.org/10.1016/B978-0-08-044894-7.01719-X

Creswell, J. W., & Plano-Clark, V. L. (2011). Choosing a Mixed Methods Design.pdf. In *Designing and Conducting Mixed Methods Research* (p. 457). https://doi.org/10.18553/jmcp.2008.14.S6-B.21

Riffenburgh, R. H. (2012). *Statistics in Medicine: Vol. 3rd ed*. Academic Press.

Highways England. (2016). *When to use a hard shoulder Smart motorways*. www.highways.gov.uk/smartmotorways

Callaghan, N., Avery, T., & Mulville, M. (2017). "Smart" motorway innovation for achieving greater safety and hard shoulder management. *Association of Researchers in Construction Management, ARCOM - 33rd Annual Conference 2017, Proceeding*, 745–754. https://doi.org/10.21427/D7N50T

Kaur, P., Stoltzfus, J., & Yellapu, V. (2018). Descriptive statistics. *International Journal of Academic Medicine*, *4*(1), 60–63. https://doi.org/10.4103/IJAM.IJAM_7_18

Jallow, H., Renukappa, S., & Alneyadi, A. (2019). The Concept of Smart Motorways. *2019 3rd International Conference on Smart Grid and Smart Cities (ICSGSC)*, 18–21. https://doi.org/10.1109/ICSGSC.2019.00-25

Statistics Solutions. (2020). *Conduct and Interpret a Cluster Analysis*. Regression [Online]. http://www.statisticssolutions.com

Department for Transport. (2020). Smart Motorway Safety - Evidence Stocktake and Action Plan. *Department for Transport*, *January*, 1–78. www.gov.uk/dftGeneralenquiries:https://forms.dft.gov.uk

IBM. (2021). *Predictor Importance*. https://www.ibm.com/docs/en/spss-modeler/18.1.0?topic=SS3RA7_18.1.0/modeler_mainhelp_client_ddita/clementine/idh_common_predictor_importance.htm

National Highways. (2021). *Dynamic Hard Shoulder enhancements*. National Highways. /our-work/smart-motorways-evidence-stocktake/dynamic-hard-shoulder-enhancements/

Transport Committee. (2021). *Rollout and safety of smart motorways Third Report of Session 2021–22*. https://committees.parliament.uk/publications/7703/documents/80447/default/