A Mixed-Methods Approach Using Virtual Reality to Study User Reactions to Self-Driving Vehicles

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1 PROBLEM

Context

- Usual data collection methods are insufficient to understand self-driving vehicle passenger experience, because most potential users have not yet experienced these vehicles.
- Virtual reality is a solution, but most previous studies using this method have analysed only one type of self-driving vehicle (usually a private car)

Objectives

Assess reactions to different aspects of self-driving cars and buses, when experienced in virtual reality

2 METHODS

6-minute experience of a virtual self-driving vehicle in MetaQuest Pro

Participants chose between car or bus, but could switch (once) during the trip

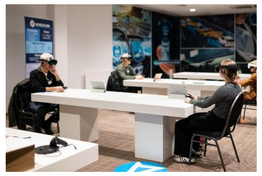
Virtual self-driving car

Virtual self-driving bus

Virtual car and bus trips had nine stages, defined by a combination of attributes

Attribute	Stages								
	1	2	3	4	5	6	7	8	9
Landscape	City centre			Industrial	Centre	Industrial	Centre	Industrial	Residential
Time of day	Daytime		Gradually getting darker					Night-time	
CAR ONLY									
Congestion	No	Progressively worse						Eases up	No
BUS ONLY									
Passengers	Few	Many		Few					None
Passenger behaviour	Mind their own business					Annoying (feet on seats, loud music)			No other passenger
Assistant	Present			Absent					

Participants wore non-invasive electroencephalography (EEG) earbuds (EMOTIV MN8).



Ratio between the beta (16-25Hz) and alpha (8-12Hz) powers was used as an indicator of stress/arousal

After the experiment, participants answered a questionnaire and talked about the two vehicles, in groups

Participants

- 92 total: 34 in Netherlands, 30 in Poland, 28 in Greece
- 53% men, 47% women, 24% aged 18-34, 44% aged 35-64, 32% aged 65+

3 RESULTS – EEG

*Stars identify differences that are significantly positive, i.e. the stress indicator is significantly higher than the baseline indicator for the same group of participants, based on t-tests. Significance levels: ***: 1%, **: 5%, *:10%.*

Difference between stress indicator (beta-alpha ratio) in each CAR scenario stage vs. baseline

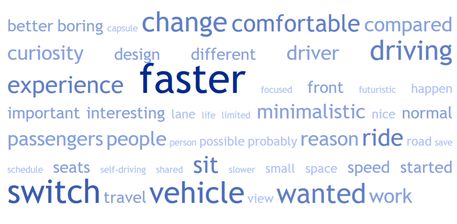
Attribute	Stages								
	1	2	3	4	5	6	7	8	9
Landscape	City centre			Industrial	Centre	Industrial	Centre	Industrial	Residential
Time of day	Daytime		Gradually getting darker					Night-time	
Congestion	No	Gets progressively worse						Eases up	No
All	-0.03	-0.03	0.02	0.05	0.05	0.09	0.11*	0.03	0.08
Men	-0.08	0.00	0.05	0.08	0.08*	0.04	0.06*	0.02	0.06
Women	0.02	-0.05	-0.02	0.03	0.01	0.14	0.15	0.02	0.11
18-34	-0.19	-0.15	-0.15	0.02	-0.02	0.08	0.08	0.07	0.09*
35-64	0.00	-0.23	-0.02	-0.11	-0.05	-0.07	0.00	-0.08	-0.03
65+	0.09	0.33**	0.41**	0.41***	0.27***	0.36***	0.33**	0.16**	0.29**

Difference between stress indicator (beta-alpha ratio) in each BUS scenario stage vs. baseline

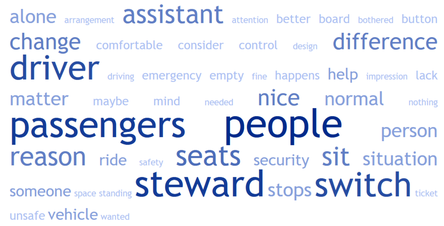
Attribute	Stages								
	1	2	3	4	5	6	7	8	9
Landscape	City centre			Industrial	Centre	Industrial	Centre	Industrial	Residential
Time of day	Daytime		Gradually getting darker					Night-time	
Passengers	Few	Many		Few					None
Passenger behaviour	Mind their own business					Annoying (feet on seats, loud music)			No other passenger
Assistant	Present			Absent					
All	0.00	0.07*	0.16**	0.19**	0.12	0.16*	0.15*	0.20*	0.09
Men	-0.01	0.00	0.13	0.15	0.09	0.12	0.08	0.08	0.06
Women	0.01	0.16**	0.22**	0.26**	0.18*	0.22**	0.28*	0.43**	0.15*
18-34	-0.02	0.13**	0.15	0.12	0.13	0.05	0.09	0.11	-0.05
35-64	-0.06	0.01	0.12	0.12	0.07	0.15*	-0.03	-0.03	0.03
65+	0.09	0.11	0.22**	0.31**	0.17	0.24**	0.37**	0.47**	0.21*

4 RESULTS – Group discussions

Most common words used to talk about the virtual CAR

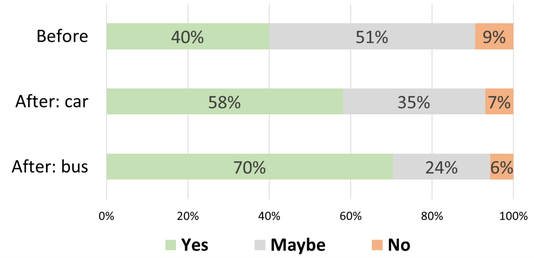


Most common words used to talk about the virtual BUS



5 RESULTS – Survey

Intention to use self-driving vehicles, before and after the experiment



6 CONCLUSIONS

- Evidence of stress/arousal in virtual self-driving bus with many passengers or when other passengers are annoying, especially among women and the 65+ group
- Less evidence of stress/arousal when travelling in virtual self-driving car, except for 65+ group.
- Discussions suggest passengers concern about self-driving car being stuck in congestion and about other passengers and lack of human steward in self-driving bus
- Despite these issues, there was a marked increased in intentions to use self-driving vehicles after experiencing them in virtual reality

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