Human-machine communication in self-driving cars
verbal feedforward and feedback increase trust, but not the intention to use it.

a population study in an immersive virtual reality experiment.

Fully autonomous vehicles as cognitive agents will be one of the notable use cas es of artificial intelligence in the middle of modern societies. However, the potential positive effects of this technology will only apply if autonomous cars are accepted by most of the society the cars will operate in. To increase acceptance and trust, we created a virtual self-explaining car informing passengers before actions. In this study, we investigate the current attitude of the German and Austrian population (N = 8599) in a virtual reality experience. Participants experienced a ninety seconds virtual drive in one of three conditions of auditive feedforward and feedback, while head tracking data and a simplified gaze vector was recorded. Our main finding is that a self-explaining car does have a positive impact on trust but does not influence the intention of using such a car.

Additionally, we can show gender and age effects with female participants being generally less trusting in all conditions than male participants and a general decrease of acceptance with increasing age. Results are in line with previous human-machine research, supporting found gender differences and the fact that communications increase driving safety and negative emotional responses. These findings reveal a need for a well-balanced self-explanatory artificial intelligence to enable human-machine interactions that foster safe traffic behavior and increase trust as well as the willingness to use such technology.

Introduction

Autonomous driving vehicles (ADVs) seem to be the primary goal of nearly all car manufacturers. More and more highly automated driving systems are implemented into newly developed cars (Dajsuren & van den Brand, 2019). Technical developments in the field are fast and continuously improving. There is little doubt that self-driving cars will significantly impact our society, such as drastically decreasing greenhouse gas emissions and reducing the number of traffic-related injuries and fatalities (Benleulmi & Blecker, 2017, Ryan 2019). However, in order for these positive aspects to be realized, it is necessary to be able to use these vehicles in public. This means public acceptance is the crucial factor for autonomous vehicles.
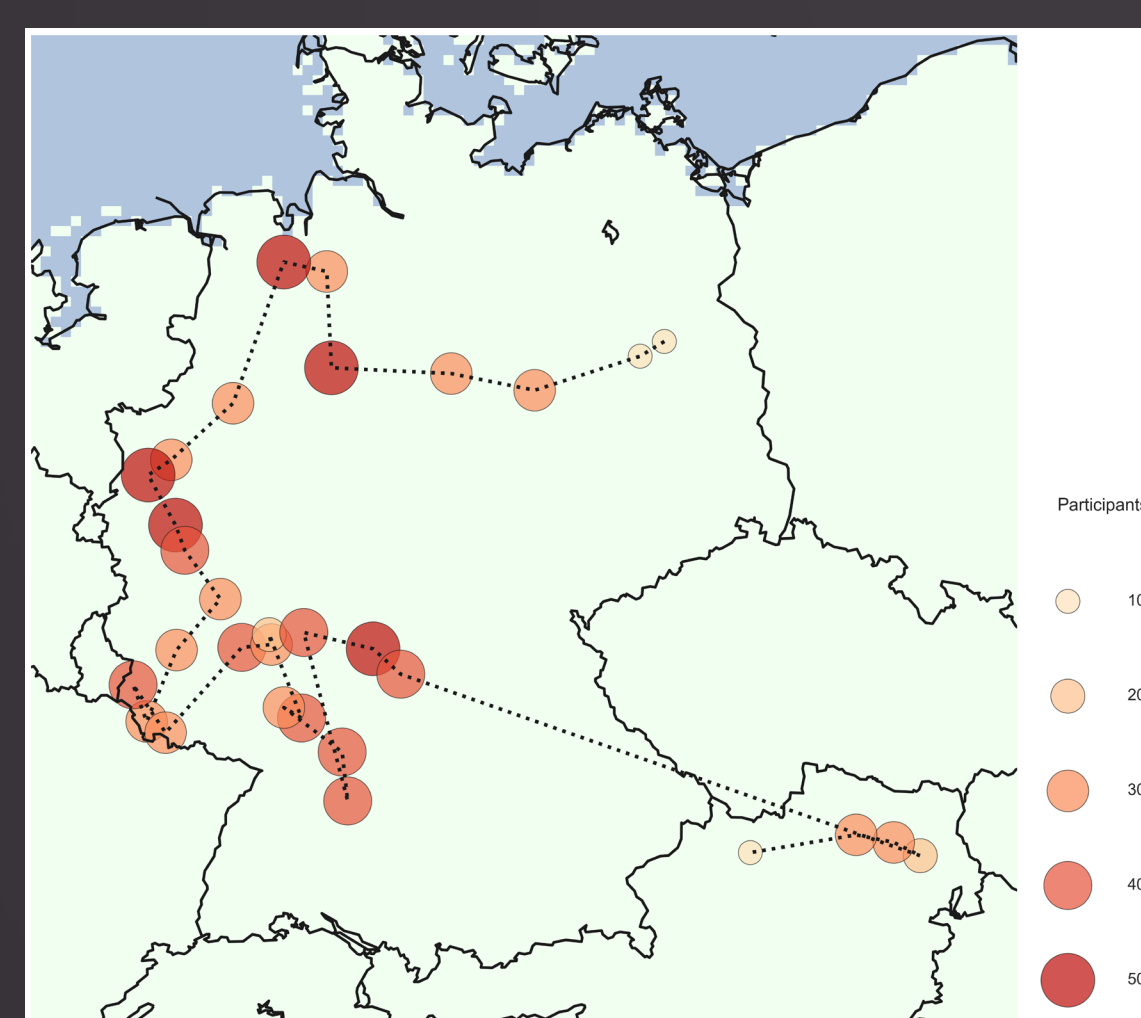
Still, It is not precisely clear yet which factors modulate the acceptance of self-driving vehicles. However, the technology must be well accepted to play out possible improvements in traffic. Previous research could already show that too much information about a car's driving state is distracting (Koo et al., 2014). However, these findings instead focus on human performance in a driving situation than on emotional valence. To gain insight into which factors modulate the acceptance towards ADVs, we developed an interactive large-scale virtual reality (VR) experiment, where participants experienced an ADV giving feedforward and feedback about its current driving status.

1. How do demographic factors affect the acceptance of self-driving cars?

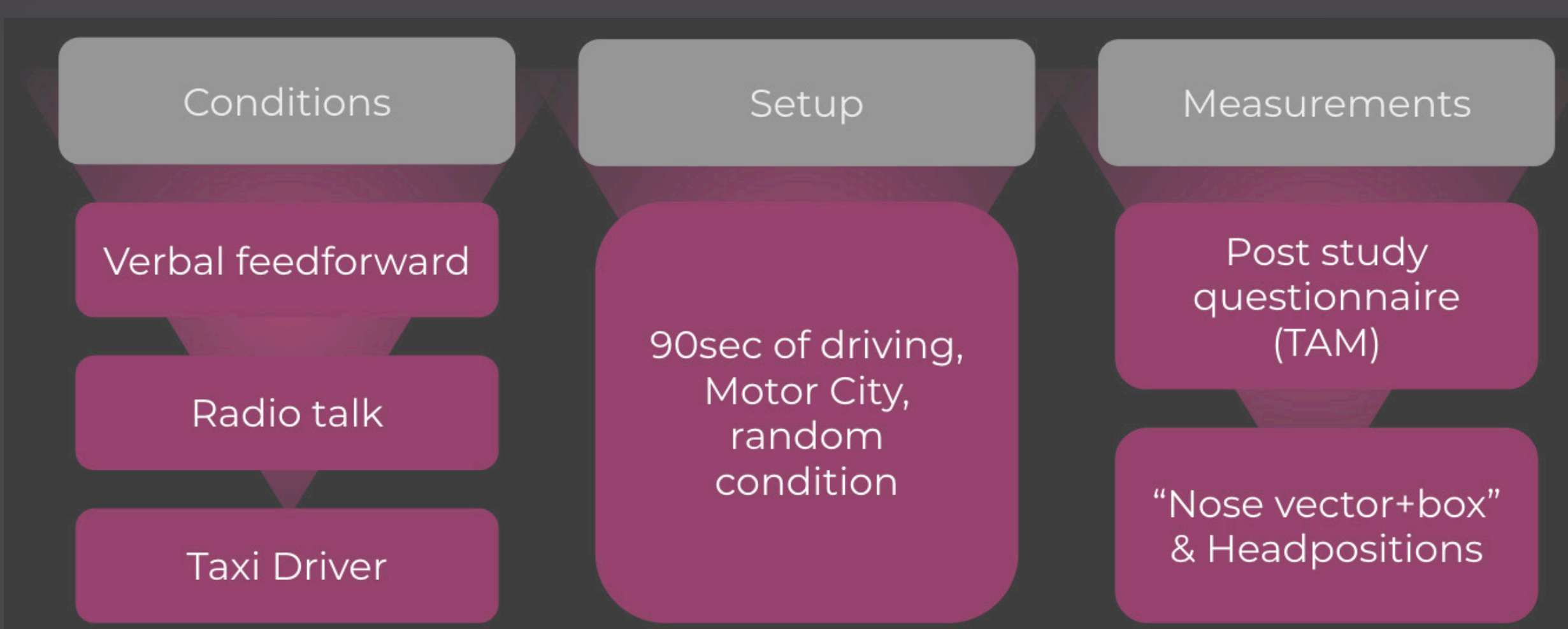2. Does a transparent AI helps to build trust in self-driving cars?

Methods

To be able to make statements about the general attitude of an entire population, a large number of subjects in a wide age spectrum are required. In the study at hand, we present a dataset of 8599 participants (3407 female) answering an adapted technology acceptance questionnaire (TAM V2). We use a setup inside the MS-Wissenschaft, a traveling exhibition ship of German's ministry of research and education, across 28 cities in Germany and three cities in Austria over six months. The participants include 4464 male and 3386 female subjects (M = 30, SD = 3.45). However, the remaining participants identify as intersex who have been excluded from the analysis due to the imbalance in the number of participants in this category compared to those who identified themselves as either male or femalewith female participants being generally less trusting in all conditions than male participants. These findings were confirmed in the second setup of the experiment.
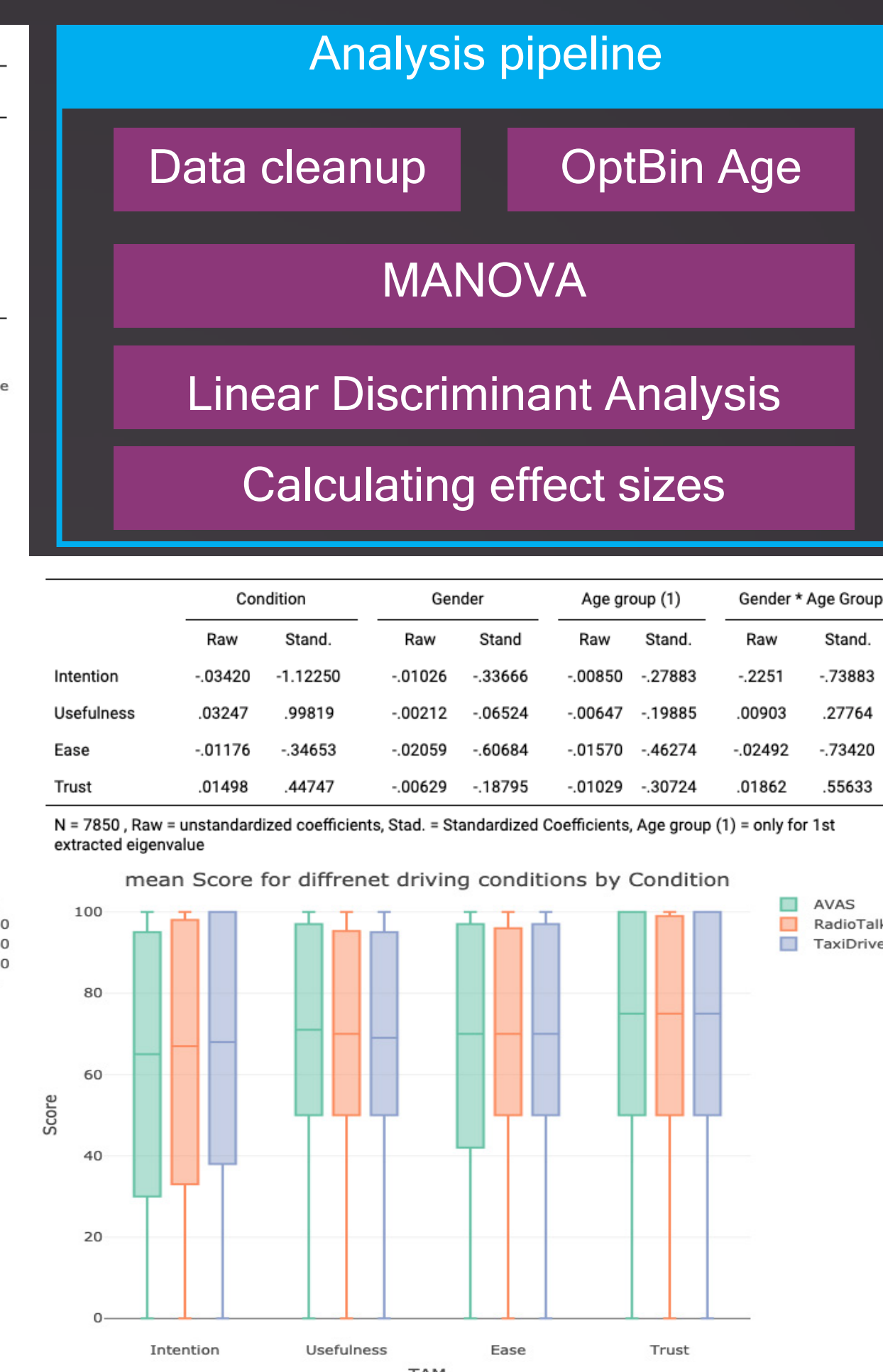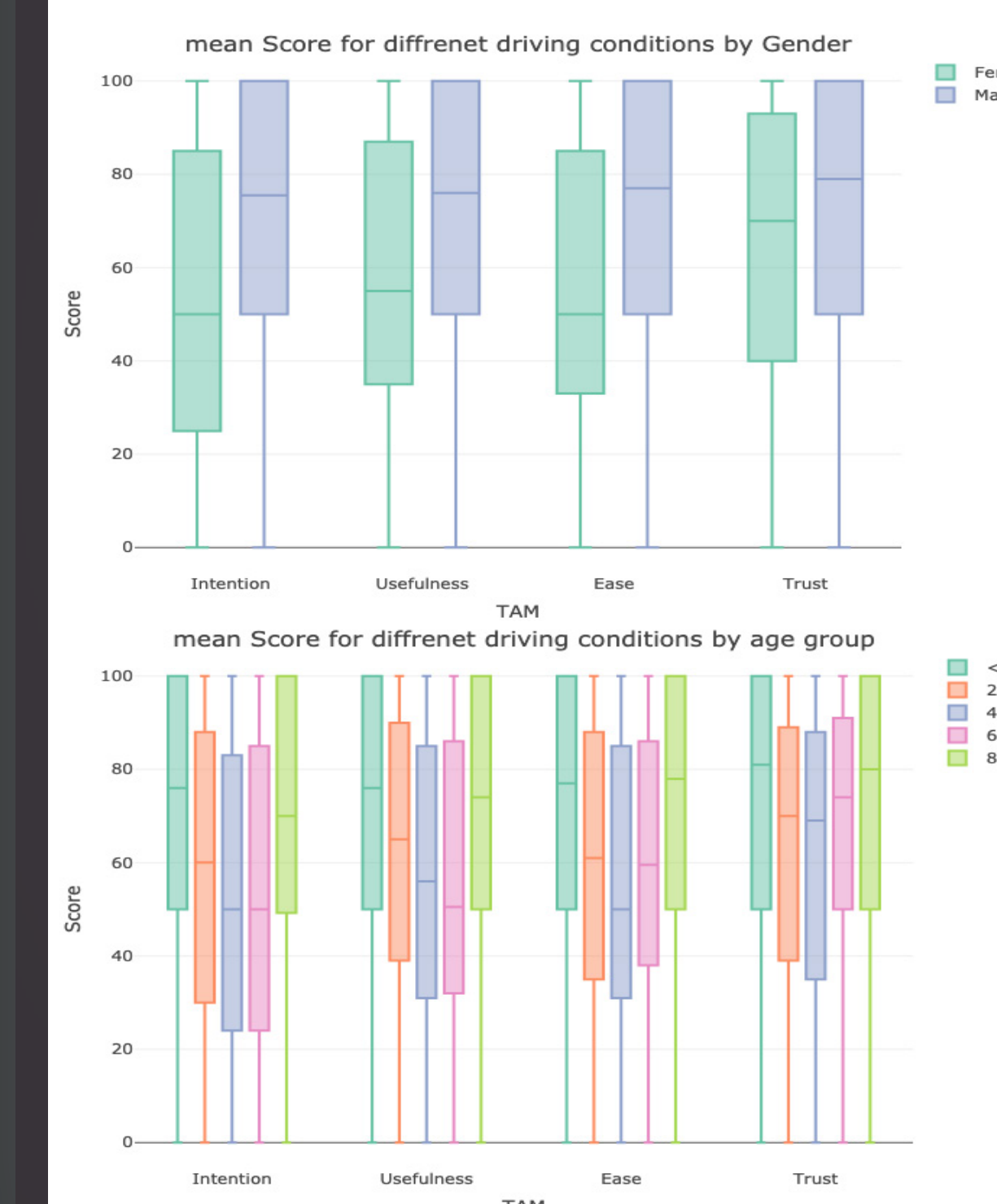
Experiment Design

Conditions	Setup	Measurements
Verbal feedforward	90sec of driving, Motor City, random condition	Post study questionnaire (TAM)
Radio talk		"Nose vector+box" & Headpositions
Taxi Driver		

Intention + Usefulness + Ease + Trust ~ Condition +
Gender +
AgeGroup +
Gender:AgeGroup

Results

Analysis pipeline

Data cleanup	OptBin Age
MANOVA	
Linear Discriminant Analysis	
Calculating effect sizes	

MANOVA

Dependant Variables	Hypo. df	Error df	Pillai's Trace	F value	P value
Condition	8.00	15672.00	.00259	2.54122	.009
Gender	4.00	7835.00	.00293	5.76144	.000
AgeGroup	16.00	31352.00	.04861	24.10754	.000
Gender:AgeGroup	16.00	31352.00	.00498	2.44198	.001

	Condition		Gender		Age group (1)		Gender * Age Group	
	Raw	Stand.	Raw	Stand.	Raw	Stand.	Raw	Stand.
Intention	.03420	-1.12250	-.01026	-.33666	-.00850	-.27863	-.2251	-.73883
Usefulness	.03247	.99819	-.00212	-.06524	-.00647	-.19885	.00903	.27764
Ease	-.01176	-.34653	-.02059	-.60684	-.01570	-.46274	-.02492	-.73420
Trust	.01498	.44747	-.00629	-.18795	-.01029	-.30724	.01862	.55633

N = 7850, Raw = unstandardized coefficients, Stad = Standardized Coefficients, Age group (1) = only for 1st extracted eigenvalue

Conclusion

Main findings

Strong effect of age group
Strong effect of gender
Strong effect of condition
Interaction of gender and age group

- Female Participants scored lower on all acceptance factors compared to their male counterparts.

- As age increases we observe an initial decline in acceptance of self-driving cars.

- for older ages we observe an increase in overall acceptance of self-driving cars.

Although driving condition has a strong effect on the acceptance, it does not affect different aspects of acceptance the same.

A self-driving car with an explainable AI, although it increases trust, it does not increase the intention of use!

Demographic factors such as age and gender has bigger impact on the acceptance of self-driving cars

Authors

Farbod N. Nezami1‡*, Maximilian A. Wächter1‡, Ashima Keshava1, Hristofor Lukanov1, Marc Vidal De Palol1, Gordon Pipa1*, Peter König1, 2*

1 Institute of Cognitive Science, University of Osnabrück, Osnabrück, Germany
2Department of Neurophysiology and Pathophysiology, Center of Experimental Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany
‡ Shared First Authorship
* shared senior authorship
*Correspondence: Farbod Nosrat Nezami, fnosratnezam@uos.de

UNIVERSITÄT OSNABRÜCK

va-eva

Stiftung
Stahlwerk Georgsmarienhütte