

Human Behavior in Severe Tunnel Accidents

Lessons learned from field and virtual reality studies

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1. SKRIBT^{Plus}
2. Motivation
3. Psychological factors in tunnel emergencies
4. VR Studies
5. Field Study
6. Conclusion and Outlook



Protection of Critical Bridges and Tunnels

German national research project on protection of
critical road transport infrastructure

www.skribt.org



Freitag, 30. April 2010 10:58 Uhr
URL: <http://www.allgemeine-zeitung.de/region/mainz/meldungen/8681757.htm>

Allgemeine Zeitung

MAINZ

Schrecksekunde im Hechtsheimer Autobahntunnel - Angeblich Lebensgefahr

24.03.2010 - MAINZ

Von Erich Michael Lang

Die Pannenserie im Hechtsheimer Autobahntunnel reißt nicht ab. Wie erst am Mittwoch bekannt wurde, versetzte am vergangenen Dienstagmorgen die Lautsprecheranlage die Autofahrer, die mal wieder in einem der üblichen Berufsverkehrsstaus steckten, in Angst und Schrecken. Lebensgefahr bestehe, alle sollten umgehend ihre Autos verlassen und die Schlüssel stecken lassen, hieß es. „Völlig verunsichert und in Panik schauten wir uns (die im Stau stehenden Autofahrer) gegenseitig an, aber niemand traute sich auszusteigen. Für fünf Minuten stand der Verkehr völlig still. Der Gegenverkehr wurde vor dem Tunnel gestoppt“, berichtet ein Augen- und Ohrenzeuge.

Grund für die nervenaufreibende Schrecksekunde war ein Fehlalarm in der Brandmeldeanlage. Wenn die Temperatur punktuell im Tunnel plötzlich ansteige und zudem eine Sichttrübung gemessen werde, löse der Computer Feueralarm aus. Die Alarmskette läuft dann elektronisch ab, einschließlich der angsteinflößenden Lautsprecheransage, so die Autobahnpolizei auf AZ-Anfrage. Innerhalb von sechs Minuten sei der Spuk vorbei gewesen.

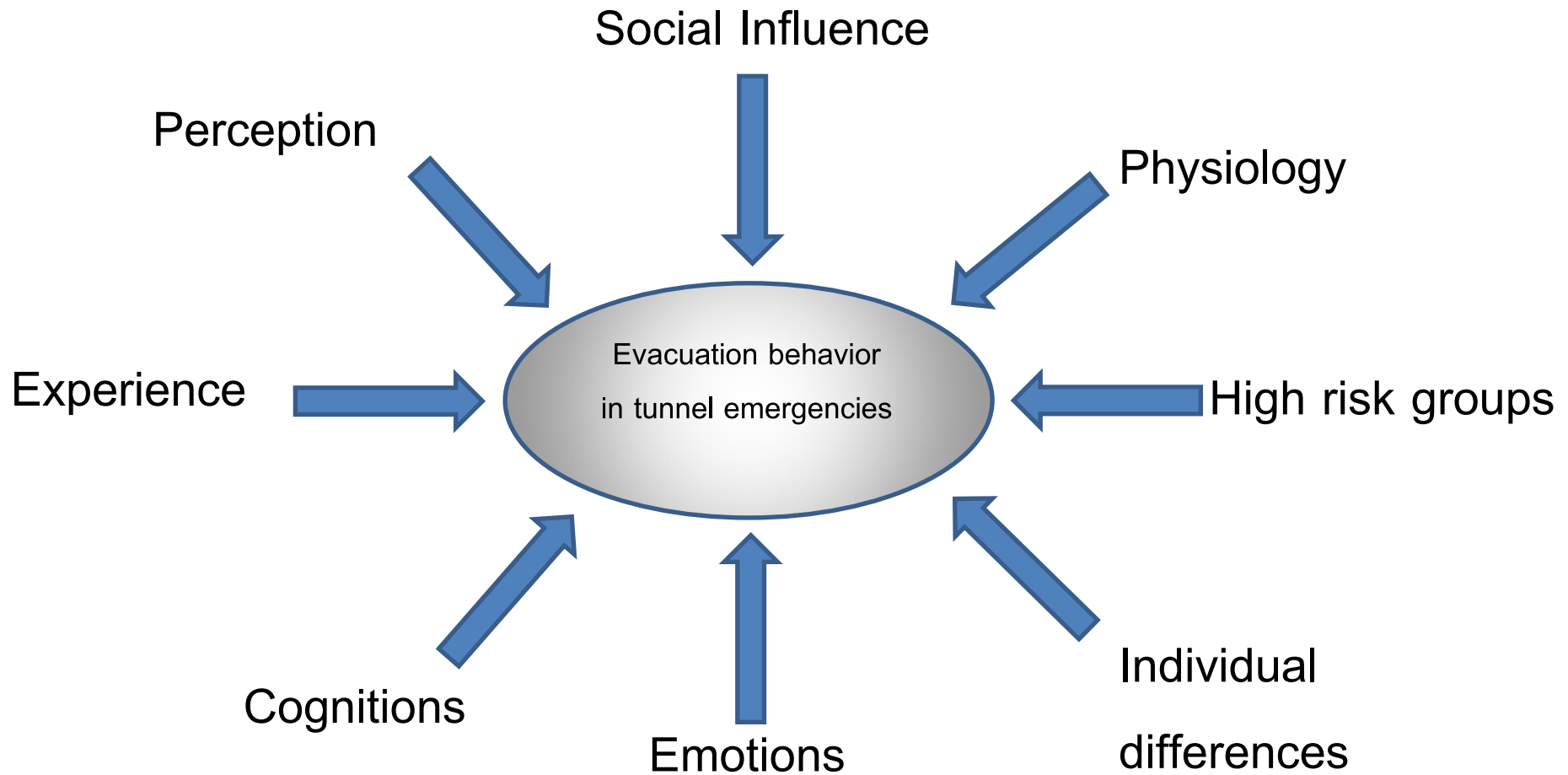


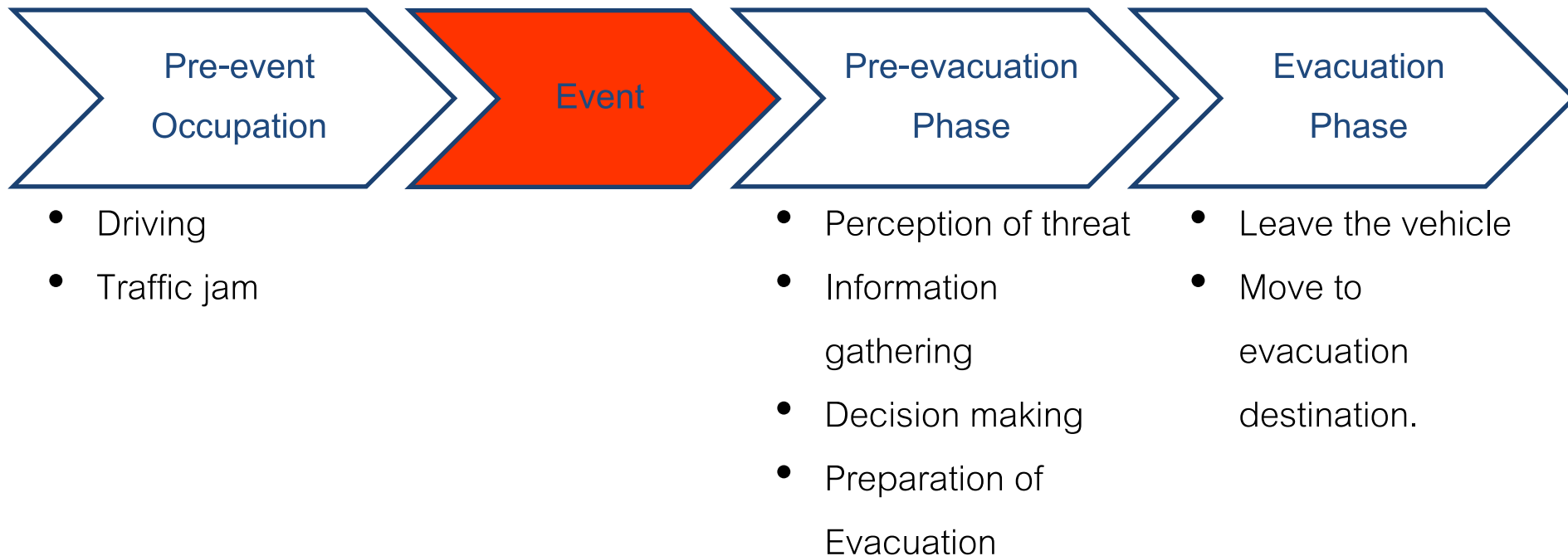
Der Autobahntunnel auf der A 60 bei Mainz-Hechtsheim. Foto: Sascha Kopp






False fire alarm in a tunnel on a national road near Mainz, Germany (2010):

Traffic participants were instructed via loudspeaker to leave the tunnel, but only few actually left their car.



“We [the traffic participants] looked at each other, but nobody dared to leave the car.”





-  Occupants do not always use emergency exits to evacuate (Nilsson, Johansson, & Frantzich, 2009)
-  Social influence on decision to leave the vehicle and the exit choice in tunnel emergencies (Nilsson, Johansson, & Frantzich, 2009)
-  Tendency to move back towards the tunnel entrance portal (Beard & Carvel, 2005; Sime, 1985)
-  Social influence becomes more important if information is limited or ambiguous (Nilsson & Johansson, 2009)
-  Passive behavior of others may thwart immediate evacuation (Latané & Darley, 1968)

Research Questions

-  How do passive virtual agents influence participants behavior during a tunnel emergency?
-  Does information improve behavior and overcome possible negative effects of SI?



N = 60



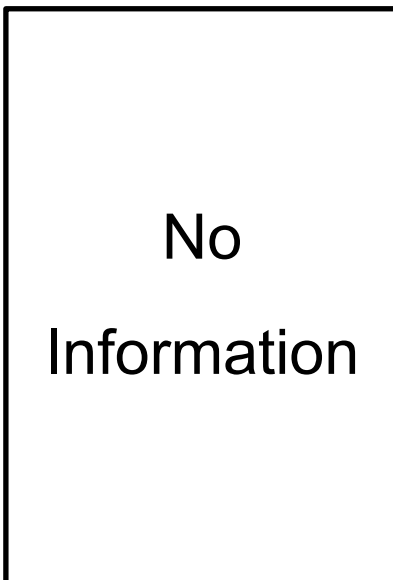
4 groups with 15 participants

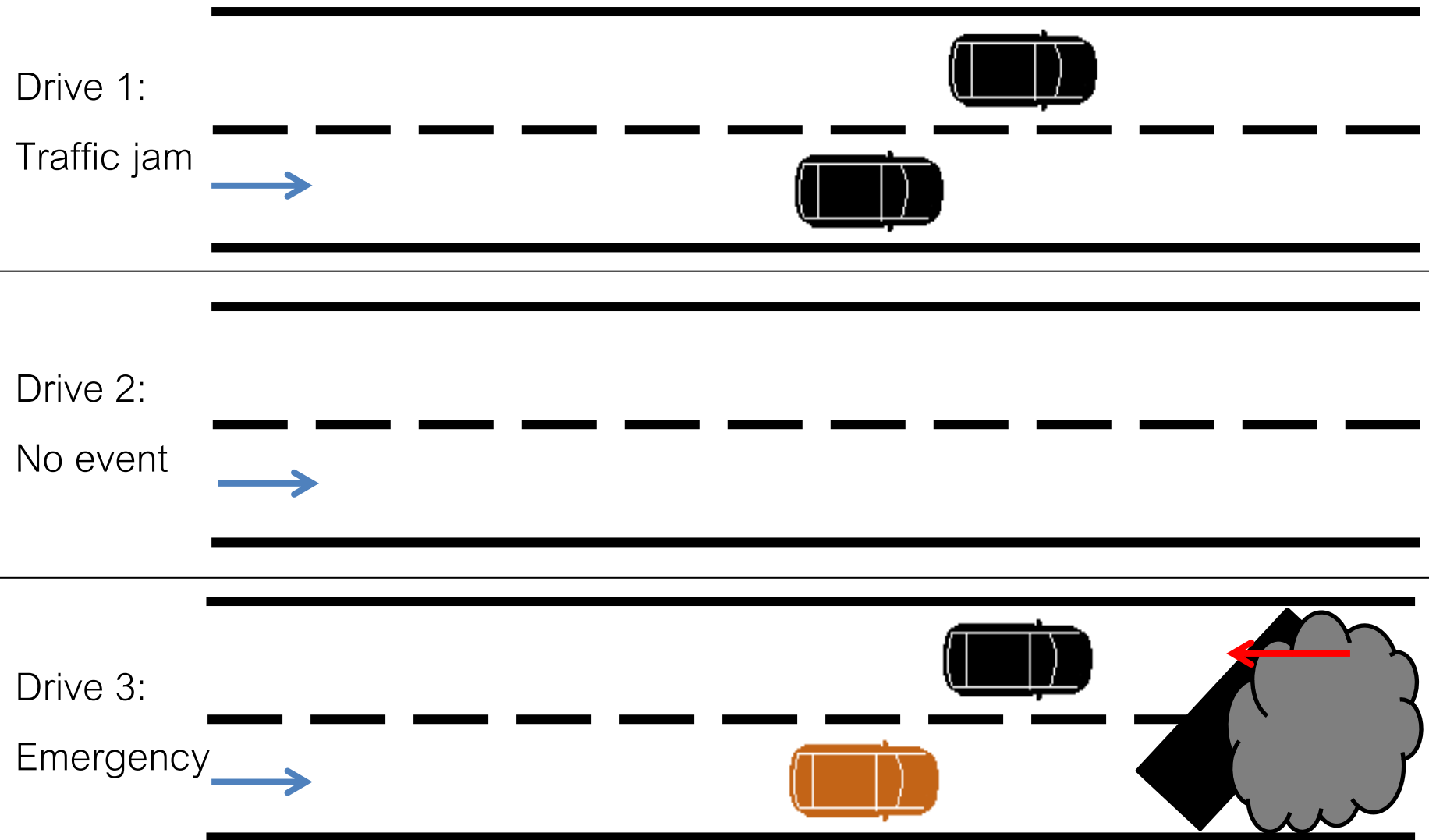


Age: 24.58 ± 5.08 years



30 Female participants

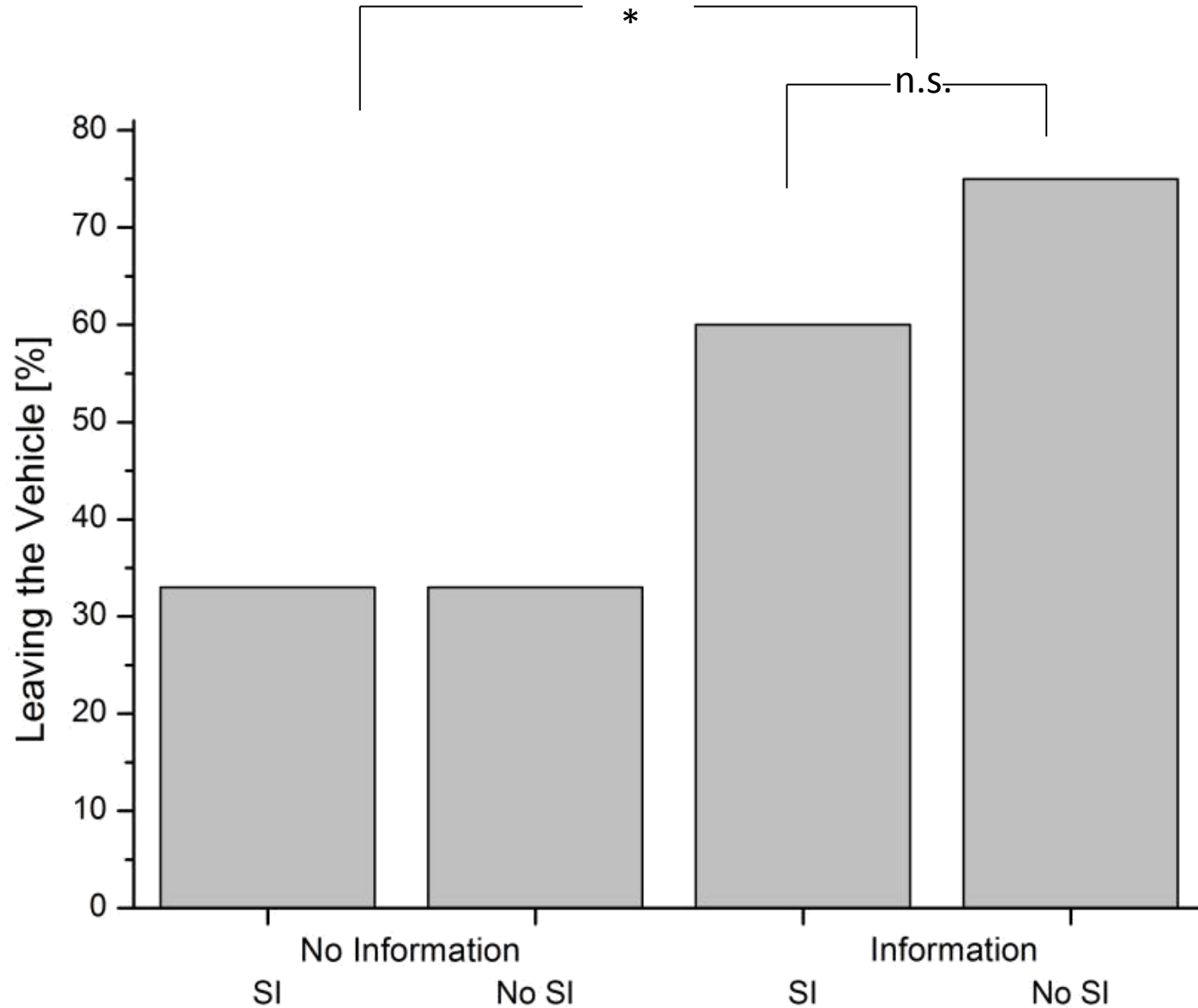




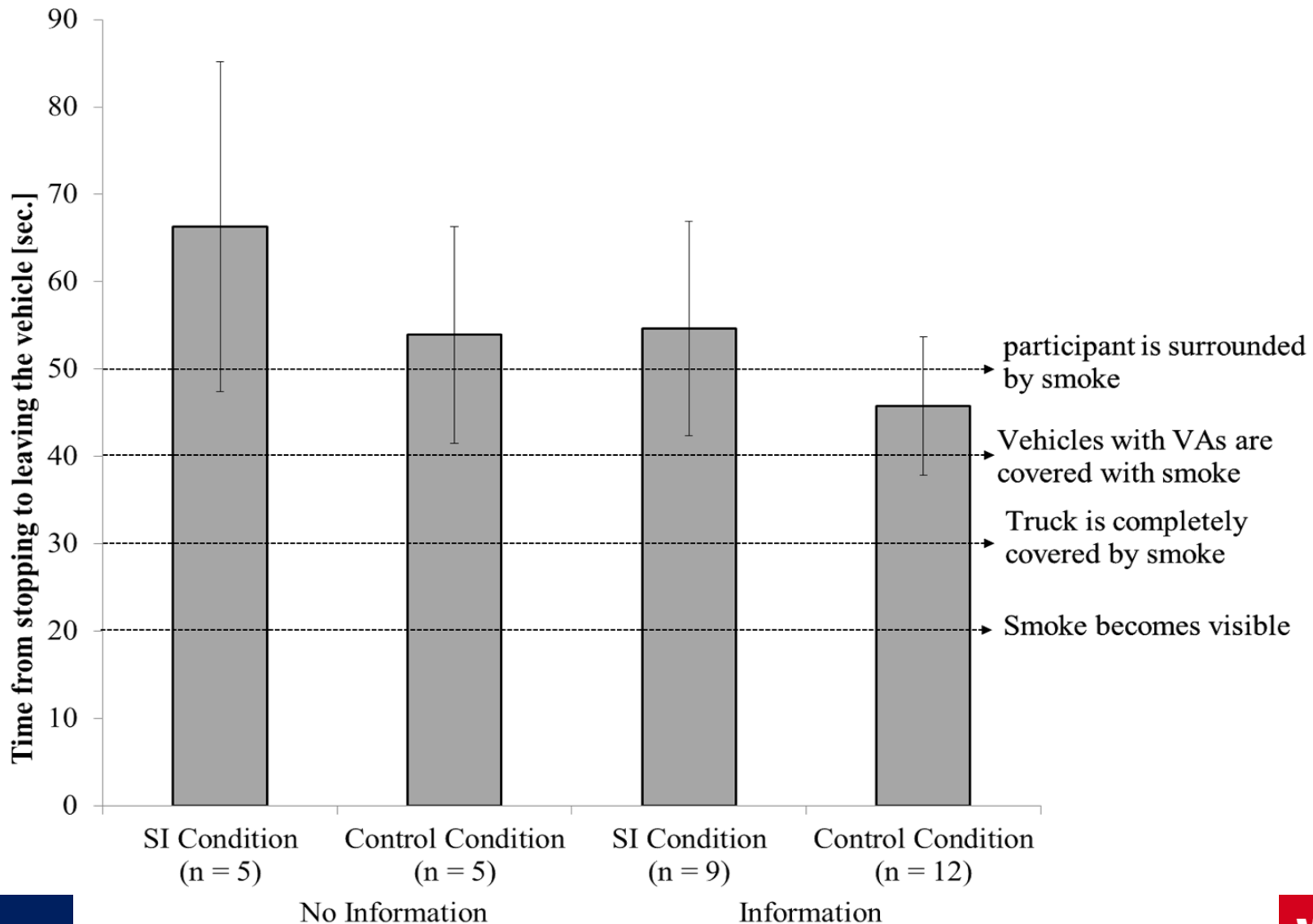


1. Head Mounted Display
2. Moving Platform
3. Navigation Devices





$$\chi^2(3) = 7.35, p = .06$$



SI = Social Influence

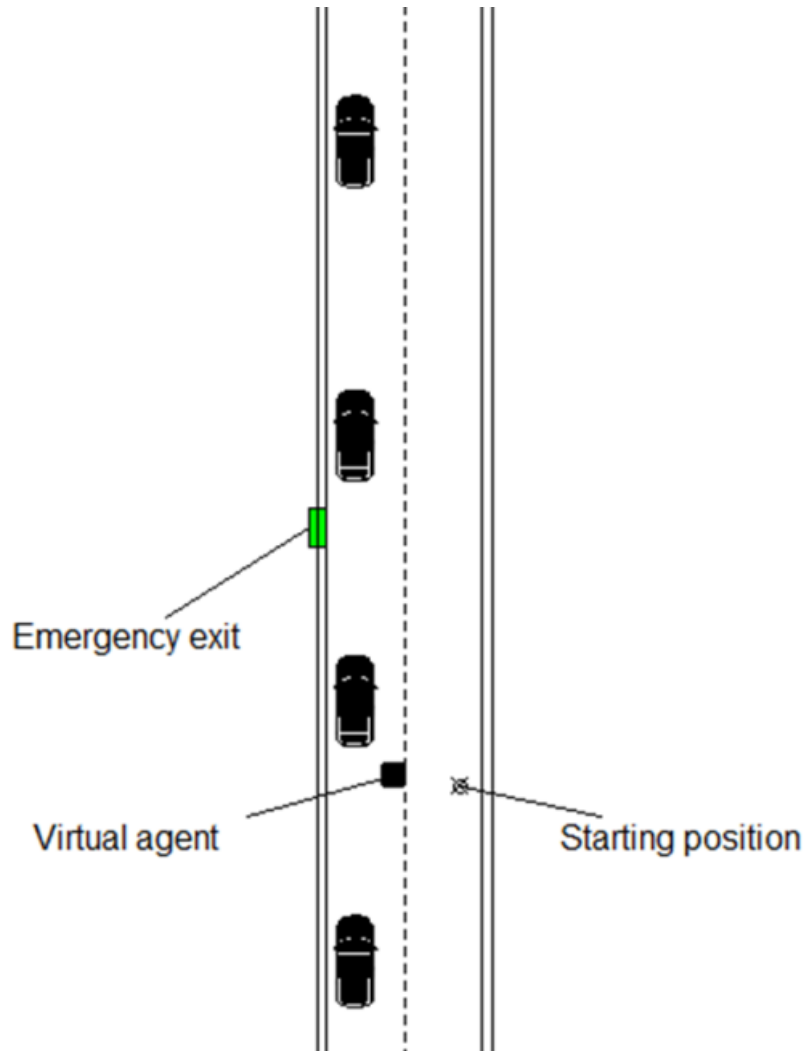
Research Questions



What happens after tunnel users leave their vehicle?



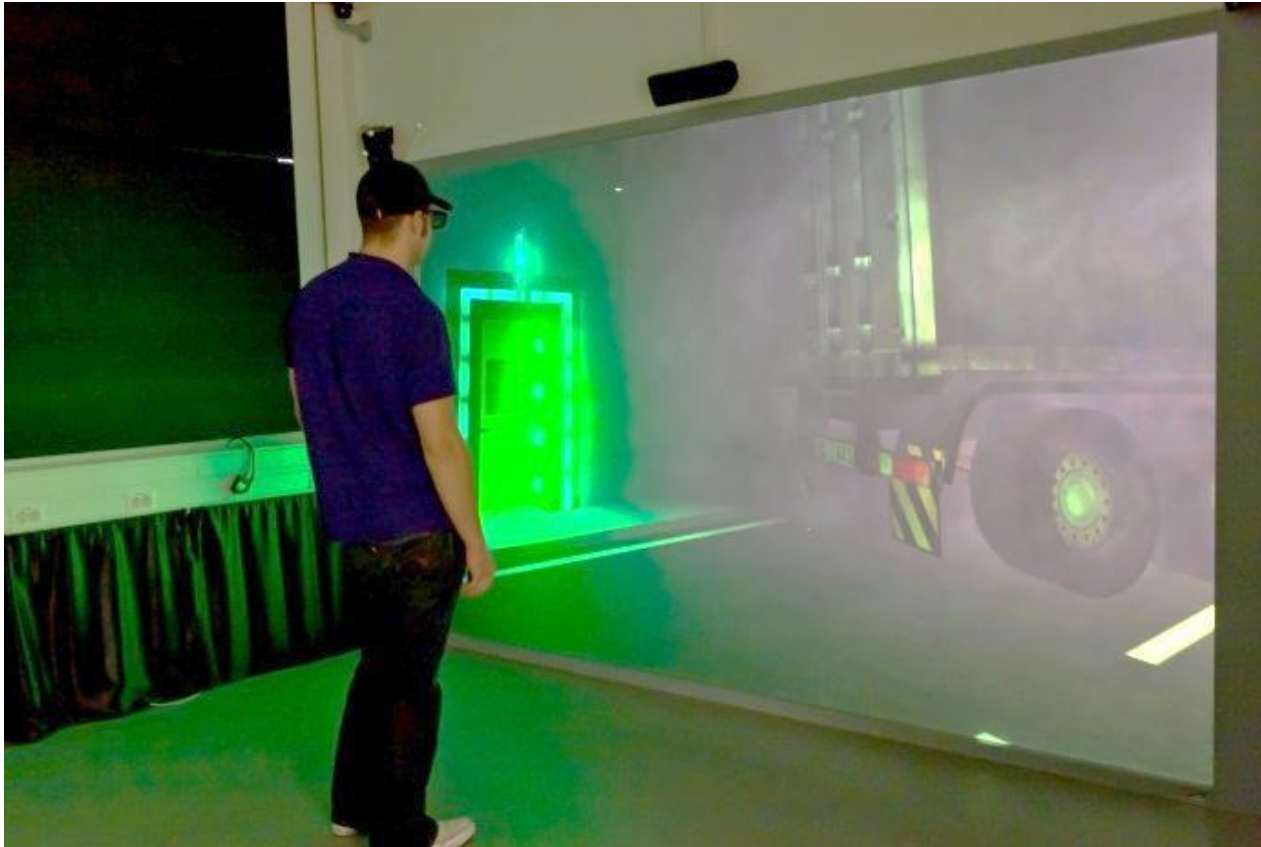
What effect does Social Influence have on the use of emergency exits?



Experimental Conditions

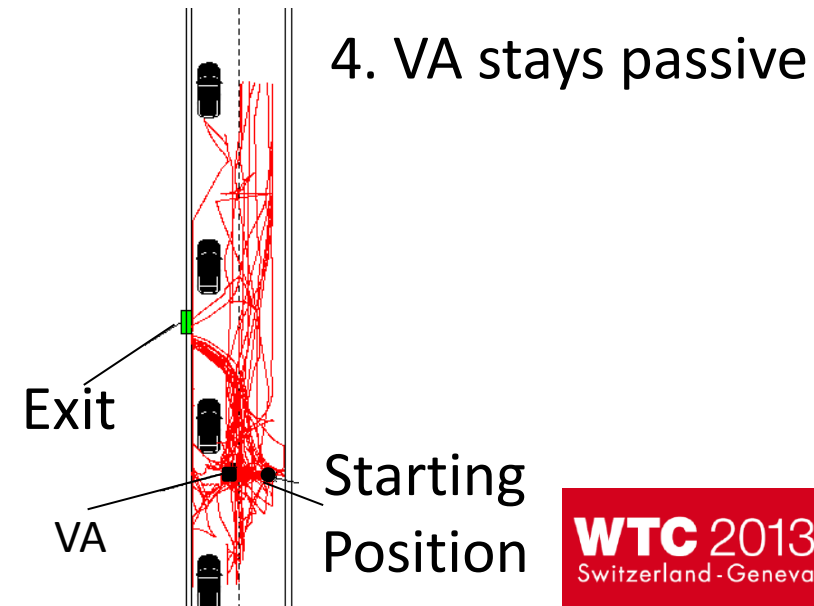
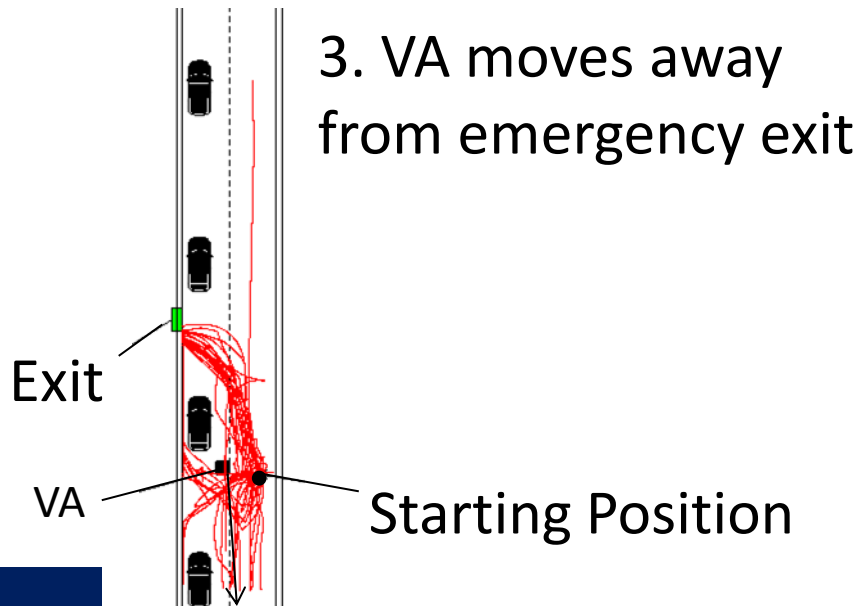
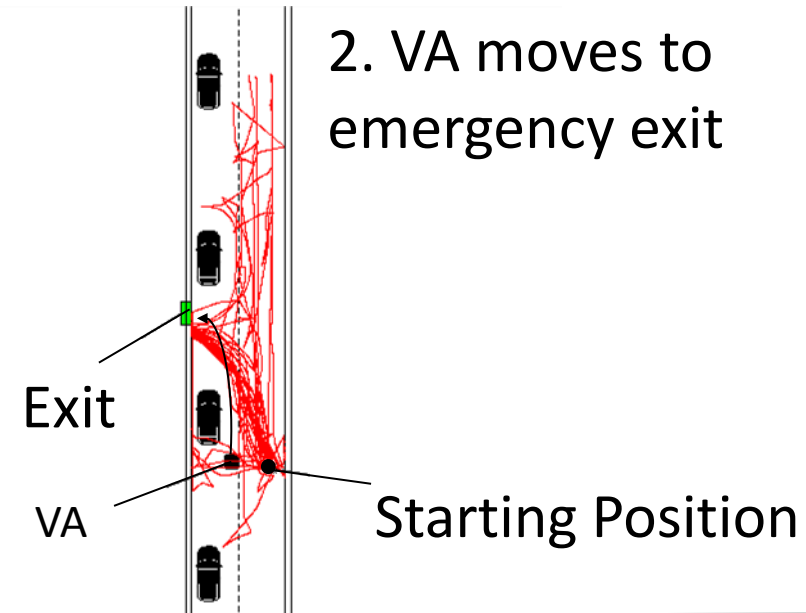
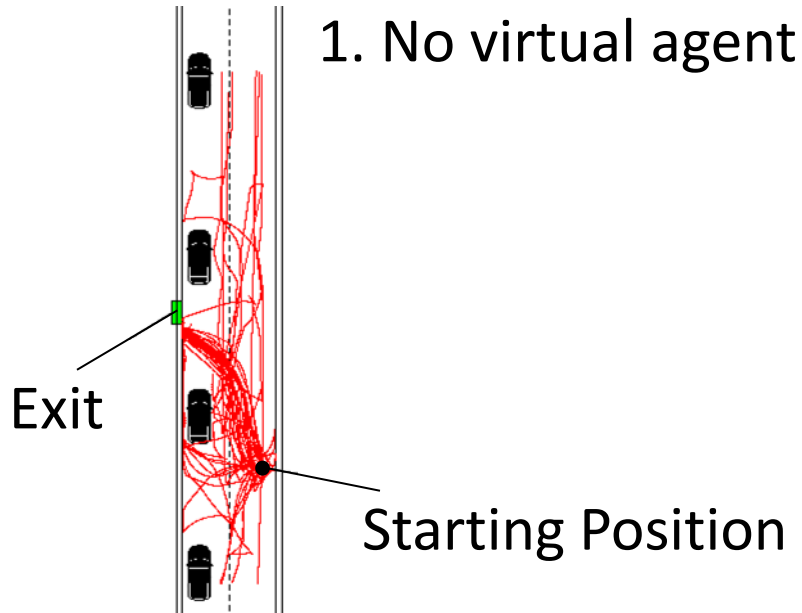
1. No Virtual Agent (VA)
2. VA goes to emergency exit
3. VA goes away from emergency exit
4. VA stays passive

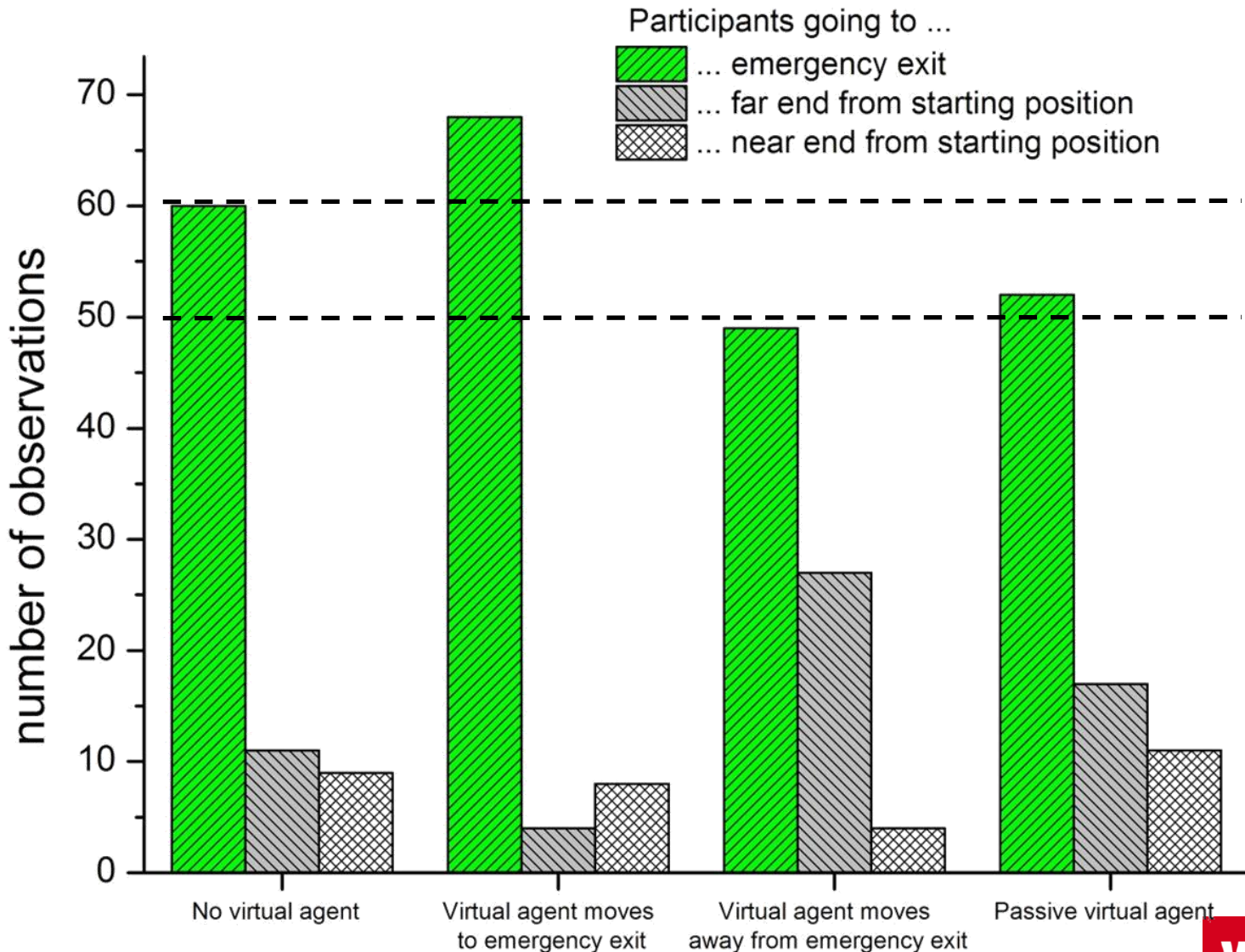
- $N = 40$; mean age = 21.13
- Repeated measures



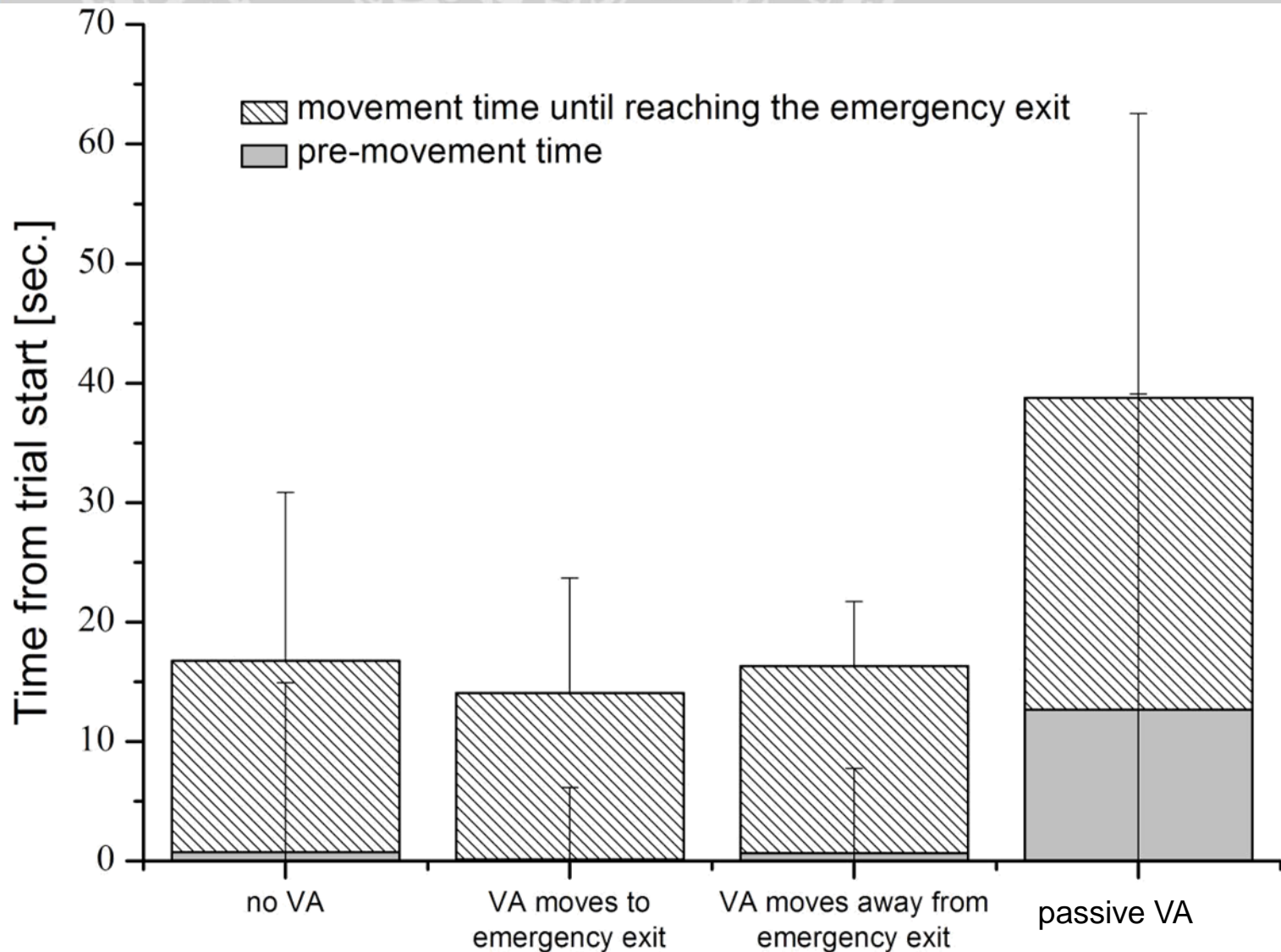
1. PowerWall
2. Stereoscopic Presentation
3. Navigation Devices







$$\chi^2 (3) = 14.09, p < .01$$



Pre-movement Time: $F(3, 38) = 3.30, p < .05$

Movement Time: $F(3, 38) = 8.09, p < .01$






VA = Virtual Agent

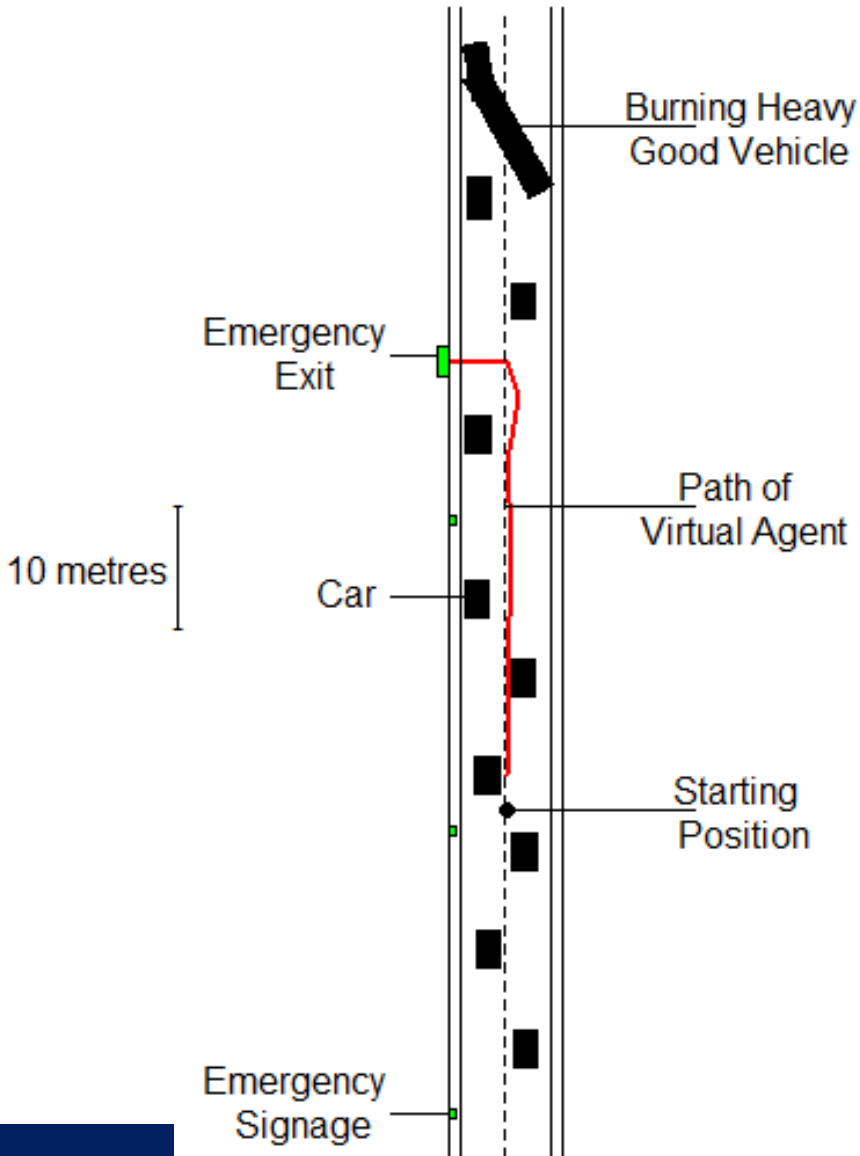
Research Question








How do Social Influence and Smoke Movement Interact?

Effect of SI and moving smoke on evacuation behaviour in a VR tunnel emergency

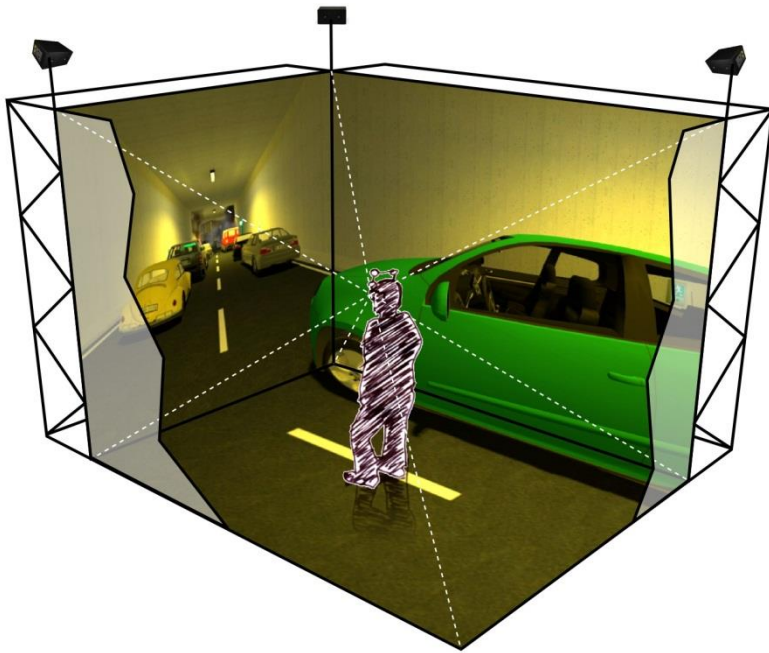
-  42 participants in a road tunnel
-  Traffic jam and burning heavy good vehicle
-  Next emergency exit is 40 metres away
-  Smoke is moving towards the participants
-  2 experimental groups
 1. Control group: Participants are alone
 2. Social Influence: Virtual Agents run to the emergency exit/ towards the smoke



-  $N = 42$
-  21 in each group (Social Influence vs. Control Group)
-  24 female/ 18 male participants
-  Age: $M = 24.48$, $SD = 3.43$ years
-  Reembursemet: 10,00€

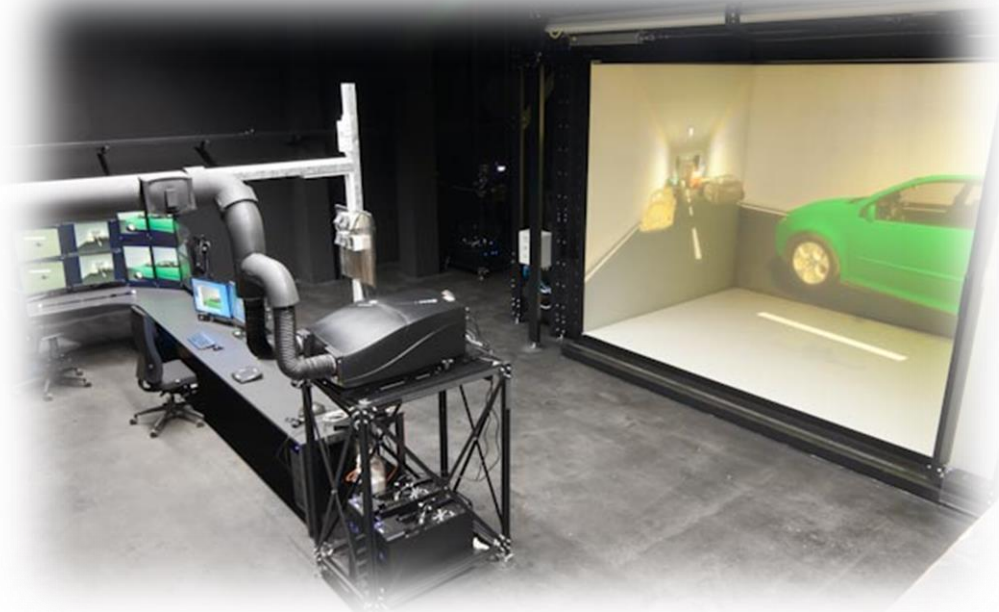


3D Multisensorial lab (CAVE)

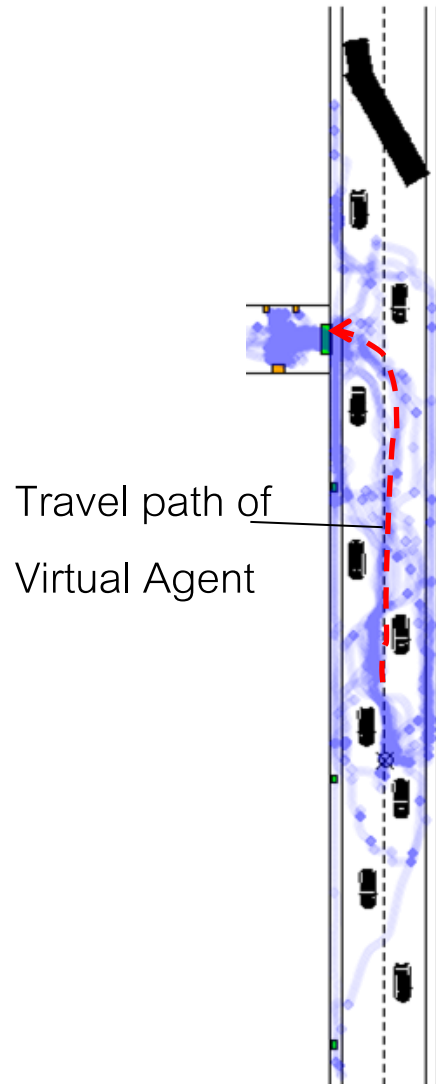


- Steam© Source Engine
- Controlled by CyberSession

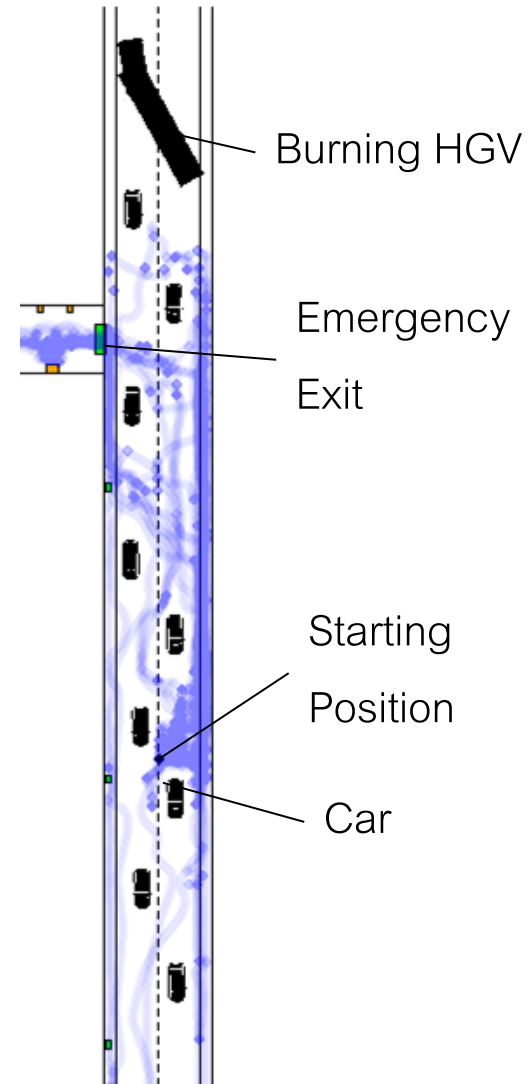
- 5 side projection
- Stereoscopic presentation
- Body-tracking
- Navigation



Social Influence



Control group



Research Question



Is VR also a useful tool to improve the behaviour of tunnel users?

45 participants (23 male), randomly assigned to 3 groups

Control group

no information/ training

Informed group

reads brochure on tunnel safety



Informed + Trained group

Reads brochure and trains actively in VR



+

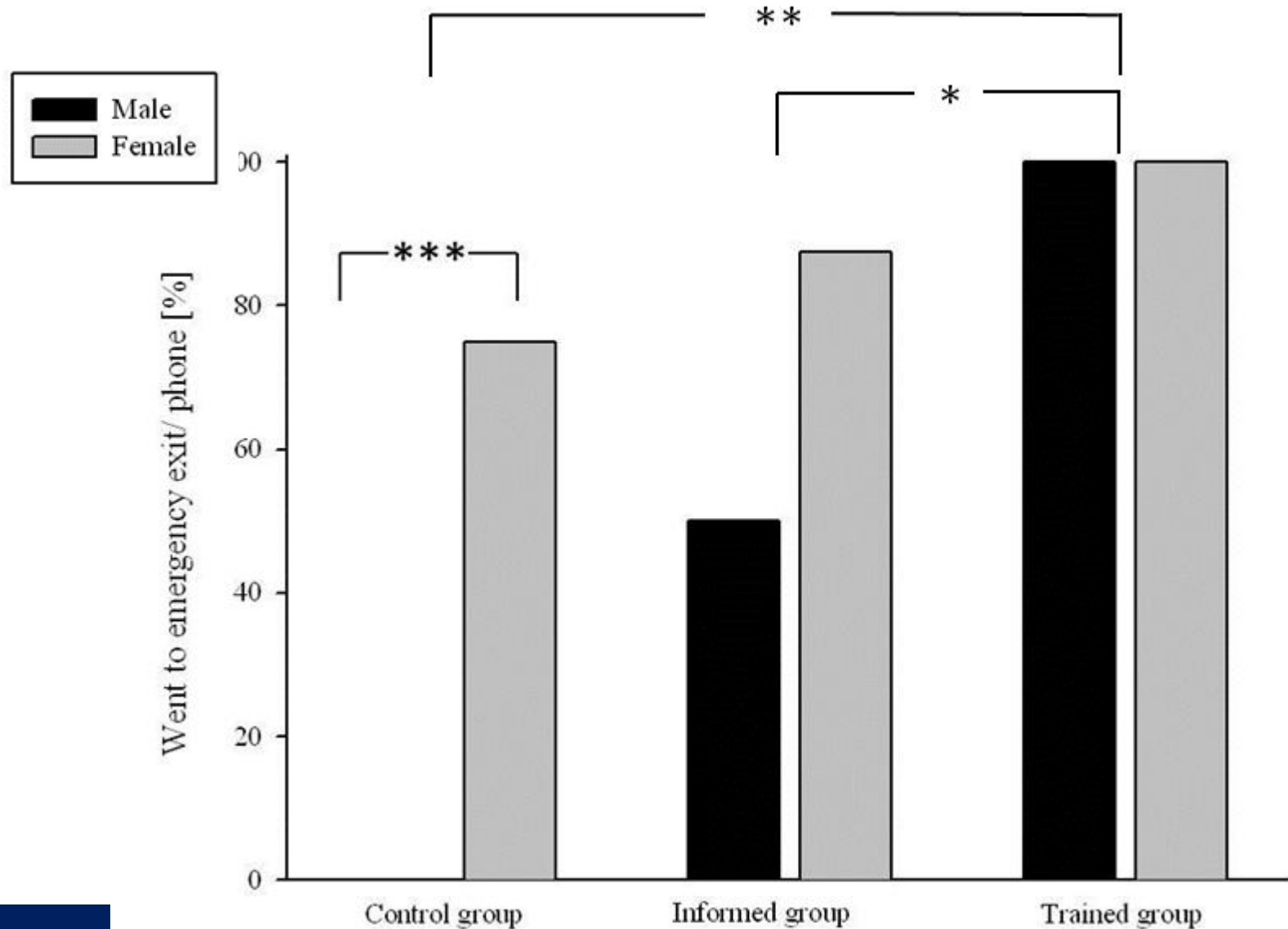









How many participants make an emergency call or go to the emergency exit?











Simulated smoke and fire in real world road tunnel





-  Similar problematic behaviour of untrained participants in VR and field studies
-  Information and especially VR behavioral training may improve tunnel evacuation
-  Strength of Social Influence varies across evacuation phases
-  Social Influence may have both positive and negative effects
-  Social Influence affects not only the outcome but also how it is achieved (travel paths)

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-  Darley, J. M., & Latané, B. (1968). Bystander Intervention in Emergencies - Diffusion of Responsibility. *Journal of Personality and Social Psychology*, 8(4p1), 377-383
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Bundesministerium
für Bildung
und Forschung



Prof. Paul Pauli & Prof. Andreas Mühlberger



Mathias Müller  virtual therapy +
research systems



Michael Jost & Markus Nehfischer



Our project partners:



Universität Stuttgart
Institut für Leichtbau,
Entwerfen und Konstruieren



Schüßler-Plan