

# Criteria for the evaluation of interaction behaviour of drivers in a bottleneck scenario

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## Introduction

- Communication and cooperation between road users are essential for road safety [1, 2]
- This also applies to autonomous vehicles → their design requires in-depth knowledge of human interaction behaviour [3], for example
  - What is successful cooperation?
  - What behaviour is linked to that?
- Studying cooperation requires appropriate methods and criteria [4]

## Research goal

Identifying potential criteria and metrics for the description and evaluation of cooperation in a road bottleneck scenario

## Method

Focused interviews were conducted and qualitatively analysed, focusing on the description and evaluation of drivers' interaction behaviour at a road bottleneck by presenting interviewees short videos of traffic encounters.

## Sample

- N = 12 traffic researchers
- 26-37 years old (m = 30.08, sd = 3.87)
- 5 male and 7 female

## Material

- Video material was recorded from two perspectives at a road bottleneck in Braunschweig, Germany (see Fig. 1) via two portable sensor poles (part of DLR's Application Platform for Intelligent Mobility Mobile Traffic Acquisition [5])
- Encounters between two drivers were extracted and rated with respect to their degree of interaction (encounter, interaction, cooperation, forced cooperation) by two raters
- Twentynine videos with identical ratings and different degrees of interaction were chosen for the interview study

## Procedure

- After answering demographic questions, every participant sequentially watched 14-15 videos while commenting aloud on the drivers' behaviour (see Instruction)
- Participants' answers were recorded
- Four interviews were conducted in person, eight were conducted via Skype for Business due to Covid-19 restrictions

## Instruction

- "Please comment aloud on the videos by describing and evaluating the behaviour of the drivers at the bottleneck. The following questions serve as a guide: How do you evaluate the behaviour of the drivers? What do you base your evaluation on? Did the drivers communicate with each other? If so, who communicated what? And how did the other react? On what do you base this? In what order did they communicate?"

## Qualitative analysis

- Interviews were transcribed and analysed via MAXQDA Analytics Pro 2020
- Codes were developed in an iterative process and organised into four categories: description of behaviour, interpretation of behaviour, factors influencing behaviour, and evaluation of behaviour
- Based on the interpretation of behaviour, interaction patterns were defined (not reported here)

1. StVO §1 and §11 (German traffic regulations)  
 2. Harris, P. B., Houston, J. M., Vazquez, J. A., Smither, J. A., Harms, A., Dahlke, J. A., & Sachau, D. A. (2014). The Prosocial and Aggressive Driving Inventory (PADi): A self-report measure of safe and unsafe driving behaviors. *Accident Analysis & Prevention*, 72, 1-8.  
 3. Färber, B. (2015). Kommunikationsprobleme zwischen autonomen Fahrzeugen und menschlichen Fahrern. In *Autonomes Fahren* (pp. 127-146). Springer Vieweg, Berlin, Heidelberg.  
 4. Bengler, K. (2019). Prinzipien für kooperatives Verkehrsverhalten-heute und morgen. In *Hands Off, Human Factors Off? Welche Rolle spielen Human Factors in Der Fahrzeugautomation?* (pp. 91-97). Darmstadt: Universitäts- und Landesbibliothek Darmstadt.  
 5. Knäke-Langhorst, S., & Gimm, K. (2016). AIM Mobile Traffic Acquisition: Instrument toolbox for detection and assessment of traffic behavior. *Journal of large-scale research facilities*, ILSRF, 2, 74.

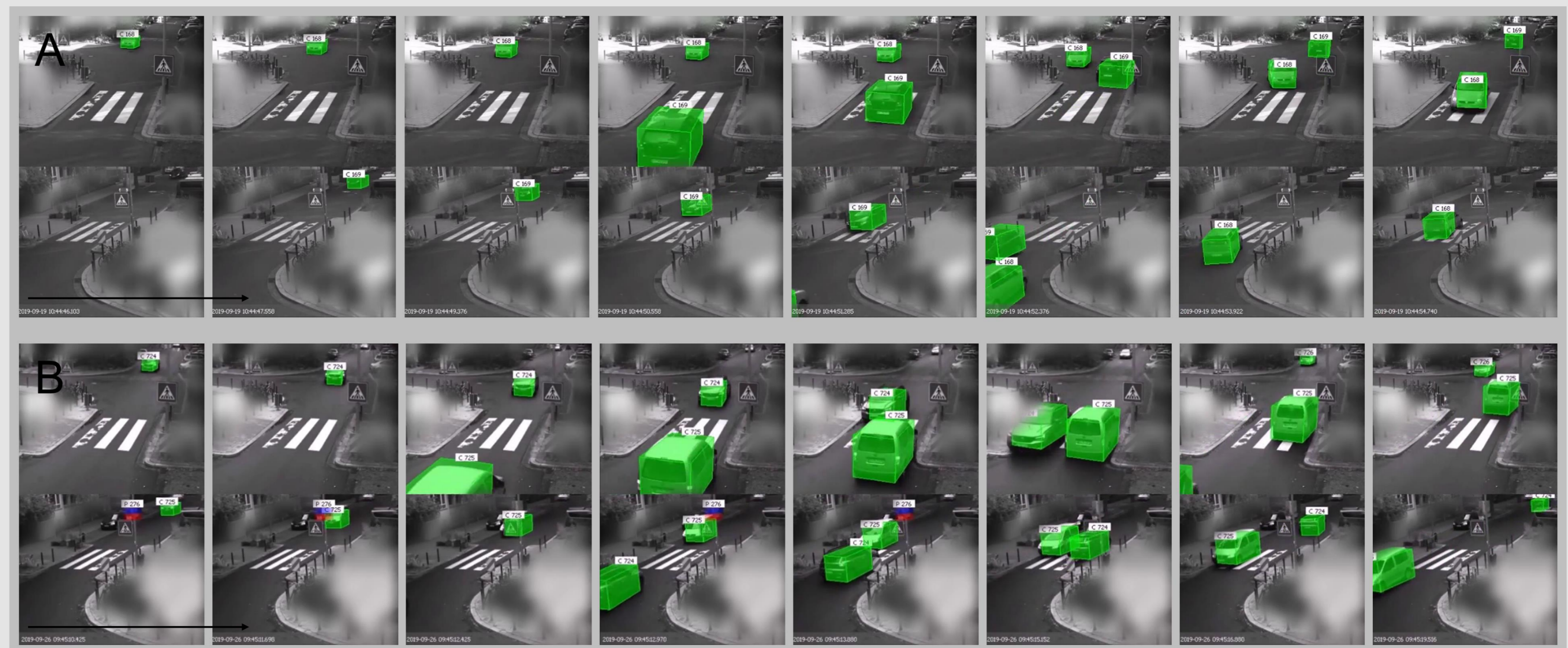


Figure 1. Screenshots of video material: Two exemplary encounters of two drivers at a road bottleneck (Bültenweg, Braunschweig, Germany).

## Results

### Description of behaviour

**Table 1.** Aspects used to describe drivers' behaviour (number of interviewees who mentioned a given aspect)

Individual behaviour		
Longitudinal behaviour	wait	(12)
	stop (standstill)	
	decelerate	
	constant	
	accelerate	
Lateral behaviour	movement to the right side	(12)
Velocity	fast	(12)
	slow	
Start of behaviour	early	(10)
	late	
Duration of behaviour	e.g. duration of standing still	(6)
Variance in behaviour	e.g. before/after encounter	(5)
Relative behaviour		
Time/space distance	successive	(12)
	simultaneous	
Arriving/leaving vehicle	same	(10)
	different	

### Evaluation of behaviour

**Table 2.** Aspects used to evaluate drivers' behaviour (number of interviewees who mentioned a given aspect)

Category	Identified aspects	
Defensiveness	defensive, passive, calm, considerate, careful, cautious, cooperative	(12)
Clarity	predictable, explicit, unambiguous, certain, clear, anticipated, expected	(11)
Offensiveness	offensive, aggressive, inconsiderate, careless, dynamic, brash, brazen, impatient, uncooperative	(10)
Criticality	critical, save, risky, dangerous, unproblematic	(10)
Efficiency	efficient, well timed, fast, flowing, time saving, obstructive	(8)
Contribution	proactive, initiating, active, intentional	(5)
Agreement	disagreed, agreed, mutual	(3)

### Factors influencing behaviour

Interviewees used the following aspects to explain why a certain behaviour was shown:

- Arrival order of drivers
- Time interval between drivers
- Platoon of vehicles on one side of the bottleneck
- Topography / available space
- Behaviour of other road users
- Speed difference between drivers
- Right-before-left intersection next to bottleneck
- Presence of other road users (e.g. cyclists)
- Wish for efficiency
- Vehicle type
- Wish for safety
- Emotions
- Parking out before passing the bottleneck

## Conclusion

Particularly relevant for the description and evaluation of the bottleneck scenario seem to be

- the time delay with which drivers arrive at the narrow passage,
- the arrival and departure order (who arrives first and who passes the narrow passage first),
- the clarity of drivers' behaviour.

These aspects are promising criteria for the evaluation of interaction behaviour in a bottleneck scenario.

## Outlook

In a next step, the influence of the three identified criteria on the evaluation of interaction between drivers at a road bottleneck will be experimentally studied in an online video study by systematically varying the three factors time delay, arrival order, and clarity of behaviour.



Figure 2. Screenshot of generated video material for the planned online video study (video generated with VICOM Editor).

## Exemplary answers

### Example 1

"Here we see that two vehicles are approaching the bottleneck at relatively the same time and therefore also meet in the bottleneck or shortly before it. And you can already see that the vehicles have to brake heavily in any case, or at least one of them, namely the 734, is really hitting the brakes. The, what is it, the T5 or whatever, it's speeding through it quite recklessly, I would say. So he says I'm the stronger one and, yes, okay, admittedly, because he's faster, he's also the first to get into the bottleneck. Well, how do I evaluate the behaviour of the drivers? Well, one of them [...] drives defensively. That's the one who brakes, of course. The T5 is driving [...] offensive, [...], also drives much faster."

### Example 2

"Unusual situation. A BMW driver is driving defensively and basically gives someone the right of way. Exactly, two vehicles are approaching the bottleneck at almost the same time. And first, both communicate by braking. This means that at that moment it is not clear who should drive first. So both behave defensively. Whereupon one of them takes the initiative, [...]. Exactly, the C 668 then basically drives after it has slowed down. But at some point someone has to drive, otherwise they stand there forever. And after he has passed through the bottleneck, the BMW driver drives through calmly and quietly."

### Example 3

"That was also a fairly simple situation. Two vehicles approaching this bottleneck from different directions, but at different times. They were both driving relatively quickly and dynamically, but they simply [...] passed through this bottleneck at different times and therefore did not actually communicate. So they don't have to brake or anything, but I would say they would have passed through just as they did if there hadn't been an oncoming vehicle. So they simply didn't have to react to each other at all."

(translated from German into English with deepl.com)