

Field observations of interactions among drivers at unsignalized urban intersections

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Introduction

- Human drivers interact with each other reaching somehow on an **agreement** about their future motion plan (Portouli et al. 2014)
- Such interactions involve:
 - **explicit** communication (e.g. gestures, vehicle signals, eye contact)
 - **implicit** cues (e.g. approach speed, acceleration)
- Some signals are ambiguous / context-based (e.g. flashing headlight)

Method

- Interactions between drivers during left and right turns in unsignalized urban intersections were recorded via **eye-tracker** worn by drivers
- **21** experienced drivers participated
 - **10 males**
 - **11 females**
- Urban circular route of **0.75 km** was driven 5 times (total of **3.75 km**)
- Mean driving duration was **18 min**
- Participants were asked to retrospectively comment aloud on the process of their **decision making** for each case of interaction



Data extraction process

An analyst labelled the interactions between the participant and another driver based on eye-gaze video + retrospective driver commentary



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Analysis

- Retrospective commentary used for:
 - identifying relevant cues and signals
 - Interpreting their meaning for ego driver
- Labels:
 - Type of interacting vehicle
 - Ego driver's signals and cues
 - Other driver's signals and cues
 - Sequence of signals and cues

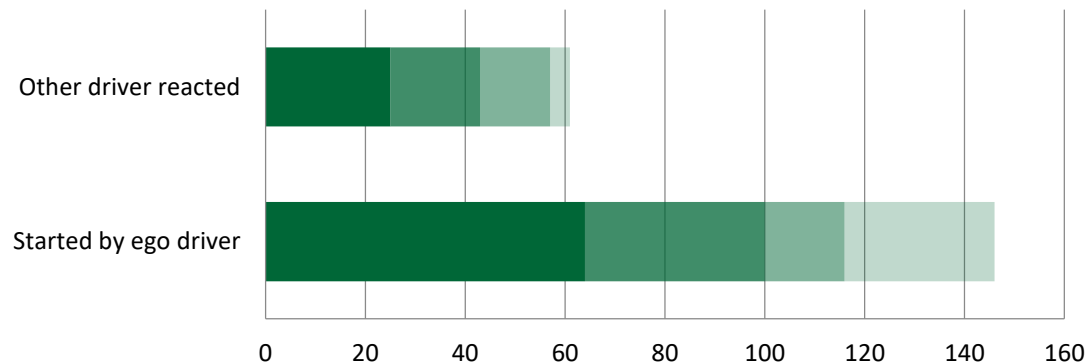
Signals and cues labelled	
Implicit	Explicit
Edging	Turn indicator
Accelerate	Headlights
Decelerate	Gesture/Nodding
Stop	Horn

Results: Observed Interactions

188 observed left turns where:

- **146** started by ego driver
- **61** other driver reacted

Left turn from 2-way street

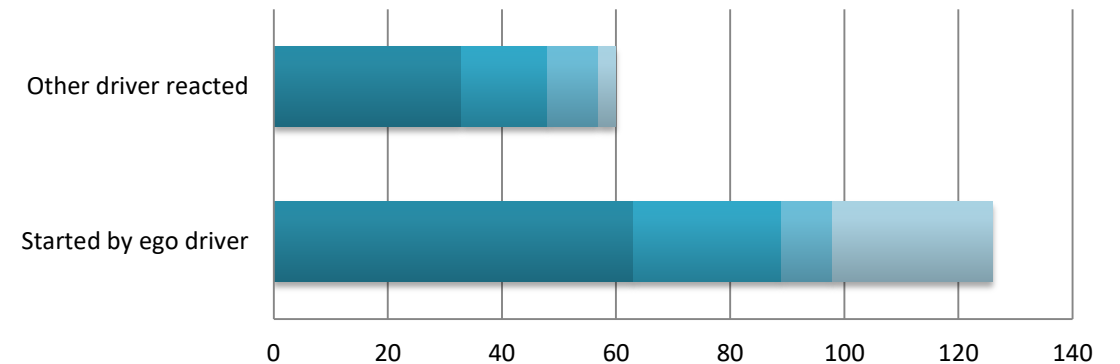


	Started by ego driver	Other driver reacted
Passenger cars	64	25
Taxis	36	18
Large vehicles	16	14
Motorcycles	30	4

179 observed right turns where:

- **126** started by ego driver
- **60** other driver reacted

Right turn to 2-way street



	Started by ego driver	Other driver reacted
Passenger cars	63	33
Taxis	26	15
Large vehicles	9	9
Motorcycles	28	3

Signals and cues by ego drivers to provoke other driver yielding

- Turn indicator alone was not so effective **(60/185)**
- Vehicle edging led in almost every case to reaction **(42/49)**
- Flashing headlights and gesture/nodding although not frequent were rather effective **(6/7)**

Notes:

“No reaction observed” refers to ego driver start turning without prior signal/cue by other driver

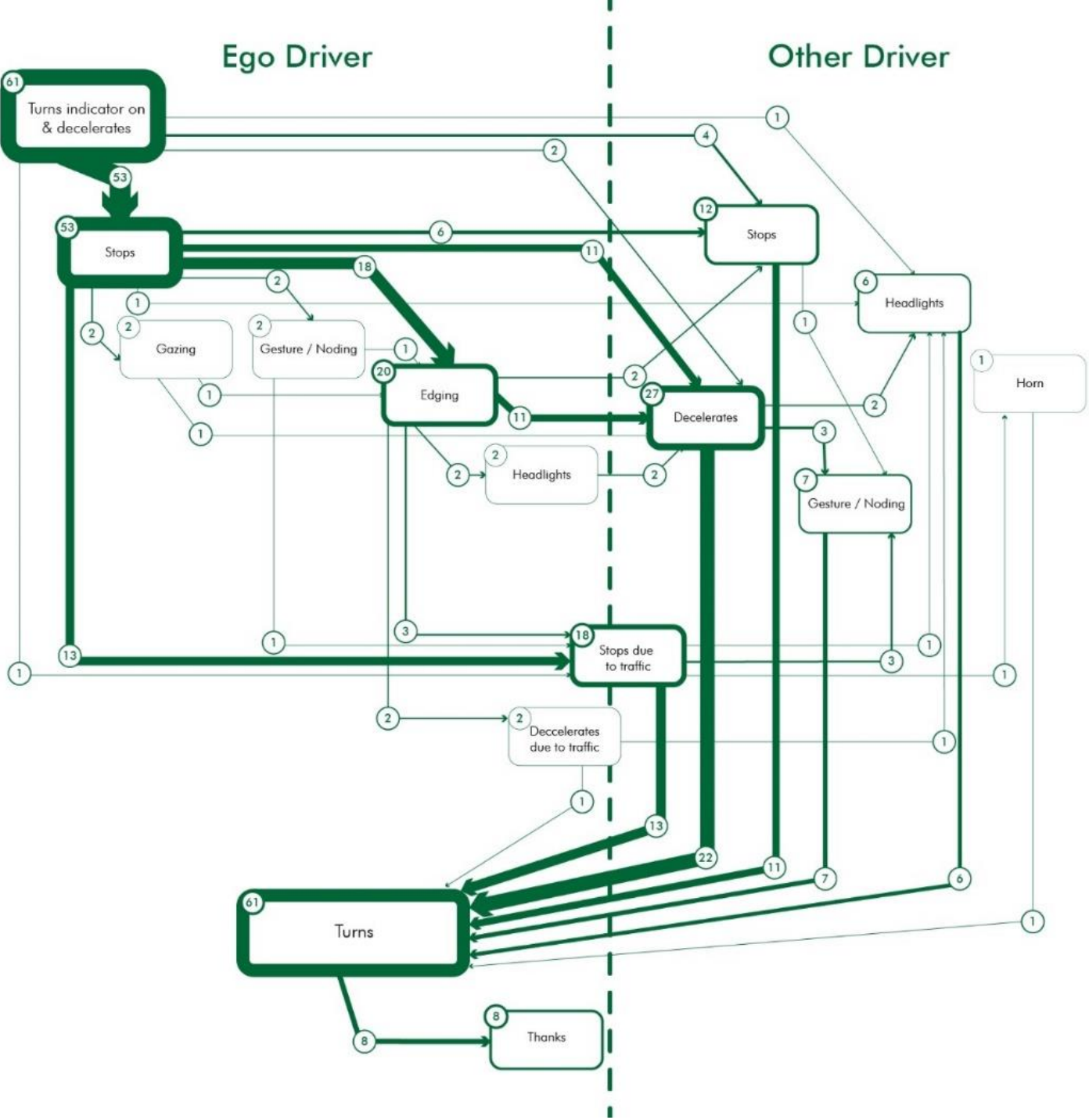
Emitted signal / cue by ego driver	Left turn from 2-way street		Right turn to 2-way street	
	Started interactions (N=146)	Other driver reacted by yielding (N=61)	Started interactions (N=126)	Other driver reacted by yielding (N=60)
Turn indicator	119	39	66	21
Turn indicator + Edging	17	17	10	10
Turn indicator + Edging + Headlights	2	2		
Turn indicator + Gesture/Nodding	1	1		
Turn indicator + Gesture/Nodding + Edging	1	1		
Edging	1	0	18	12
Gesture/Nodding			3	2
No reaction observed	5	1	29	15

Signals and cues emitted by other drivers indicating yielding

- Other driver's deceleration or stopping was always followed by ego driver turning **(107/107)**
- Gesture/nodding and turn indicator resulted in the same **(12/12)**
- Headlights did not always result in ego driver turning **(9/12)**
- Acceleration and use of horn was not followed by ego driver turning **(1/4)**

Observed signal / cue by ego driver	Left turn from 2-way street		Right turn to 2-way street	
	Started interactions	Other driver reacted by yielding	Started interactions	Other driver reacted by yielding
	(N=146)	(N=61)	(N=126)	(N=60)
Gesture/Nodding			1	1
Headlights	7	4	2	1
Horn	1	0		
Accelerate			2	0
Decelerate	22	22	22	22
Decelerate + Gesture	3	3	2	2
Decelerate + Headlights	1	1		
Decelerate + Headlights + Gesture			1	1
Stop	25	25	24	24
Stop + Gesture	4	4	1	1
Stop + Headlights	1	1		
Stop + Horn	1	1		
Turn indicator			4	4
Opportunity due to another event			3	2
No reaction observed	81	1	64	2

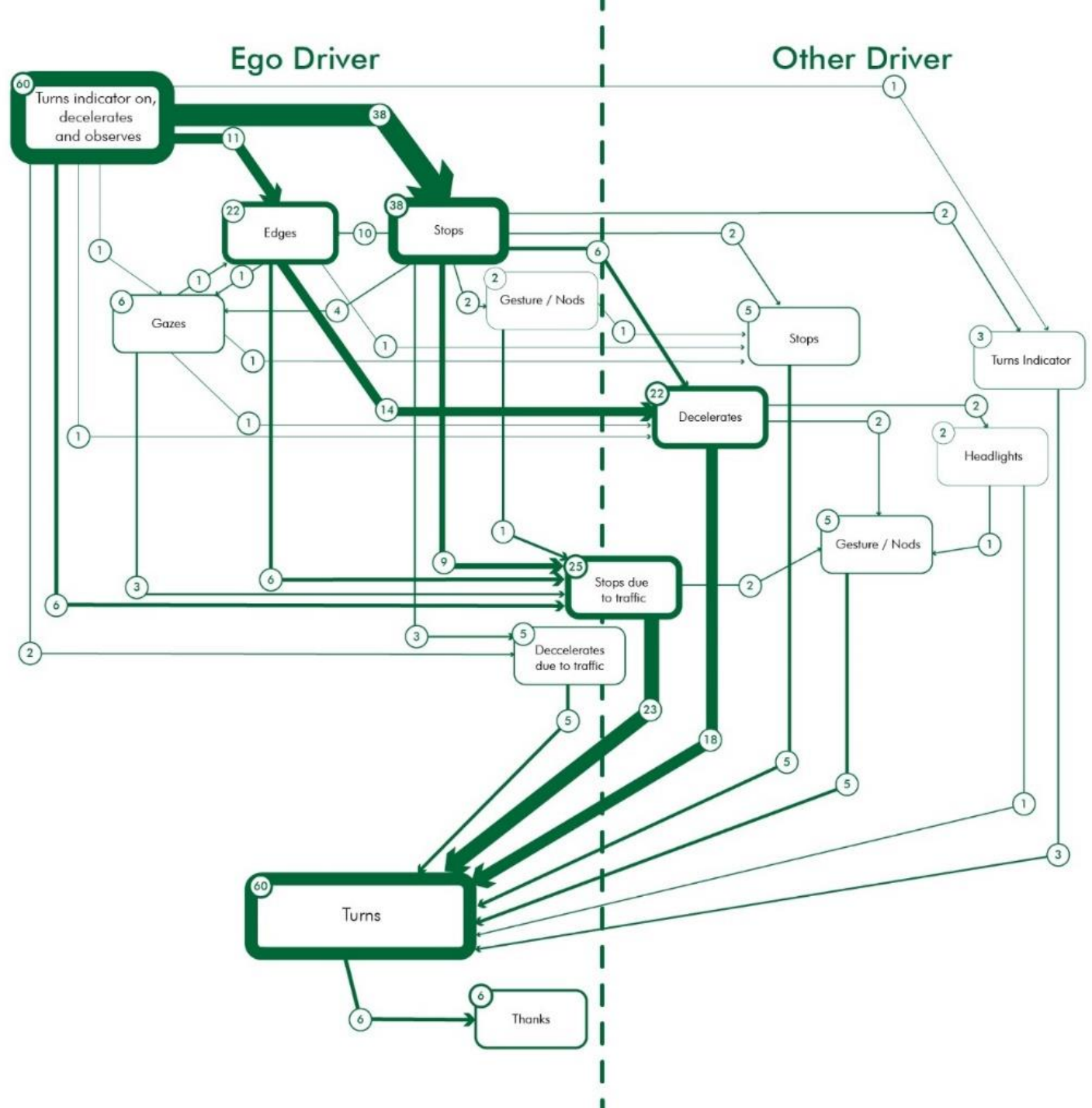
Sequences of observed signals/cues in interactions between drivers
Left turns



Sequences of observed signals/cues in interactions between drivers

Right turns

- In most cases **one response** by the other driver was sufficient for ego driver to finish the interaction
- In many cases ego driver takes advantage of the **traffic congestion**
- In the few cases when an explicit signal by the other driver was observed the sequence typically contained more than two steps



Suggestions

- Progressive edging and directed communication to other drivers should be implemented in automated vehicles' interaction strategies
- Designers of automated vehicles should take into account that human drivers may sometimes neglect safety criteria in order to save time.
- Automated vehicles should use an explicit signal to inform the other drivers of their intention to yield

Thank you
Q & A