



Observations of driver-driver interactions in urban environment

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DRIVING IS A SOCIAL ACTIVITY



- Different road users share a common resource, the road
- They coordinate their actions
- Communication and anticipation of others' intent is an essential component of driving, necessary for safe and efficient traffic flow



THE PROBLEM



- Trajectory prediction based on vehicle dynamics is not enough
- Interactions of automated vehicles should be in accordance to human road users' expectations
- But interactions among drivers have not been studied in detail

Observations of interactions during lane changes



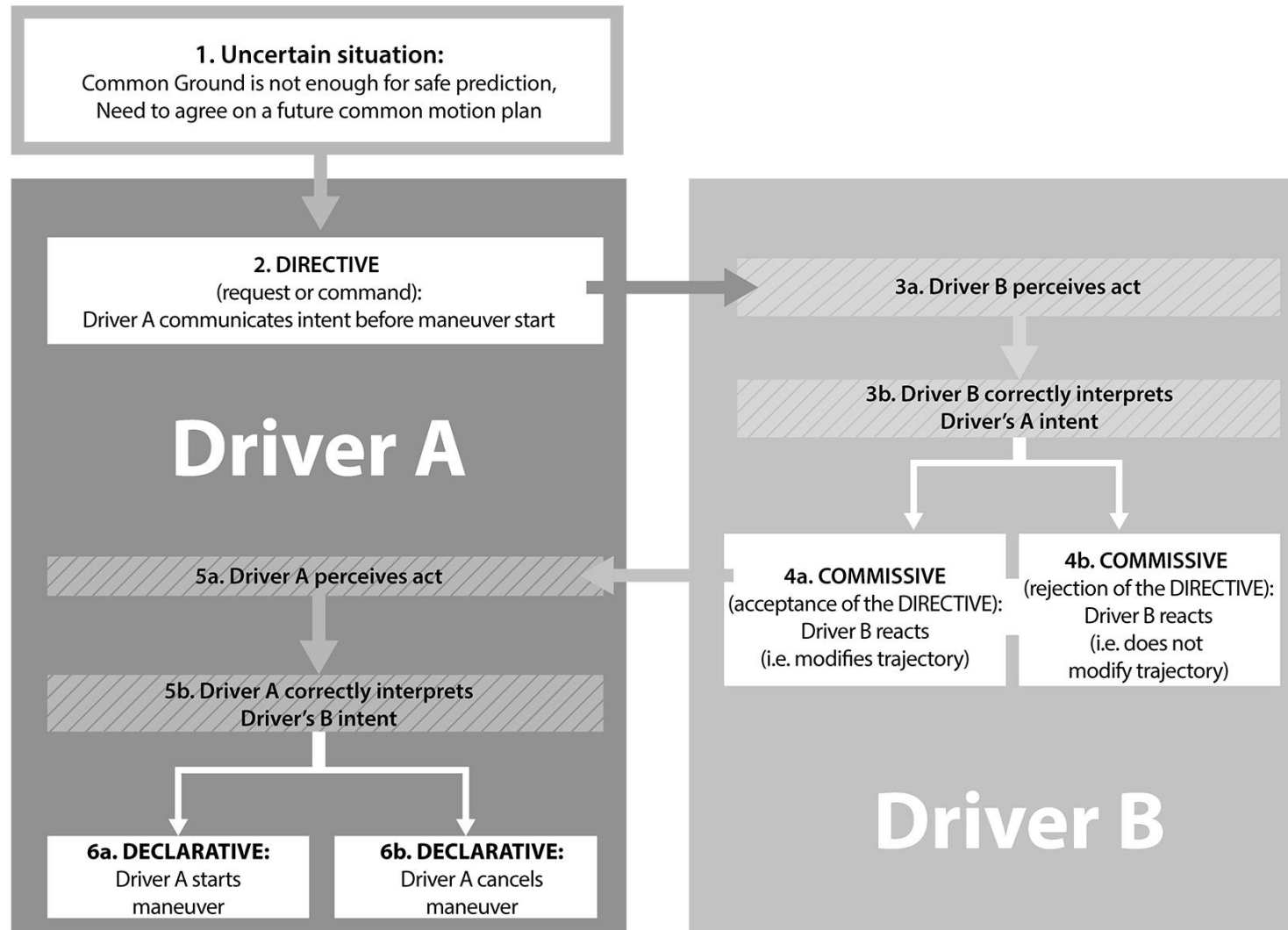
- 25 experienced drivers were asked to drive their vehicles for a 16,8 min route on a divided two-way road with two lanes per direction with parallel running commentary of their thinking
- 68 interactions relevant to lane changes were observed:
 - a) initiated by the participants when they wished to:
 - change lane and there was another vehicle in the target lane (8 cases)
 - drive faster than a lead vehicle (5 cases)
 - enforce their wished action on another driver (3 cases)
 - b) initiated by other drivers who:
 - would cut-in in front of the participant's vehicle (25 cases)
 - wished to drive faster (27 cases)

Signals / cues in interactions relevant to lane changes



- 13 cases of **explicit communication** (direction lights, gestures, head movements)
- 43 cases of **implicit cues by the other vehicles** (driving at speed different than that of the flow, higher or lower, unjustified speed change, close following of lead vehicle, driving on the lane marking, observed variation in lateral position and steering angle of other vehicles, unusual manoeuvring, aggressive driving = any **disturbance of the expected smooth motion** that could not be attributed to road geometry or obstacles on the road)
- 6 cases of **cues from the environment** (change in the number of lanes, i.e. merging)
- 5 cases of references to **stereotypes** (colour, model, type of vehicle)

Linguistic Model of Drivers Interactions



Observations of drivers' interactions during turns in urban environment



- 21 experienced drivers drove their passenger car in a predefined course wearing an eye glass mounted gaze sensor
- Trip length: 3.75 km, mean driving duration: 18 minutes
- Driver's off-line commentary while watching the eye gaze video recording



Left / right turns locations and example interactions



37°58'44.0"N 23°45'57.3"E

37°58'43.4"N 23°45'59.8"E



37°58'41.5"N 23°46'08.1"E



Interaction start



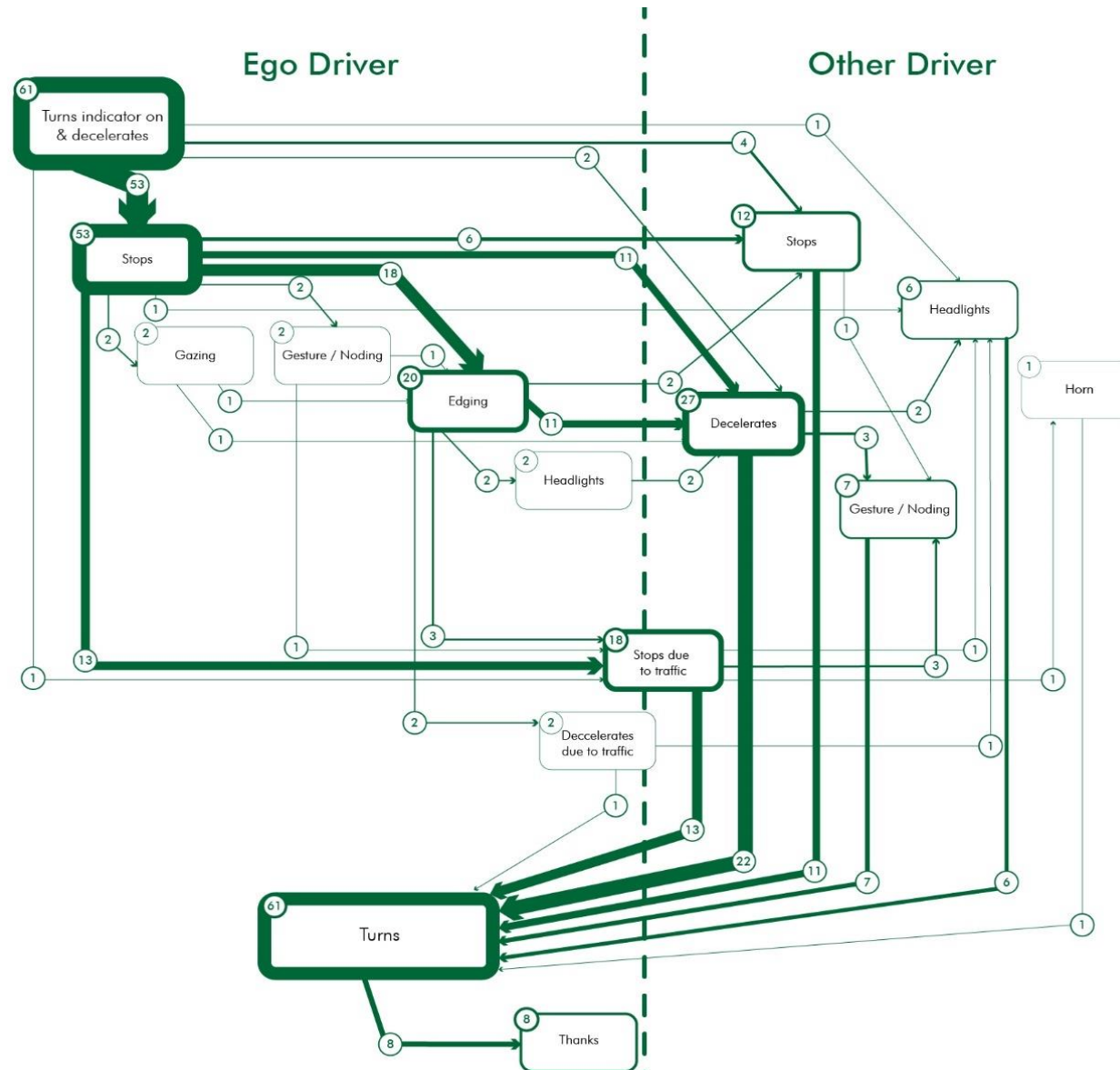
- i) the participant had to wait for a gap in the oncoming traffic before turning
or
- ii) the participant started turning knowing that the oncoming driver would have to modify his/her vehicle motion



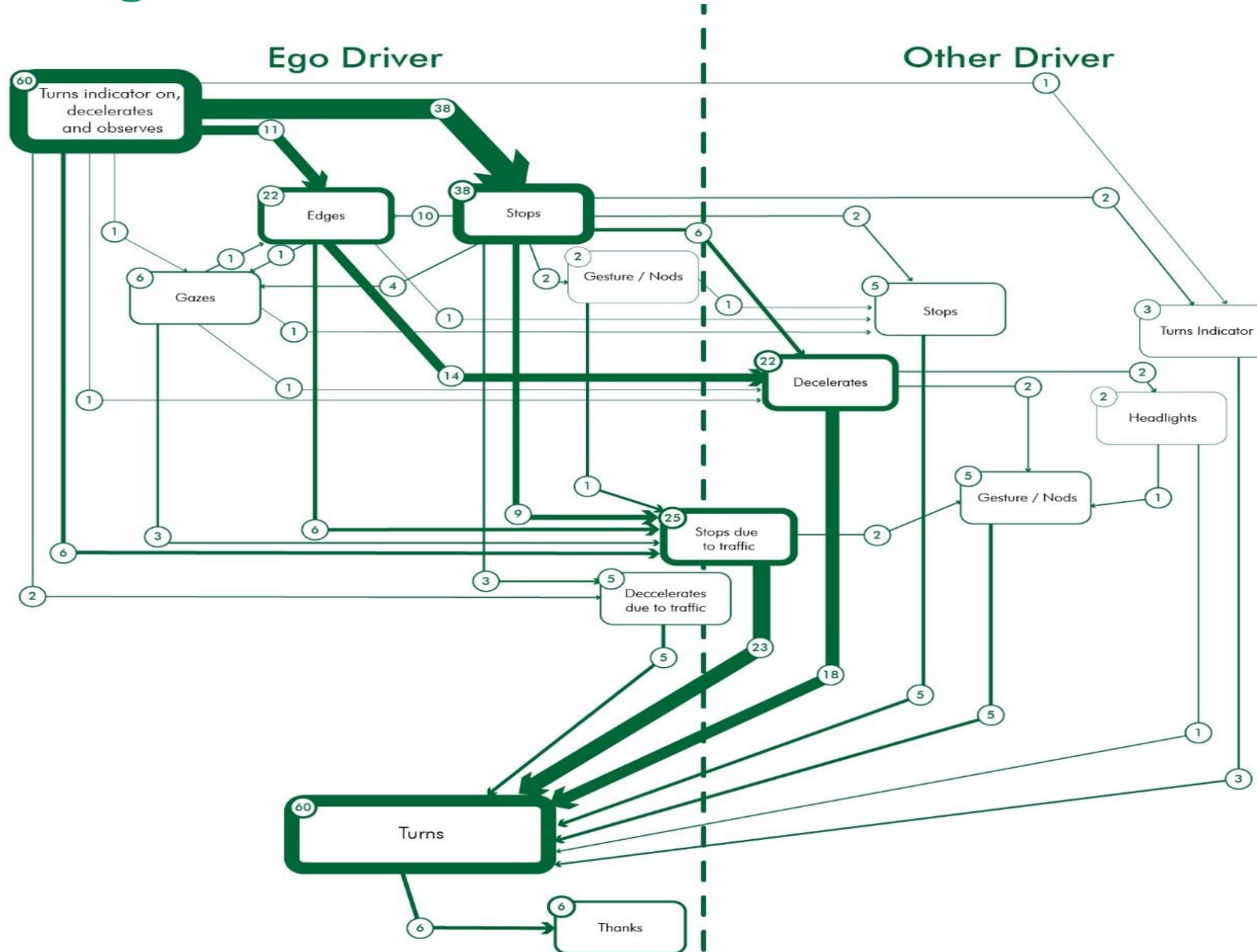
Observed interactions

	Number of turns	Number of interactions (started by the subjects)	Number of interactions where the other driver reacted
Left turn from 2-way street	188	146 (64 passenger car, 36 taxi, 16 large vehicle, 30 motorcycle)	62 (26 passenger car, 18 taxi, 14 large vehicle, 4 motorcycle)
Right turn to 2-way street	179	126 (63 passenger car, 26 taxi, 9 large vehicle, 28 motorcycle)	60 (33 passenger car, 15 taxi, 9 large vehicle, 3 motorcycle)

Sequences of signals / cues in interactions relevant to left turns



Sequences of signals / cues in interactions relevant to right turns



Effectiveness of signals / cues



- Edging, use of headlights and gesture/nodding were followed by a response
- The turn indicator alone was not so effective
- The other driver's deceleration or stopping was always followed by turning
- Use of headlights by the other driver was interpreted complementary to other signals / cues
- Acceleration and use of horn were rather interpreted as other's intention to not yield
- Other cues were mentioned (a motorcyclist's foot moving to the ground, people waiting at the bus stop)

Commentaries highlights

- Achieving eye contact is considered a good means to convince the other driver to yield
- Intentional avoidance of eye contact is interpreted by the subjects as “he/she will not yield”
- Edging is intentionally used, as a not-annoying signal, to make the other driver yield
- Use of headlights is a means to attract the other driver’s attention
- Drivers monitor the other drivers’ gaze and plan their behaviour according to whether they believe that the other driver has or has not perceived them
- Drivers estimate the time that they will need to wait and adjust their decision
- Drivers take advantage of opportunities due to external events

Conclusions



- Vehicle edging seems an effective technique
- Directed communication to other drivers at low speeds will be beneficial (simulating eye contact), to attract their attention and to ensure that each other understands that they are each other's focal point
- Drivers do not always respect safety distances (according to physics laws)
- An explicit signal by an automated vehicle to inform the other drivers that it will yield may be beneficial for the traffic flow and efficiency



Thank you!



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