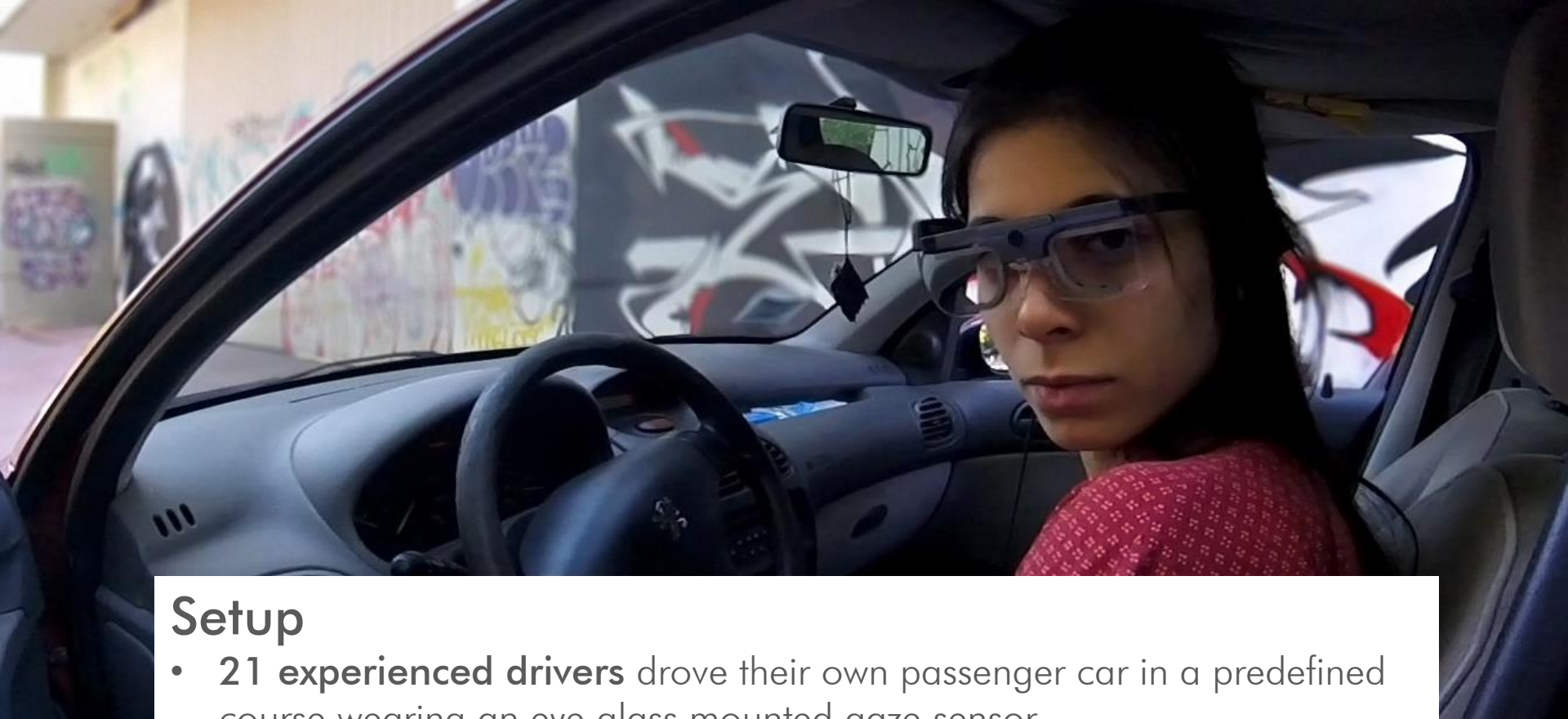




# Naturalistic observation of interactions between car drivers and pedestrians in high density urban settings



Dimitris Nathanael, Evangelia Portouli, Vassilis Papakostopoulos, Kostas Gkikas, Angelos Amditis



## Setup

- **21 experienced drivers** drove their own 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

## Analysis

- Manual labelling of eye-gaze video with drivers comments embedded



Geographical Coordinates:  
37°58'42.5"N 23°46'04.2"E

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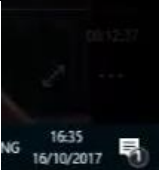


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Subject	Event code	Time	Type of ego-car manoeuvre	Parallel / Crossing	Same direction / Opposite direction	Turn timing	Individual / Group	Type of Person	P-movements while approaching	Potential Distractions	Signals from our driver	Signals from Pedestrian	Pedestrian position while	Number of ego-drive	who passed in front	Commentary of eye-driver
	P Bettina Portouli 001	0:00:17	Straight section course	Crossing	Vertical		Individual	Elderly	Initiated crossing movement	None	Turn indicator; Hand Gesture	P body movement; Orientation of P body/Head; Eye contact	On both	4	Pedestrian	Dd : Tou eipe peraste; Dv : Ekshgigi ot tou
	P Bettina Portouli 002	0:00:38	Straight section course	Crossing	Vertical		Individual	Elderly	Remained idle	None		Orientation of P body/Head; Eye contact; Hand Gesture	On street	1	Ego car	Dd: Eipe Ot ton eide
	P Bettina Portouli 003	0:00:58	Turn from 1way street to 1way street	Parallel	Same	2-after initiating m	Individual	Standard	Kept pace	None	Turn indicator	P body movement; Orientation of P body/Head; Eye contact	On street	3	Ego car	
	P Bettina Portouli 004	0:04:20	Straight section course	Parallel	Same		Individual	Standard with bag	Kept pace	None		P body movement; Orientation of P body/Head; Eye contact	On street	2		
	P Bettina Portouli 005	0:08:42	Left turn from 2way street	Parallel	Same	1-prior to manoeuv	Individual	Standard	Kept pace	None	Turn indicator	P body movement; Orientation of P body/Head	On street	3		
	P Bettina Portouli 006	0:07:40	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None		P body movement; Gaze	On street	3	Pedestrian	
	P Bettina Portouli 007	0:07:53	Turn from 1way street to 1way street	Parallel	Same	2-after initiating m	Individual	Standard	Kept pace	None		P body movement; Gaze	On both	1		
	P Bettina Portouli 008	0:08:24	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement	On street	3	Pedestrian	
	P Bettina Portouli 009	0:08:46	Straight section course	Crossing	Vertical		Group	Elderly with bag	Kept pace	None	Car movement/ Position	P body movement	On street	4	Pedestrian	
	P Bettina Portouli 010	0:08:56	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None	Car movement/ Position	P body movement; Eye contact	On street	3	Pedestrian	
01 Bettina Portouli	P Bettina Portouli 011	0:12:35	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement	None	Car movement/ Position; Turn indicator	P body movement; Orientation of P body/Head	On street	3	Pedestrian	
	P Bettina Portouli 012	0:12:10	Straight section course	Crossing	Vertical		Individual	Standard with bag	Stopped	None	Car movement/ Position; Hand Gesture	Orientation of P body/Head; Gaze	On street	1	Ego car	Dv: Eipe ot louvi eprepe na thn afhsh na pe
	P Bettina Portouli 013	0:18:18	Straight section course	Parallel	Same		Individual	Standard with stroller	Stopped	None	Car movement/ Position	P body movement; Orientation of P body/Head; Gaze	On street	4	Pedestrian	Dd : This eipe peraste; Dv: Eipe ot parlo po
	P Bettina Portouli 014	0:18:55	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement	None	Car movement/ Position; Turn indicator	Orientation of P body/Head; Eye contact; Hand Gesture; NoDi	On street	4	Pedestrian	Dd : This eipe peraste; Dv: Eipe ot parlo po
	P Bettina Portouli 015	0:17:05	Left turn from 2way street	Crossing	Vertical	2-after initiating m	Individual	Standard	Stopped	Talking on mobile phone	Car movement/ Position; Turn indicator	Orientation of P body/Head; Gaze	On pavement	1	Ego car	Dv: Eipe ot eprepe na thn afhsh na perase
	P Bettina Portouli 016	0:17:20	Straight section course	Parallel	Same		Individual	Standard	Stopped	None	Car movement/ Position; Hand Gesture	P body movement; Eye contact	On street	3	Pedestrian	Dd : This eipe peraste; Dv: Eipe ot thn afhsh
	P Bettina Portouli 017	0:19:40	Straight section course	Crossing	Vertical		Group	Standard; Elderly with bag	Initiated crossing movement	Reading	Car movement/ Position; Turn indicator	Orientation of P body/Head; Eye contact	On street	3	Pedestrian	Dv: Eipe na perasou ol xristiano!
	P Bettina Portouli 018	0:19:47	Turn from 1way street to 1way street	Parallel	Same	2-after initiating m	Group	Standard; Elderly with bag	Kept pace	Reading	Turn indicator	P body movement	On street	4	Pedestrian	Dv: Eipe tvra tous pataw -den tous pataw
	P Bettina Portouli 019	0:20:42	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement	None	Car movement/ Position	P body movement; Gaze	On street	1	Pedestrian	Dv: Eipe ot perase ego o pezoz owp na na
	P Bettina Portouli 020	0:22:10	Straight section course	Parallel	Same		Group	Standard; Kid	Stopped	None	Car movement/ Position	P body movement; Gaze	On street	1	Pedestrian	Dv: Eipe ot ton fovthike ton paouo mhm pe
	P Bettina Portouli 021	0:22:18	Straight section course	Crossing	Vertical		Group	Standard; Kid	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head; Gaze	On street	2	Pedestrian	Dv : Eipe ot i kuria den eprepe na perase;
	P Bettina Portouli 022	0:22:25	Straight section course	Parallel	Same		Individual	Elderly with bag	Kept pace	None	Car movement/ Position	P body movement	On street	4	Pedestrian?	Dd: Eipe daksti tvra kai o paouo me th m
	P Evdokia Papanikolaou 001	0:00:16	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement	On street	4	Pedestrian	Dd: Eipe ediv pou einai h gunaikia me to ka
	P Evdokia Papanikolaou 002	0:00:30	Left turn from 2way street	Parallel	Opposite	1-prior to manoeuv	Group	Standard; standard with bag	Kept pace	None	Car movement/ Position	P body movement; Eye contact	On street	2		
	P Evdokia Papanikolaou 003	0:00:42	Straight section course	Parallel	Opposite		Individual	Standard	Initiated crossing movement	None	Car movement/ Position	P body movement; Orientation of P body/Head; Gaze	On street	2	Pedestrian	
	P Evdokia Papanikolaou 004	0:00:46	Straight section course	Parallel	Opposite		Individual	Standard	Speeded up	None	Car movement/ Position	Orientation of P body/Head; Gaze	On street	5	Pedestrian	
	P Evdokia Papanikolaou 005	0:01:26	Straight section course	Parallel	Same		Individual	Standard with bag	Initiated crossing movement	None	Car movement/ Position; Hand Gesture	Orientation of P body/Head; Eye contact; Hand Gesture	On street	3	Pedestrian?	Dv : Eipe ot i sthn afsh den thn eise del'ala n
	P Evdokia Papanikolaou 006	0:03:26	Left turn from 2way street	Crossing	Vertical		Individual	Kid with bag	Speeded up	None	Car movement/ Position; Turn indicator	P body movement; Gaze	On street	2	Pedestrian	Dd: Eipe ot apo to paidi pou perase katafa;
P Evdokia Papanikolaou 007	0:04:22	Straight section course	Crossing	Vertical		Individual	Kid with bag	Kept pace	None	Car movement/ Position	P body movement; Gaze	On street	3	Pedestrian	Dv: Eipe ot i kuria den eprepe na perase;	
P Evdokia Papanikolaou 008	0:04:39	Right turn on 2way street	Crossing	Vertical	2-after initiating m	Individual	Standard	Initiated crossing movement	Looking at mobile phone	Car movement/ Position	Orientation of P body/Head; Eye contact	On both	2	Pedestrian	Dv: Eipe ot thn stamathise me a mania. Ro	
P Evdokia Papanikolaou 009	0:06:01	Straight section course	Parallel	Same		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head	On street	1		Dv : Eipe ot guriste to kefali tou oplate katali	
P Evdokia Papanikolaou 010	0:06:10	Straight section course	Parallel	Opposite		Group	Standard	Remained idle	Working	Car movement/ Position	Orientation of P body/Head	On street	4		Dv : Eipe ot otan eide pws milane metaksu	
P Evdokia Papanikolaou 011	0:06:50	Straight section course	Parallel	Same		Individual	Standard with bag	Stopped	None	Car movement/ Position	P body movement; Gaze	On street	4	Ego car	Dv: Eipe Ot htan me plath kai den thn eixe	
P Evdokia Papanikolaou 012	0:08:30	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement	On street	1	Pedestrian		
P Evdokia Papanikolaou 013	0:09:00	Straight section course	Crossing	Vertical		Individual	Standard	Remained idle	None	Car movement/ Position (slowed down)	Orientation of P body/Head	On street	2	Ego car	Dv: Eipe ot o pezoz koitouse pliv ths opote	
P Evdokia Papanikolaou 014	0:10:25	Left turn from 2way street	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement; Orientation of P body/Head; Eye contact	On street	7	Pedestrian	Dv: Eipe ot sthn afsh den thn eise del'ala n	
P Evdokia Papanikolaou 015	0:10:40	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None	Car movement/ Position (stopped)	P body movement; Orientation of P body/Head; Gaze	On street	5	Pedestrian	Dd: Eipe ot ton prosekse id'astera apedh e o	
P Evdokia Papanikolaou 016	0:11:13	Straight section course	Parallel	Opposite		Individual	Standard	Kept pace	None	Car movement/ Position	P body movement; Eye contact	On street	4		Dv: Eipe ot pghane siga perimotantos o p	
P Evdokia Papanikolaou 017	0:11:45	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head	On street	3	Pedestrian	Dv : Eipe ot kotaxthkan kai epeidh eixe st	
P Evdokia Papanikolaou 018	0:13:25	Left turn from 2way street	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement; Orientation of P body/Head; Gaze	On street	3	Pedestrian	Dv: Eipe o pezoz den thn eide kathouo ano	
P Evdokia Papanikolaou 019	0:13:10	Straight section course	Parallel	Opposite		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement	On street	2		Dv: Eipe ot o dromos htan farduo kai h kop	
P Evdokia Papanikolaou 020	0:14:25	Right turn on 2way street	Crossing	Vertical		Group	Standard with bag	Kept pace	Talking to each other	Car movement/ Position	P body movement; Orientation of P body/Head; Eye contact	On both	4	Pedestrian	Dv: Eipe ot thn exiane del'oi pezo!, alla eix	
P Evdokia Papanikolaou 021	0:16:20	Right turn on 2way street	Crossing	Vertical		Individual	Standard	Remained idle	Listening to headphones	Car movement/ Position	Orientation of P body/Head; Gaze	On street	1	Ego car	Dv: Eipe ot h kopelia htan stamathismh; o	
P Evdokia Papanikolaou 022	0:16:30	Straight section course	Crossing	Vertical		Individual	Standard	Kept pace	None	Car movement/ Position	Orientation of P body/Head; Gaze	On street	3	Ego car		
P Evdokia Papanikolaou C																e ot i thn kollitaxe kats proswoo opto
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## Pedestrians' 3 levels of Behavioral Expressiveness towards Driver During Crossing

- |     |                                |
|-----|--------------------------------|
| 1st | Emitting body cues             |
| 2nd | Gaze toward vehicle (aware of) |
| 3rd | Eye-contact and/or signal to D |



## Pedestrians' 3 levels of Behavioral Expressiveness towards Driver During Crossing

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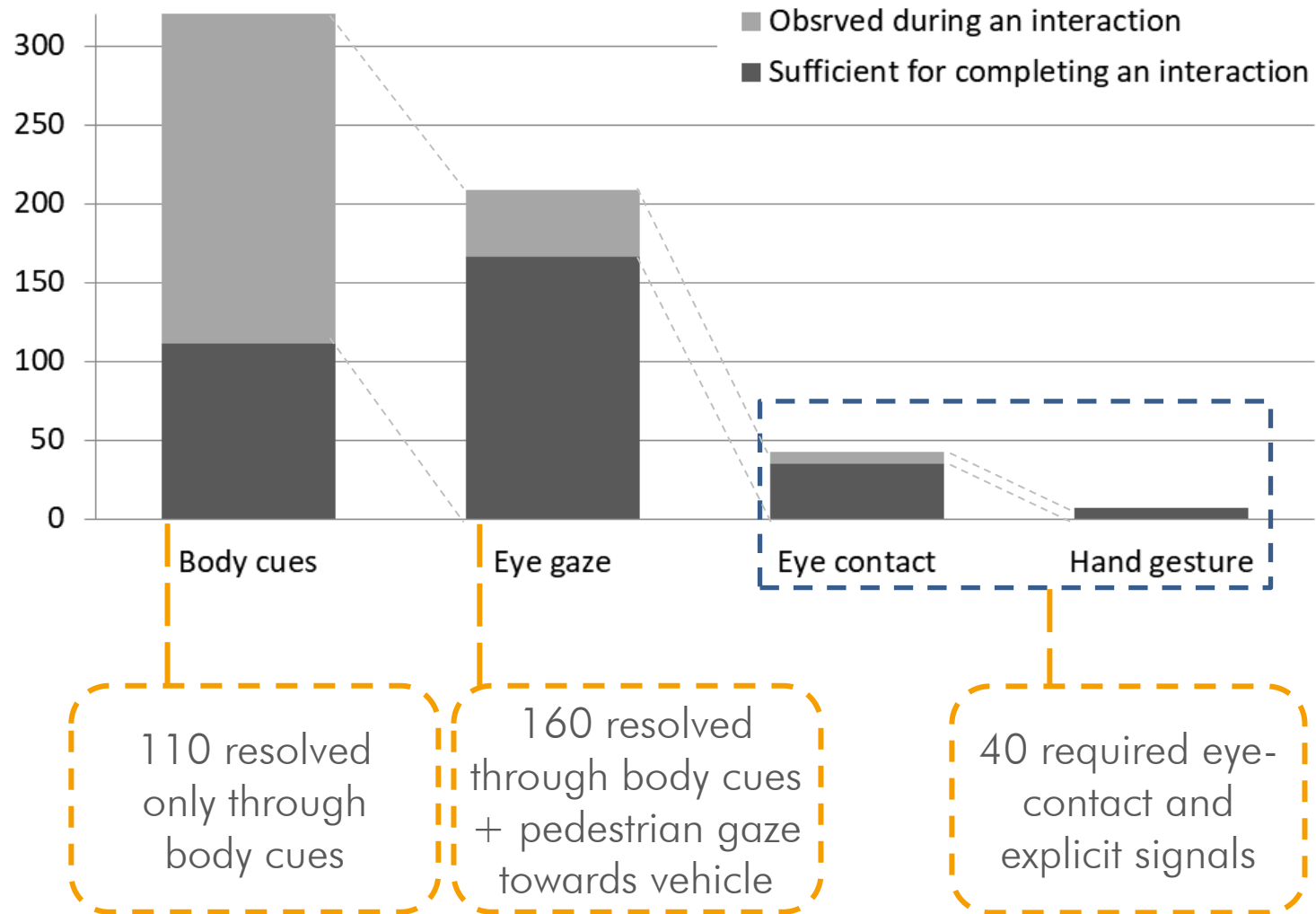
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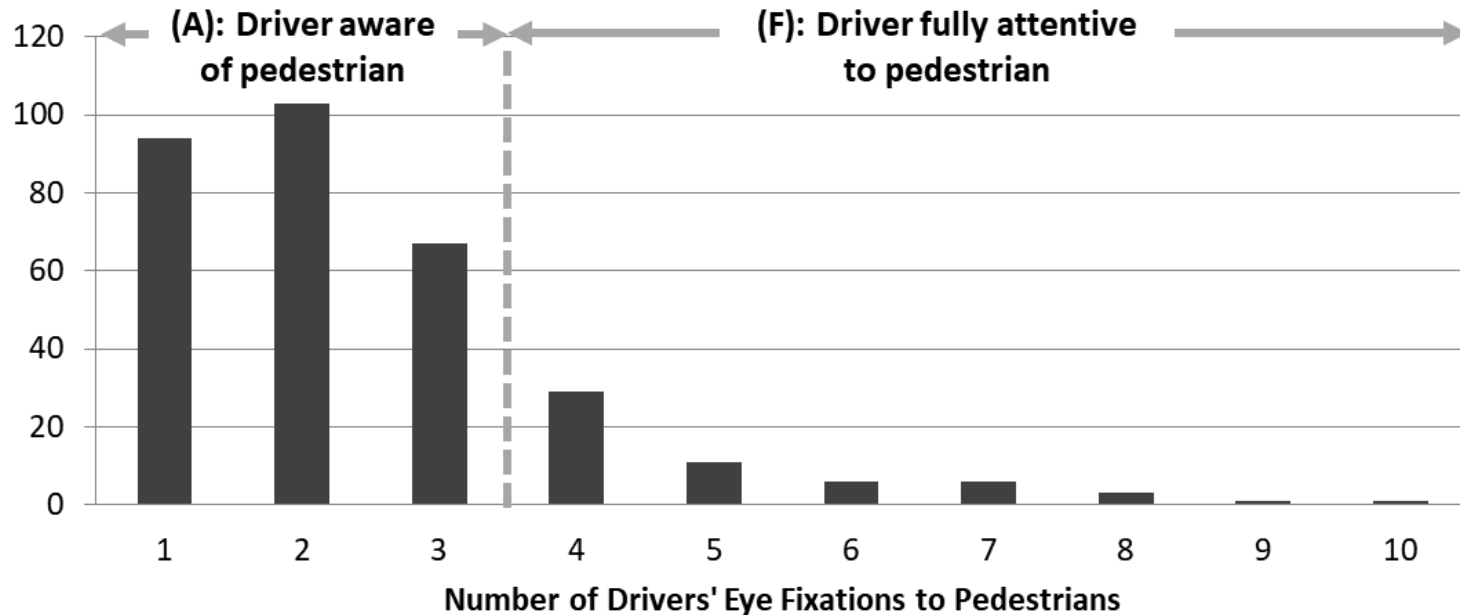
# Levels of Pedestrians' Behavioral Expressiveness and sufficiency in completing an interaction

(based on 321 P-V pedestrian crossings)



# Drivers' Attentiveness to Pedestrians

Measured through numbers of eye-fixations on a particular Pedestrian



3 successive eye-fixations on Pedestrians was chosen as a criterion to divide interaction cases into **two levels** of drivers' attentiveness to pedestrians:

- (i) the driver is considered to be **Aware** of the pedestrian but does not allocate his full attention to him
- (ii) the driver is considered to be **Fully attentive** to the pedestrian, at least at some point in time during the interaction

# Modelling assumptions

3 levels of **pedestrian expressiveness**

1st Emitting only body cues

2nd + gaze toward vehicle (aware of)

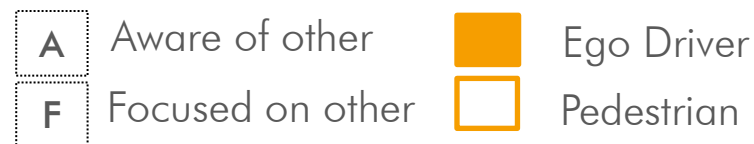
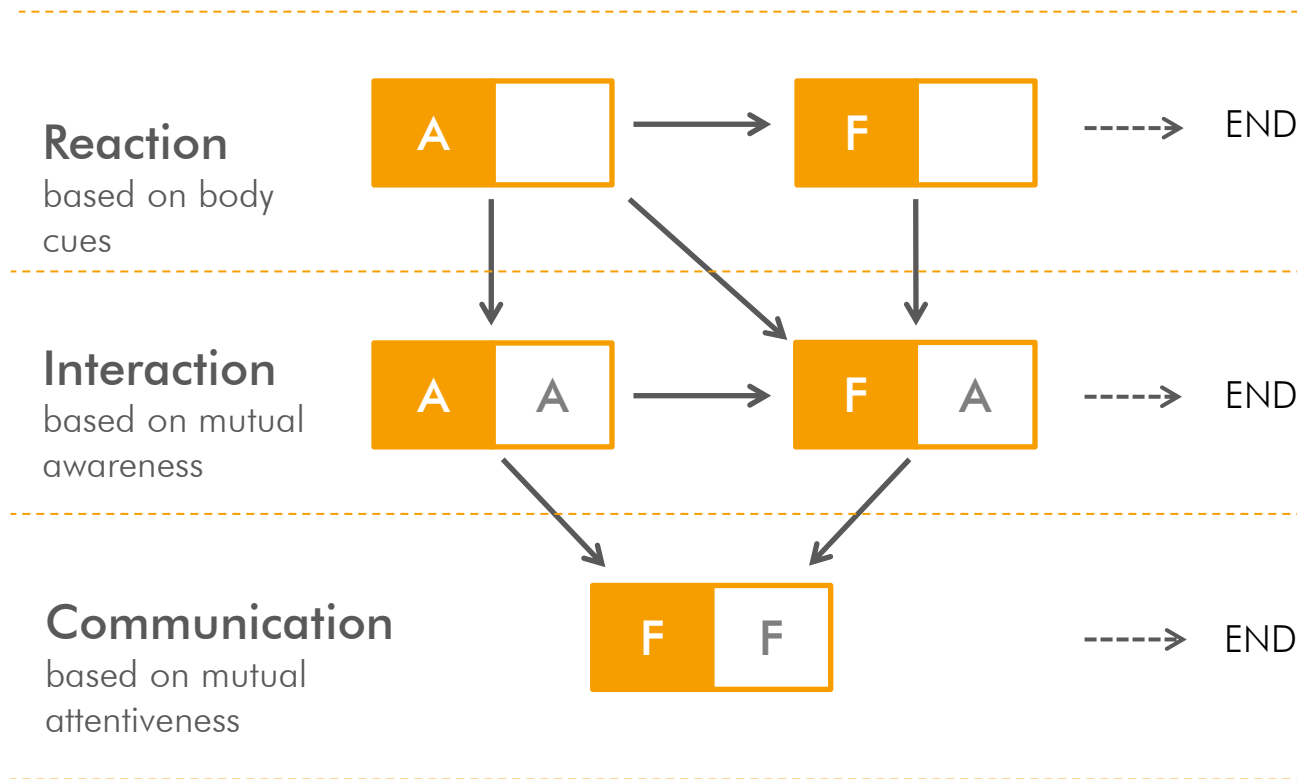
3rd + eye-contact and/or signal

2 levels of **driver attentiveness**

1st **Aware of P**

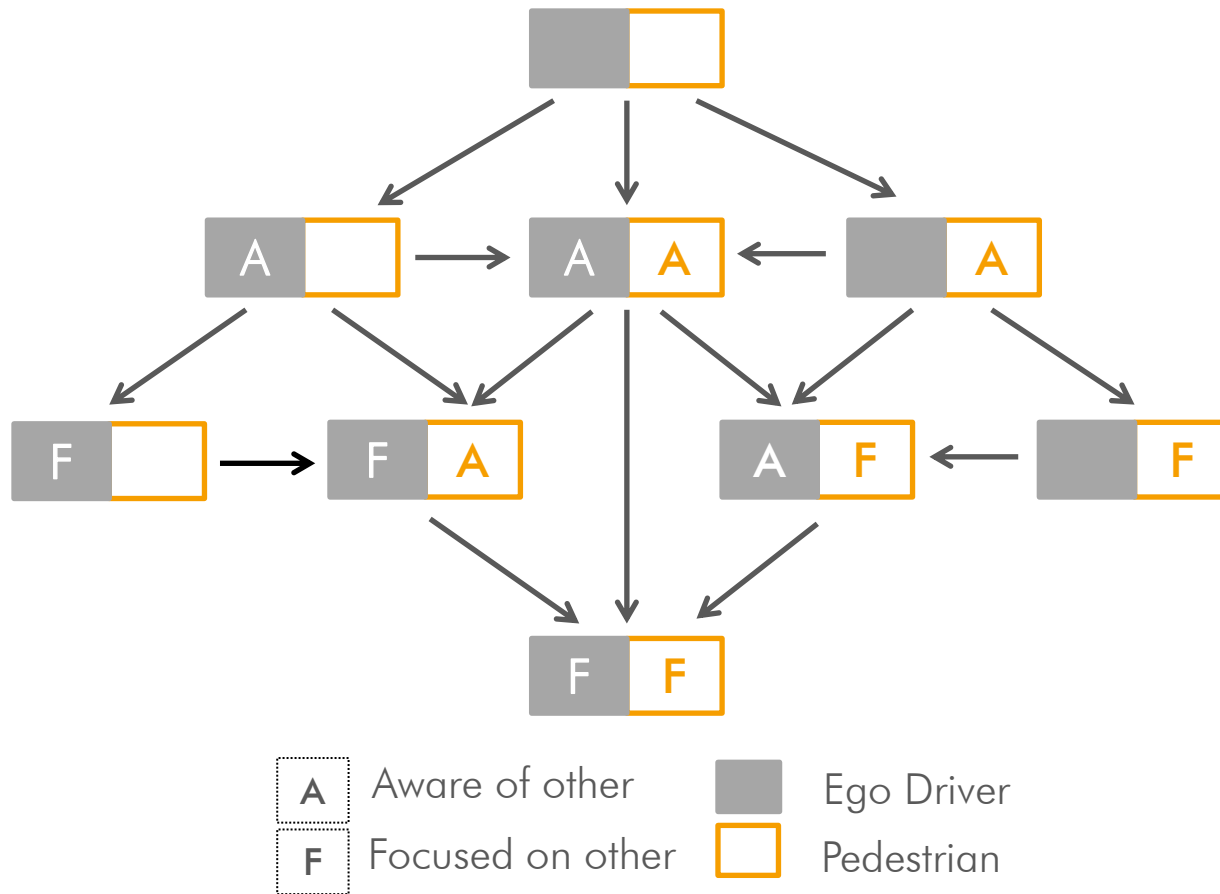
2nd **Fully attentive to P**

# Possible states of driver's and pedestrian's attentiveness to each other (from a driver's point of view)



# Future development

- Verify and substantiate the present models with more data
- Complement the model with the Pedestrian's point of view:



# Potential use of the emerging models

- The need to develop technologies for **detecting pedestrian's states of awareness** for use in future self-driving vehicles
- The need to provide pedestrians with a first level feedback that **they have been detected**
- The need to provide pedestrians with a second level feedback for clarifying if a particular pedestrian is the **primary focus of attention** of the vehicle