PERSONAL EXPOSURE MEASUREMENT IN TRAFFIC: HOW CONTEXT INFLUENCES EXPOSURE PERCEPTION

Dr. Heike Marquart
Institute of Transport Research, German Aerospace Center (DLR)

Workshop Receptor modelling, applications and technical solutions (by IGSTC)
27.10.2025

Measuring air pollution in traffic – why does it matter?

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

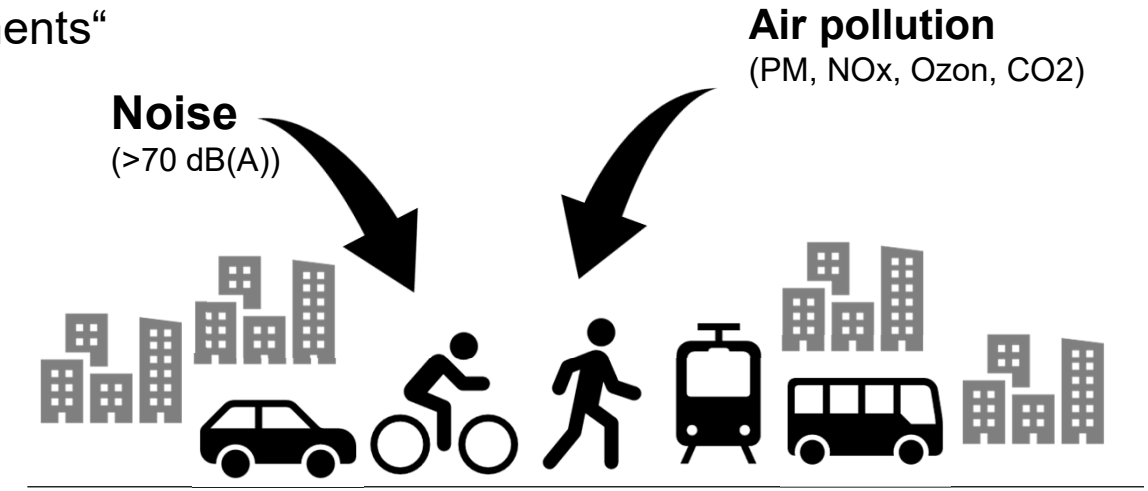
Background:
Personal exposure to air pollution during travel

- 4-7% of the day urban dwellers are in „traffic-influenced microenvironments“
  (Matz et al. 2018)

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Background:
Personal exposure to air pollution during travel

- 4-7% of the day urban dwellers are in „traffic-influenced microenvironments“ (Matz et al. 2018)

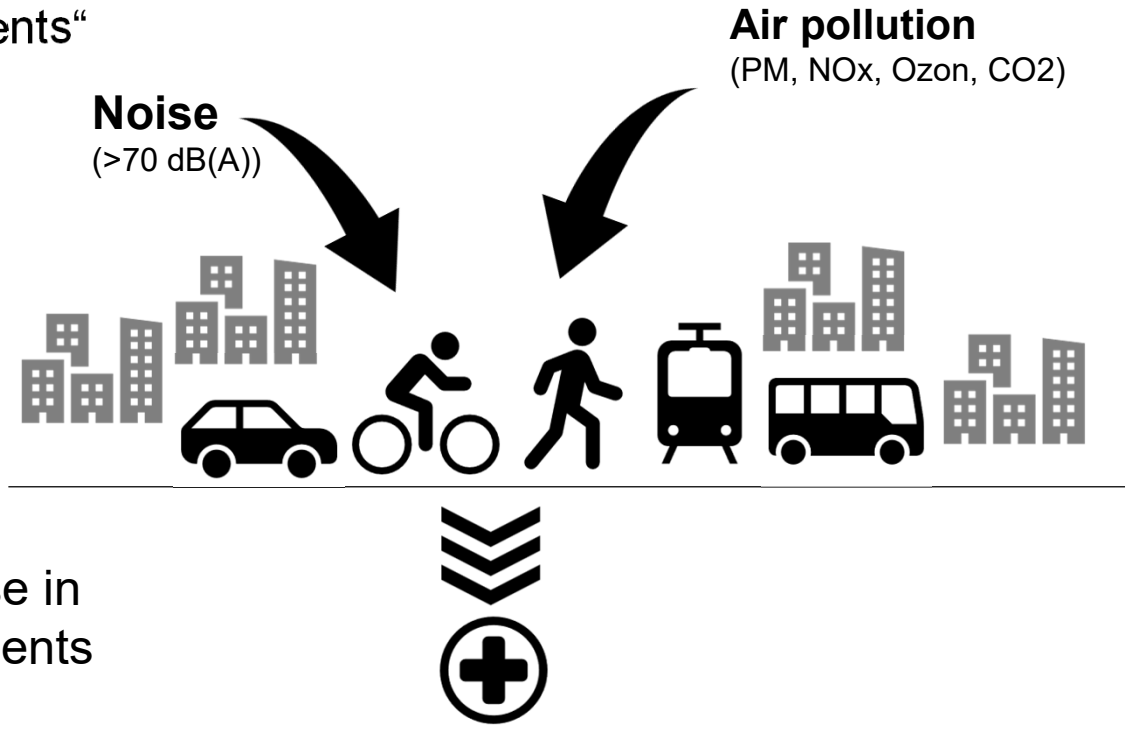


(e.g. Alotaibi et al., 2019; Eriksson et al., 2018; Howell et al., 2019; Kelly & Fussell, 2015; Künzli et al., 2000; Li et al, 2018; Lin et al, 2019; Nieuwenhuijsen 2018; Sass et al., 2017; Sears et al., 2018; WHO 2018).

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Background:
Personal exposure to air pollution during travel

- 4-7% of the day urban dwellers are in „traffic-influenced microenvironments“ (Matz et al. 2018)
- **Perceived** and **measured** exposure to do not always match, specifically on-the-move (see Riley et al. 2021)
  - ➢ e.g. **85%** of cyclists underestimate exposure towards air pollution (Ueberham et al. 2018)
- Severity of air pollution and noise in traffic-influenced microenvironments is underestimated

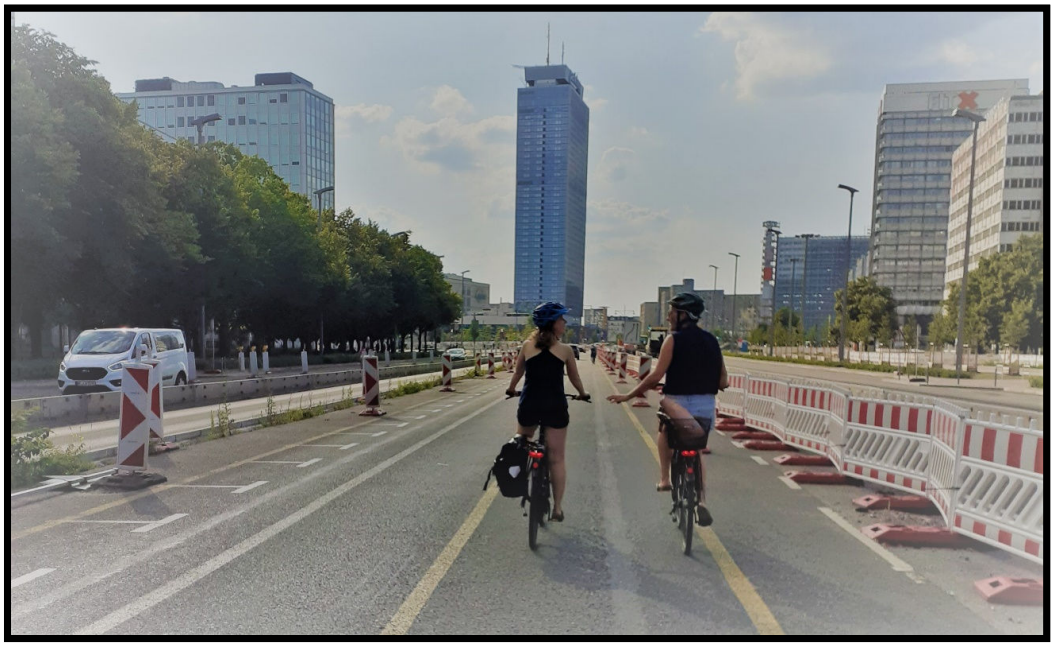


Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Research interest

How are people exposed to air pollution and noise during their daily mobility in the city?

How do people perceive air pollution and noise and how does that influence their well-being, health perception and protective practices?



INDIVIDUAL EXPOSURE SENSING AND SITUATIONAL CONTEXT: BERLIN

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

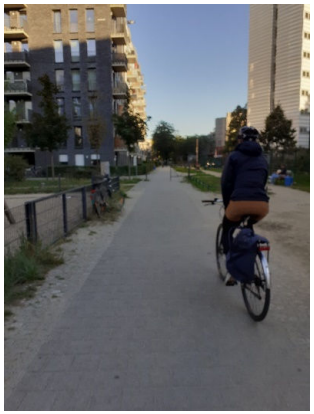
Sample and procedure

- October 2019 – November 2020
- Commuting in Berlin, Germany
  - 28 participants
  - 57% female, 43% male
  - Mean age: 38 years
  - Bicycle 75%; walking+PT 18%, cycling+PT 7%

Dr. Heike Marquart, I
Aerospace Center (DL

Method: Go- and Ride-Alongs and wearable sensors

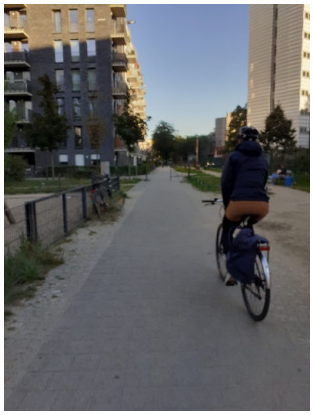
- **On-the-move qualitative interview**
- Interviewer accompanies an interviewee on-the-move
  (Kusenbach, 2003; Evans & Jones, 2011; Sheller & Urry 2006; Kühl 2016)



- Semi-structured interview to explore:
  - ➢**Perception of air pollution and noise**
  - ➢**Protective practices**
  - ➢**Perceived physical health and wellbeing**
  - ➢**Emotional experiences**
- Observations of the environment

Method: Go- and Ride-Alongs and wearable sensors

- **On-the-move qualitative interview**
- Interviewer accompanies an interviewee on-the-move
  (Kusenbach, 2003; Evans & Jones, 2011; Sheller & Urry 2006; Kühl 2016)



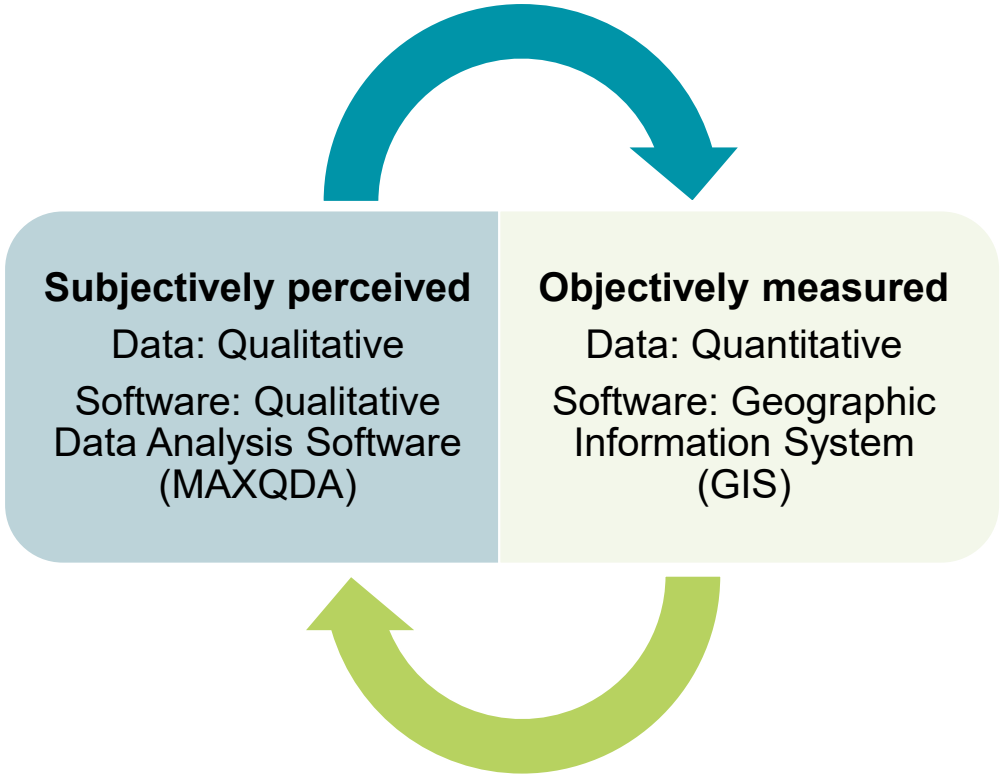
- Semi-structured interview to explore:
  - ➢**Perception of air pollution and noise**
  - ➢**Protective practices**
  - ➢**Perceived physical health and wellbeing**
  - ➢**Emotional experiences**
- Observations of the environment

…complemented by wearable sensors

- **PM2.5 [counts] (per minute)**
- **Noise (dBA) (2sec)**
- **GPS (2sec)**

(see Ueberham & Schlink 2018)

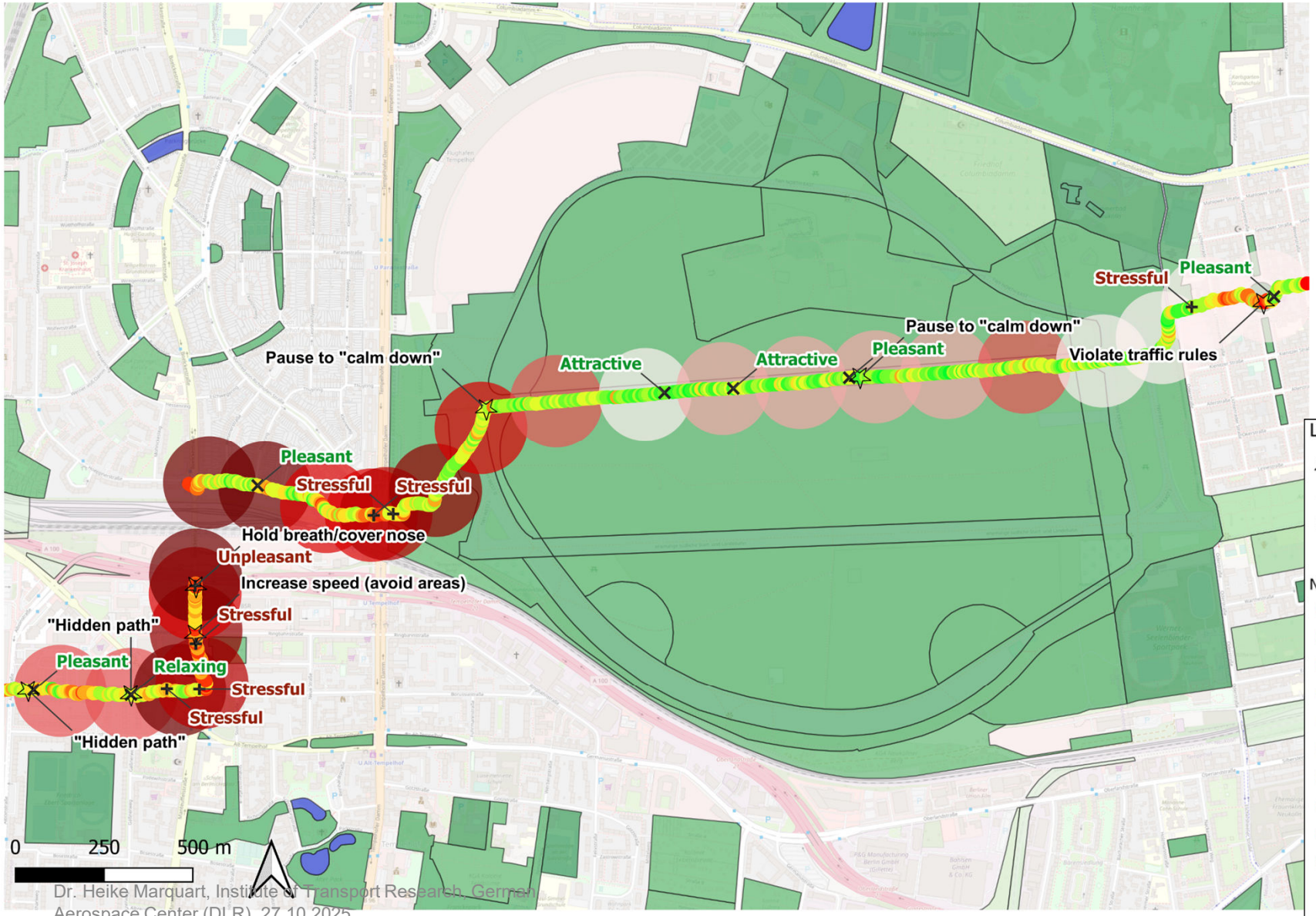
Data analysis and software tools: Qualitative and measurement data



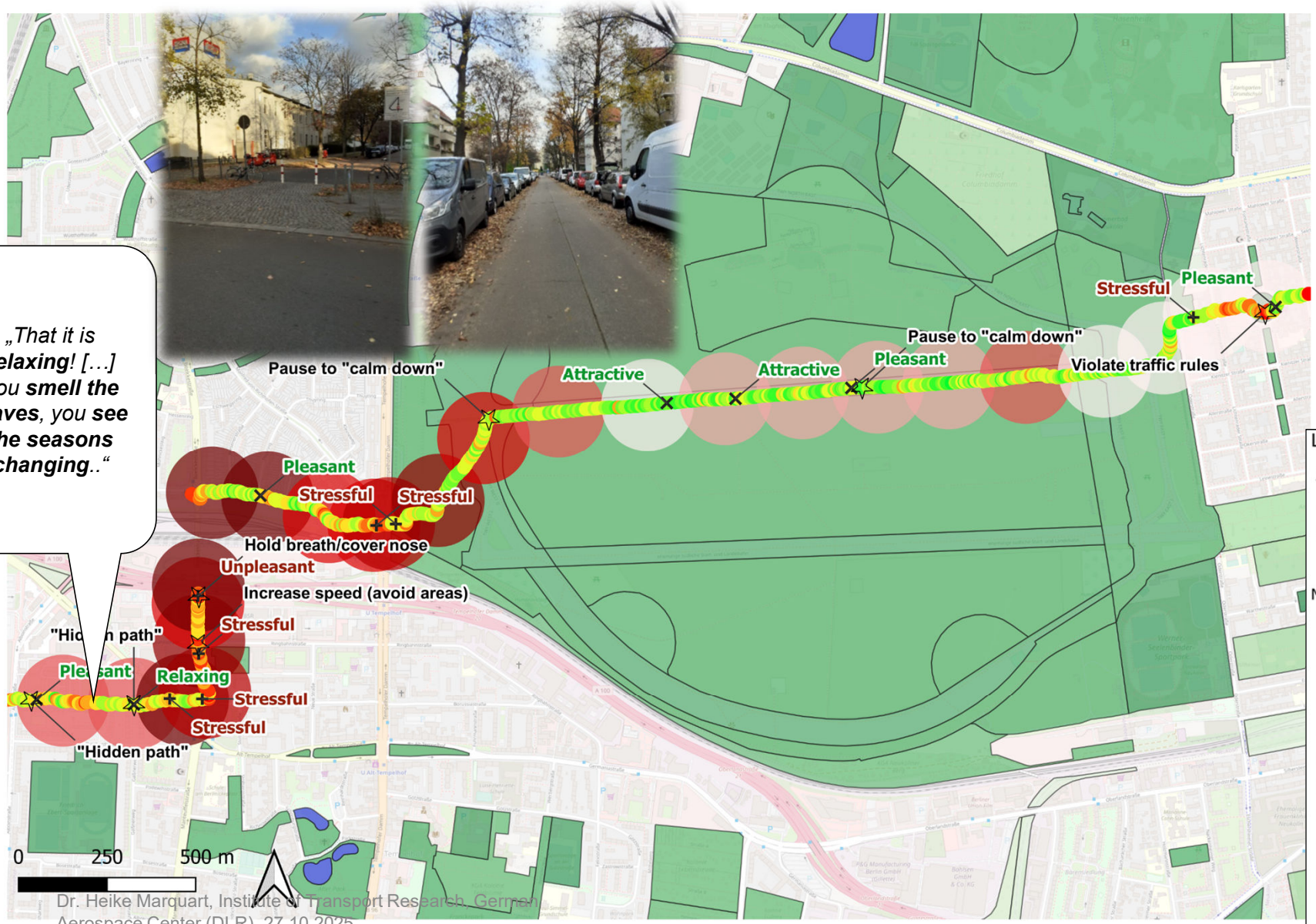
Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Perception of air pollution and noise: Cycling in Berlin

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025



Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

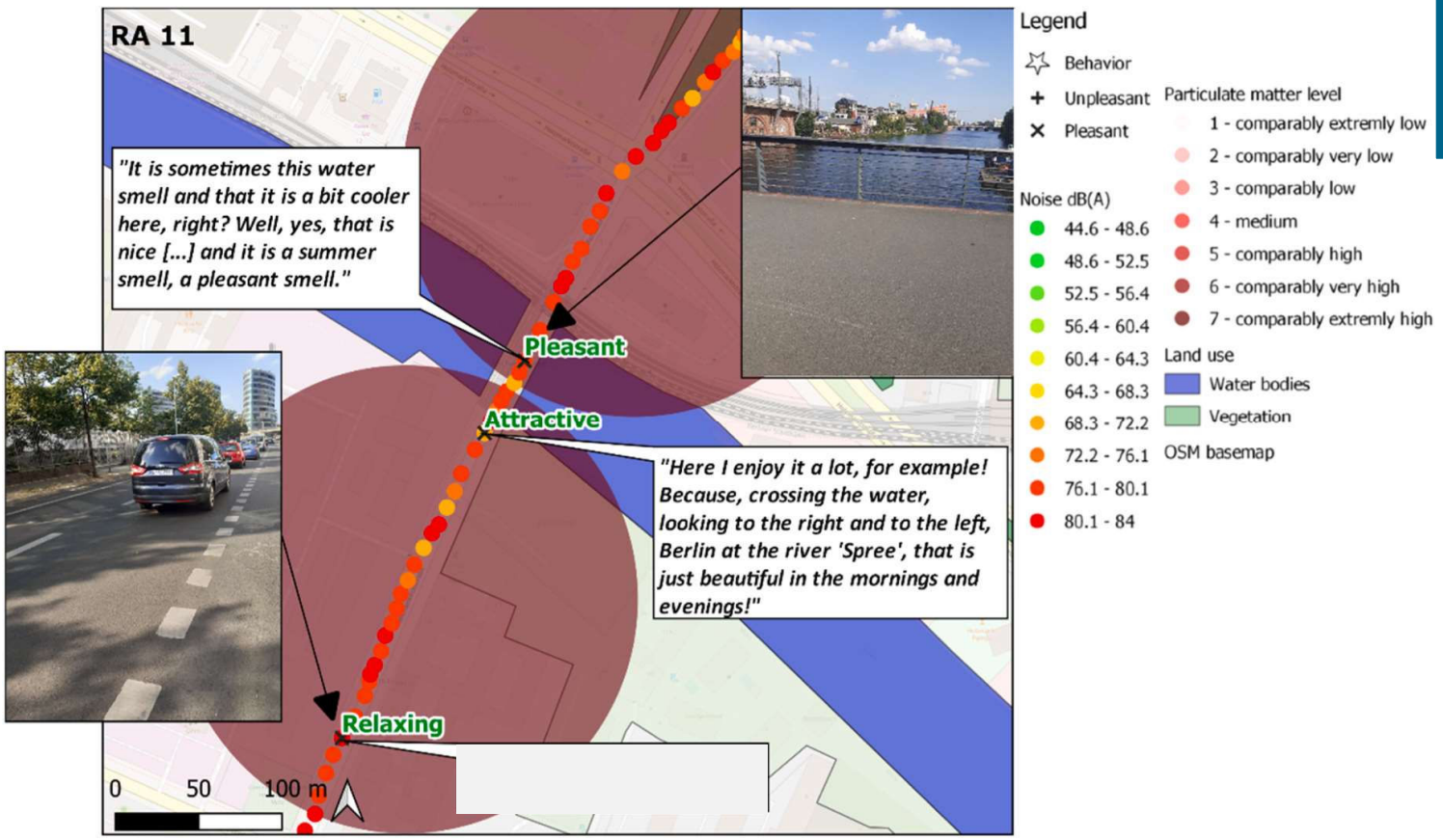

„That it is **relaxing**! […] You **smell the leaves**, you **see the seasons changing**..“
Pause to "calm down"
Attractive
Attractive
Pleasant
Pause to "calm down"
Violate traffic rules
Stressful
Pleasant
Pleasant
Stressful
Stressful
Hold breath/cover nose
Unpleasant
Increase speed (avoid areas)
Stressful
"Hid n path"
Pleasant
Relaxing
Stressful
Stressful
"Hidden path"
0
250
500 m
Legend
Behavior
Unpleasant
Pleasant
Noise dB(A)
44.6 - 48.6
48.6 - 52.5
52.5 - 56.4
56.4 - 60.4
60.4 - 64.3
64.3 - 68.3
68.3 - 72.2
72.2 - 76.1
76.1 - 80.1
80.1 - 84
Particulate matter level
1 - comparably extremly low
2 - comparably very low
3 - comparably low
4 - medium
5 - comparably high
6 - comparably very high
7 - comparably extremly high
Land use
Water bodies
Vegetation
OSM basemap


Pause to "calm down"
Attractive
Attractive
Pleasant
Pause to "calm down"
Violate traffic rules
Stressful
Pleasant
Pleasant
Stressful
Stressful
Hold breath/cover nose
Unpleasant
Increase speed (avoid areas)
Stressful
"Hidden path"
Pleasant
Relaxing
Stressful
Stressful
"Hidden path"
„It **is the worst**! It is getting **louder**, you are **trapped on this cycle paths**."
„And here it is always a bit **stressful**."
0
250
500 m
Legend
Behavior
Unpleasant
Pleasant
Noise dB(A)
44.6 - 48.6
48.6 - 52.5
52.5 - 56.4
56.4 - 60.4
60.4 - 64.3
64.3 - 68.3
68.3 - 72.2
72.2 - 76.1
76.1 - 80.1
80.1 - 84
Particulate matter level
1 - comparably extremly low
2 - comparably very low
3 - comparably low
4 - medium
5 - comparably high
6 - comparably very high
7 - comparably extremly high
Land use
Water bodies
Vegetation
OSM basemap

GoldDrive


„I love it, that you see so much of the sky here!“
„That is important, when the people surrounding you have a great time, [...] that relaxes me.“
Pause to "calm down"
Attractive
Attractive
Pleasant
Pause to "calm down"
Stressful
Pleasant
Violate traffic rules
Pleasant
Stressful
Stressful
Hold breath/cover nose
Unpleasant
Increase speed (avoid areas)
Stressful
"Hidden path"
Pleasant
Relaxing
Stressful
Stressful
"Hidden path"
0
250
500 m
Legend
Behavior
Unpleasant
Pleasant
Noise dB(A)
44.6 - 48.6
48.6 - 52.5
52.5 - 56.4
56.4 - 60.4
60.4 - 64.3
64.3 - 68.3
68.3 - 72.2
72.2 - 76.1
76.1 - 80.1
80.1 - 84
Particulate matter level
1 - comparably extremly low
2 - comparably very low
3 - comparably low
4 - medium
5 - comparably high
6 - comparably very high
7 - comparably extremly high
Land use
Water bodies
Vegetation
OSM basemap

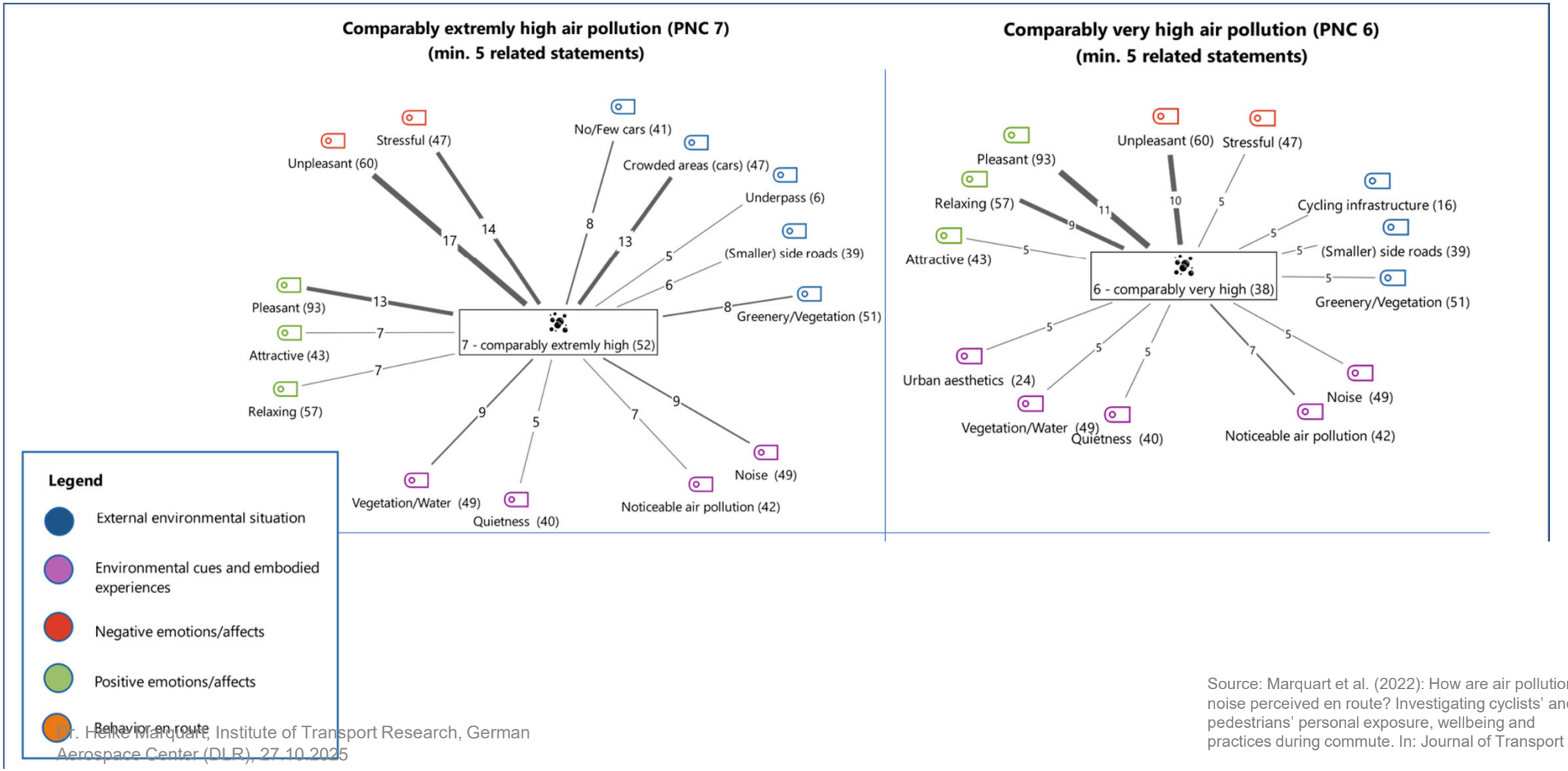
Results: Perception during high exposure levels



Vegetation, greenery and water

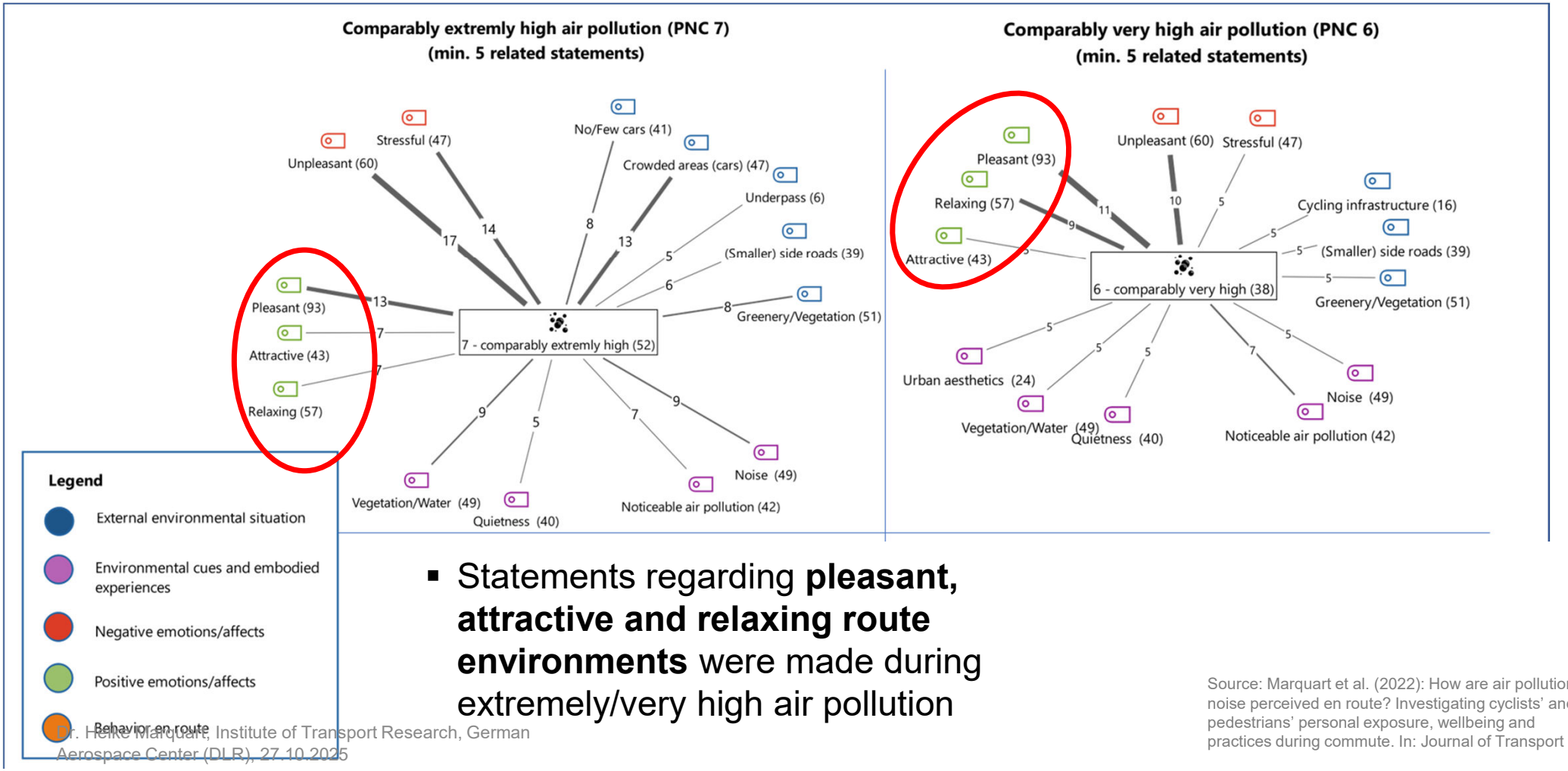
Source: Marquart et al. (2022): How are air pollution and noise perceived en route? Investigating cyclists' and pedestrians' personal exposure, wellbeing and practices during commute. In: Journal of Transport & Health

Results: Perception during high exposure levels



Source: Marquart et al. (2022): How are air pollution and noise perceived en route? Investigating cyclists' and pedestrians' personal exposure, wellbeing and practices during commute. In: Journal of Transport & Health

Results: Perception during high exposure levels



- Statements regarding **pleasant, attractive and relaxing route environments** were made during extremely/very high air pollution

Source: Marquart et al. (2022): How are air pollution and noise perceived en route? Investigating cyclists' and pedestrians' personal exposure, wellbeing and practices during commute. In: Journal of Transport & Health

Results: Other built- and non-built environmental factors

Smaller side-roads

"I cycle, completely in peace, facing the church, free handing, nearly dancing." (RA27)

PM: 7 - comparably extremely high

Urban aesthetics

"I like places which have this 'flair', have a history. […] Every house has a story to tell." (GA15)

PM: 6 - comparably very high

Neighbourhood feeling / „liveable" street

"Here are little shops, people sitting on a bench, the vegetable store. I look into […] and I am happy." (GA13)

PM: 5 - comparably high

Infrastructure and distance to traffic

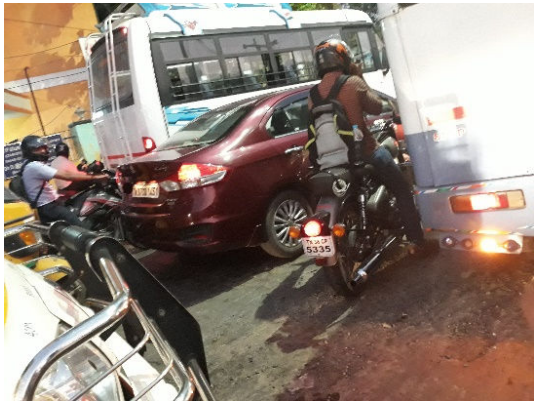
"Here we have a separation of street and cycling path and I perceive the car traffic peripheral." (RA 24)

PM: 7 - comparably extremely high

INDIVIDUAL EXPOSURE SENSING AND SITUATIONAL CONTEXT: CHENNAI

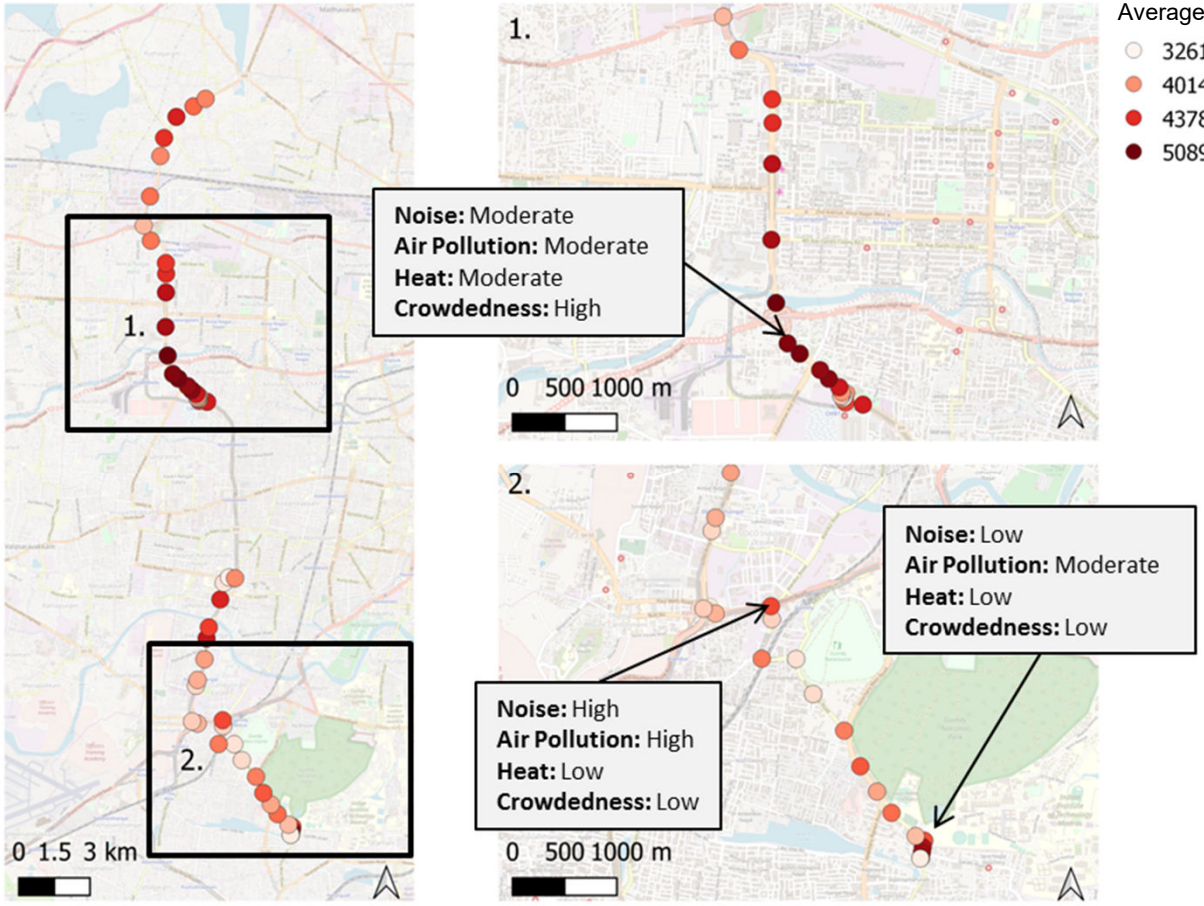
Perception of air pollution and noise: Commuting in Chennai

Interviewed individuals (*N*)	Gender (*N*)	Age (Mean ±SD)	Drivers license (%)	Own vehicle (%)	Commuting type (N)
15	Female (10)	30.4 ±5.3	Yes (73%)	Yes (60%)	Motorbike (8)
	Male (5)		No (27%)	No (40%)	Bus, walking (2) Walking (2) Train, walking (2) Cycling (1)



Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Perception of air pollution and noise: Commuting in Chennai



1. Crowded; interviewee stands in the aisle; doors open; air flow; 3-4 lanes highway, social contact with friend

2. Almost empty; sitting next to open window; 2-lane street covers his/her face with cloth

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Source: Marquart , H.; Schlink, U.; Shiva Nagendra, S.M. (2021): Complementing mobile measurements with Walking Interviews: a case study on personal exposure of commuters in Chennai, India, International Journal of Urban Sciences

Conclusion

- People in traffic have **varying exposure profiles**
- People undertake **protective practices** to protect themselves from pollution
- **Context** is relevant for wellbeing and health perception
- **Built environmental features** and **social context** play a role for exposure perception and can improve wellbeing
  → **Urban planning** plays crucial role

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025

Outlook and further research interests

- How can we effectively **combine perception, exposure and health** applying wearable sensors?
- How can the **built environment** support exposure protection on-the-move? Especially for the **most vulnerable**, e.g. on the route to school?
- What effect does **exposure information / awareness** has on personal wellbeing? → ethical concerns

Thank you.

Contact: heike.marquart@dlr.de

Dr. Heike Marquart, Institute of Transport Research, German Aerospace Center (DLR), 27.10.2025