TRAMWAJE WARSZAWSKIE

EYE TRACKING RESEARCH CENTER
SWPS University

Exploring Visual Attention Dynamics in Tram Driving. Differentiating between Expert and Novice Drivers for Gaze-Enhanced Training

Anna Warchoł-Jakubowska
Institute of Psychology, SWPS University, Warsaw, Poland
Warsaw Trams Ltd., Psychological Support Department

Krzysztof Krejtz, Filippo Baldisserotto, Iga Szwoch, Izabela Krejtz
Institute of Psychology, SWPS University, Warsaw, Poland

DDI 2024
MICHIGAN
October 22–24

Source of funding: Project "Doktorat wdrożeniowy" nr DWD/5/0498/202

Ministerstwo Edukacji i Nauki

Main goal

- to explore differences in attention distribution of tram drivers: novices and experts

- to design visual attention training for novice tram drivers based on the visual paths of expert tram drivers

Eye tracking in transport – research review

Application of eye tracking to observe driving strategies since the 1970s (Soliday 1971)

Eye trackers, in the driving domain, are used to:

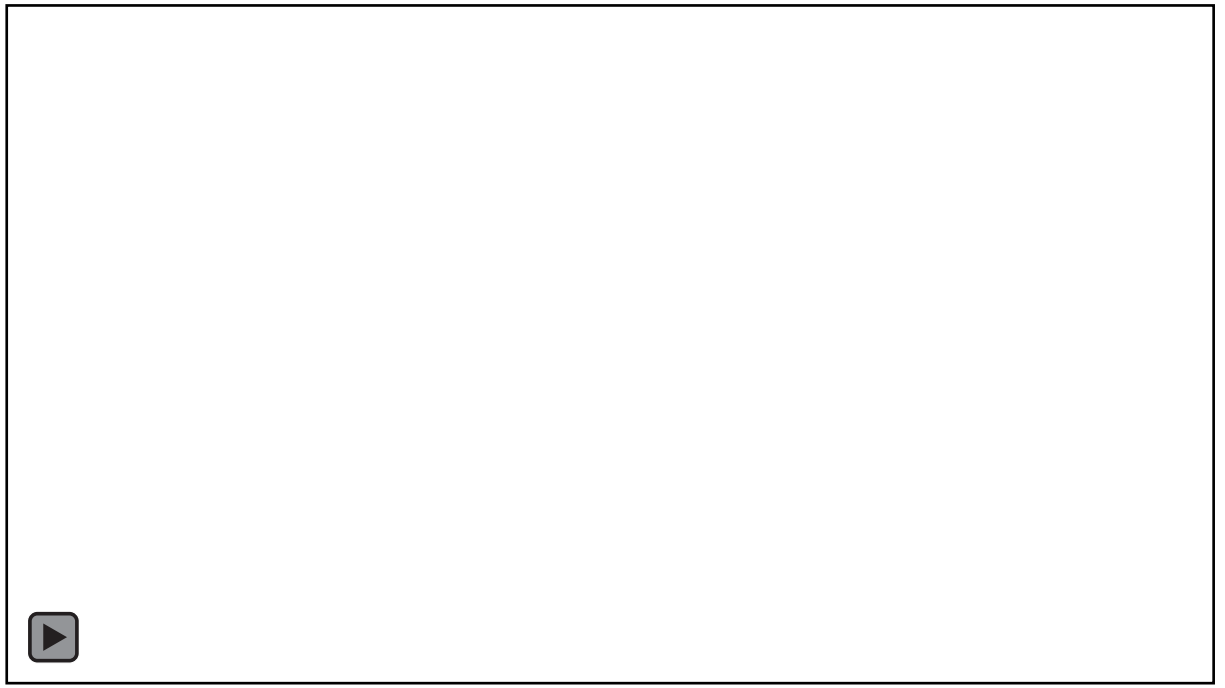
- train drivers (Pollatsek et al. 2006, Sellberg et al. 2022)
- construct vehicles (Chang et al. 2013, Khan and Lee 2019)
- design roads and their surroundings (De Ceunynck et al. 2015, Skjermo 2022)
- design automatic driver support systems (You et al. 2017)

Eye-movement measurements

Fixations – the relative stopping of eye movements on a selected object.

The typical median of fixation durations is 200-250 ms.

Saccades – rapid eye movements between successive fixations, quickly relocating the visual attention to a different region in the visual environment (Duchowski 2003)



Eye-movement characteristics: Ambient and Focal Attention

The two **modes of visual information processing** (Velichkowsky et al. 2005)
Ambient-focal attention K coefficient (Krejtz et al. 2016):

Ambient (exploration)
relatively short fixations are followed by relatively long saccades
(negative values of K coefficient)

Focal (inspection)
long fixations are followed by short saccade amplitudes
(positive values of K coefficient)

Focal attention is related to greater analytical cognitive processes, while ambient attention suggests more visual skimming (Krejtz et al. 2016)

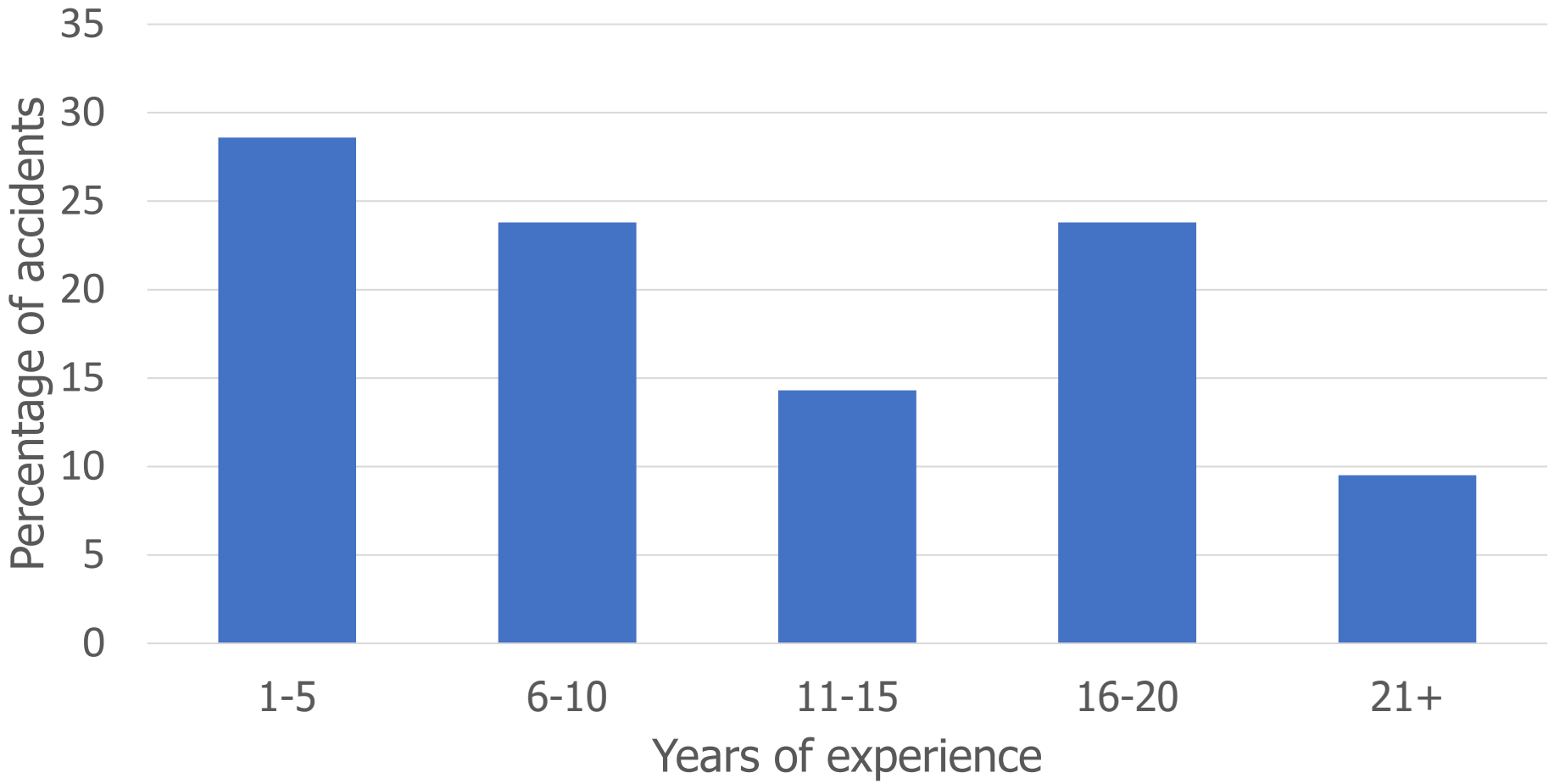
Eye tracking in transport – novices & experts

Novice and expert drivers differ in their visual scan paths (Nabatilan et al. 2011, Robbins & Chapman 2019)

Eye-tracking data provide information on critical moments for driving safety.
80-90% of information is obtained through the eyes of the driver (Smiley et al. 2004, Alvarez-Peregrina et al. 2021)

The **driving experience** (Chapman and Underwood 1998; Neyens and Boyle 2008) and **visual attention** (Crundall et al. 2004) are key predictors of accident rates.

Warsaw Tram accidents report (2022)



Warsaw Tram accidents report (2022)

Eye tracking in transport – type of vehicle

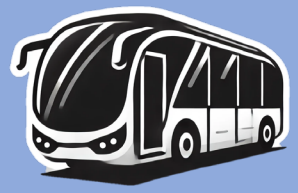
- **motorcyclists vs. car drivers** - motorcyclists developed a significantly richer visual strategy than car drivers - a higher number of fixations, especially on objects on the road and sidewalk - strategy focused on minimizing risks related to other road users (Muttart et al. 2011)
- **truck drivers vs. car drivers** - the amplitude of eye movements is significantly wider when driving large vehicles (truck, bus) compared to driving a small car (Kito et al. 1989)
- **race-car drivers** adopt different driving strategies and exhibit higher steering activity resulting in lower lap-times than **regular drivers** in a simulated car race (Negi et al. 2019)

running on tracks

no steering wheel

long straight sections

of tracks



driving on the road

steering wheel

handling city traffic

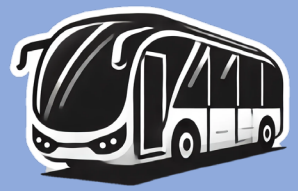
service to passengers

running on tracks

no steering wheel

long straight sections

of tracks



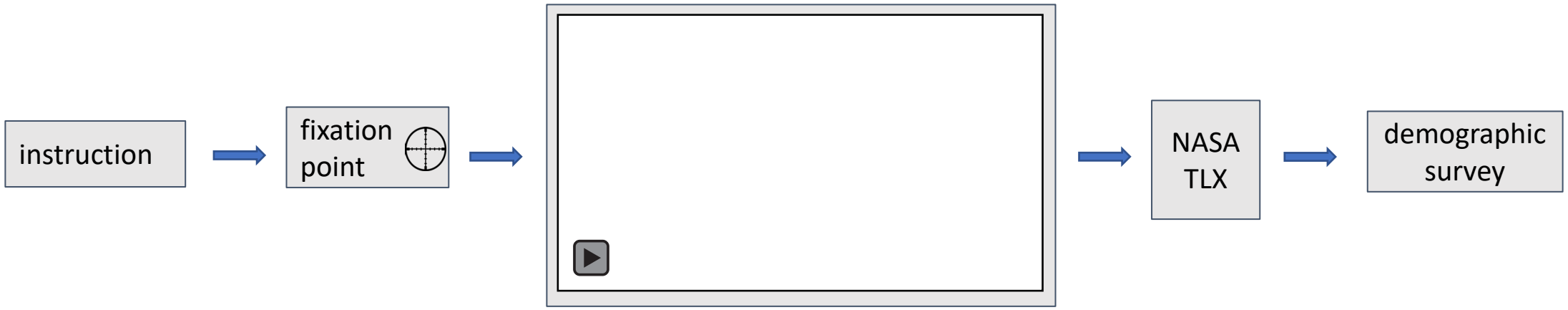
driving on the road

steering wheel

handling city traffic

service to passengers

Previous study



Participants

23(4F) experts (M_{age} = 44.5, *SD* = 7.58)
with a minimum of 5 years of accident-free tram driving (M =15.4, *SD* = 8.88)

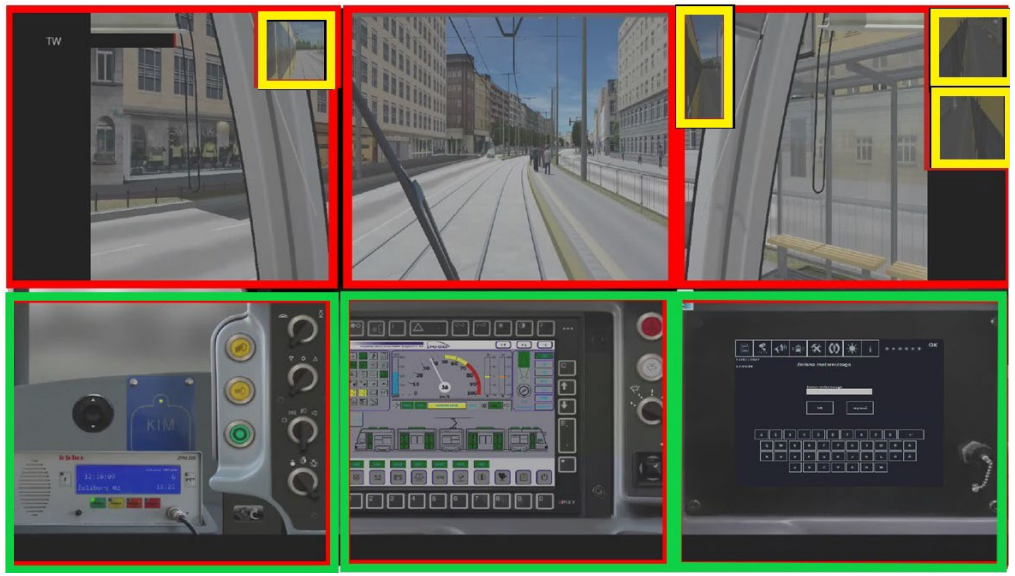
24(4F) novices (M_{age} = 39.3, *SD* = 8.25)

Eye-tracking equipment

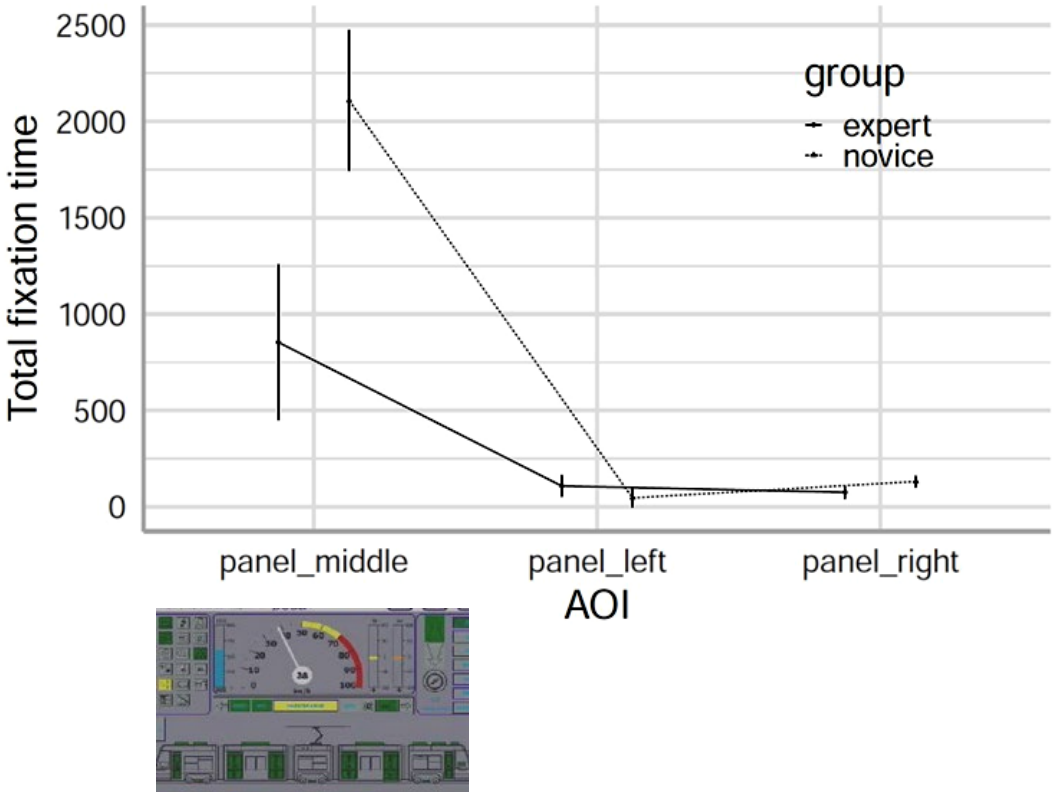
Gazepoint GP3 HD
150Hz stationary eye tracker

Warchoł-Jakubowska et. al. ETRA 2023

Previous study



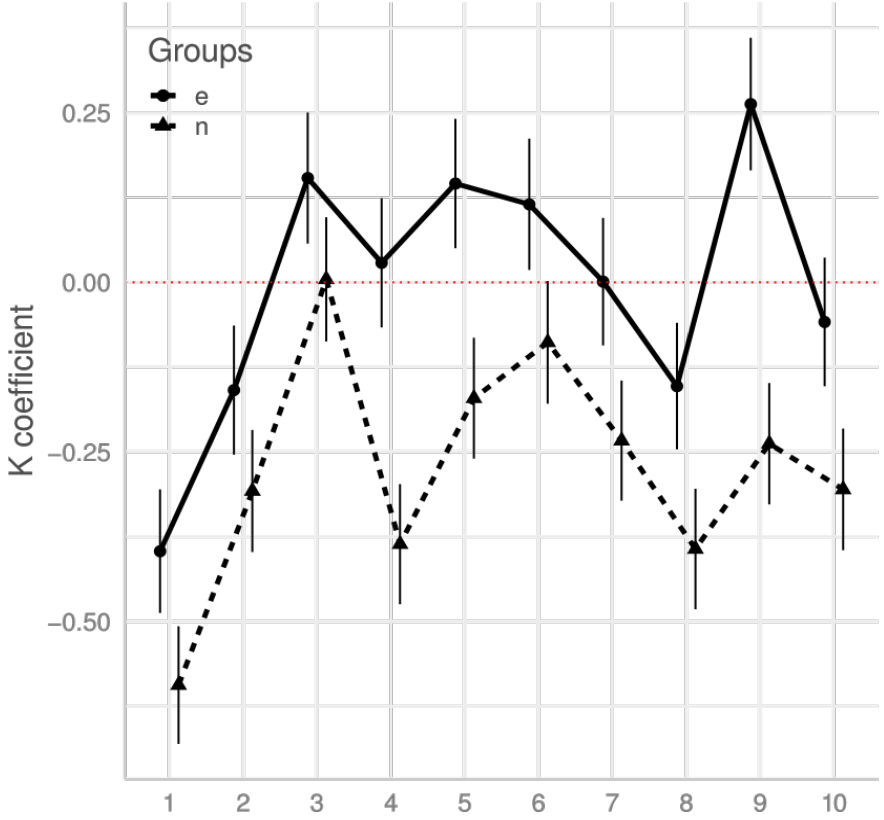
(Warchoł-Jakubowska et. al. ETRA 2023)



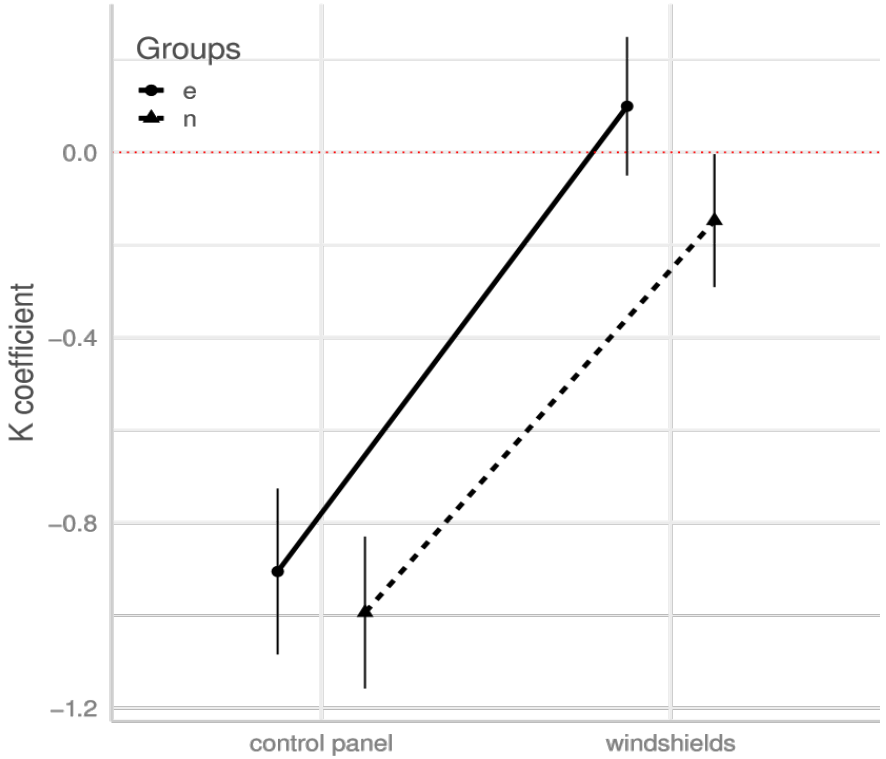
Interaction effect of participants group and AOI

$F(1.04, 45.90) = 5.58$, $p < .05$, $"\eta" \hat{} 2 = .074$

Previous study



Dynamics in ambient-focal attention expert (e) vs. novice (n) tram drivers



Differences between expert and novice tram drivers in ambient-focal attention (K coefficient) in **windshields and control panel**

Warchoł-Jakubowska et al. (2023) Transport Problems

Present study

Do expert drivers exhibit attentional patterns that can improve tram safety?

- **Hypothesis 1:** experts maintain more focal attention during the critical phases of different tram tasks
- **Hypothesis 2:** experts pay more attention to instruments (control panels, windshields, or mirrors) that are more relevant to certain task phases

1. potentially hazardous events (pedestrians stepping out from behind a tram, vehicle forcing right-of-way)

instruction →  → 5-point Likert-type scale → demographic survey

1. potentially hazardous events (pedestrians stepping out from behind a tram, vehicle forcing right-of-way)
2. tram stops operating

instruction →  → 5-point Likert-type scale → demographic survey

1. potentially hazardous events (pedestrians stepping out from behind a tram, vehicle forcing right-of-way)
2. tram stops operating
3. right and left turns making (each turn requiring timely switch point operation)

instruction →  → 5-point Likert-type scale → demographic survey

Participants

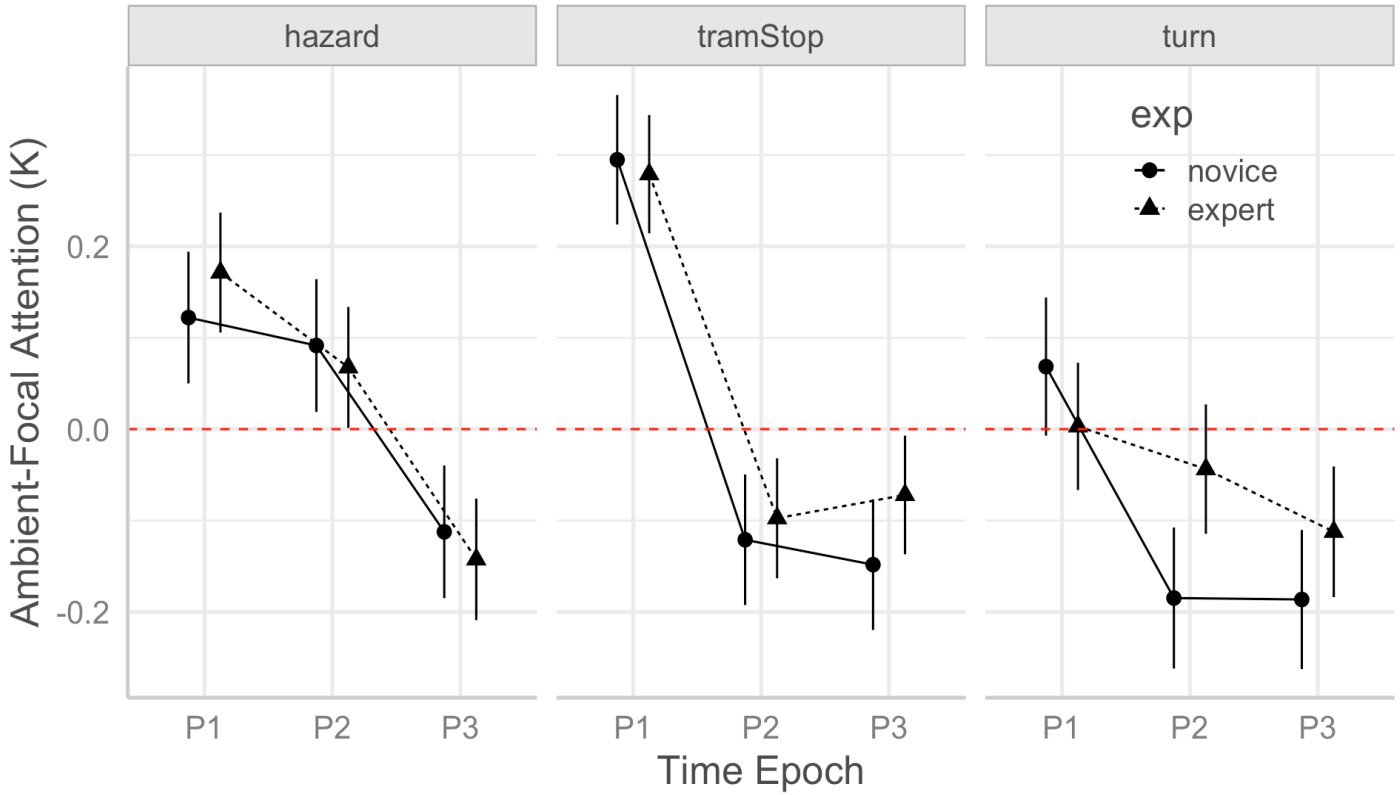
Forty-five **tram drivers** in two groups:
25(5F) experts (M_{age} = 43.07, *SD* = 5.97)
20(5F) novices (M_{age} = 37.90, *SD* = 7.54)

Eye-tracking equipment

PupilLabs Invisible

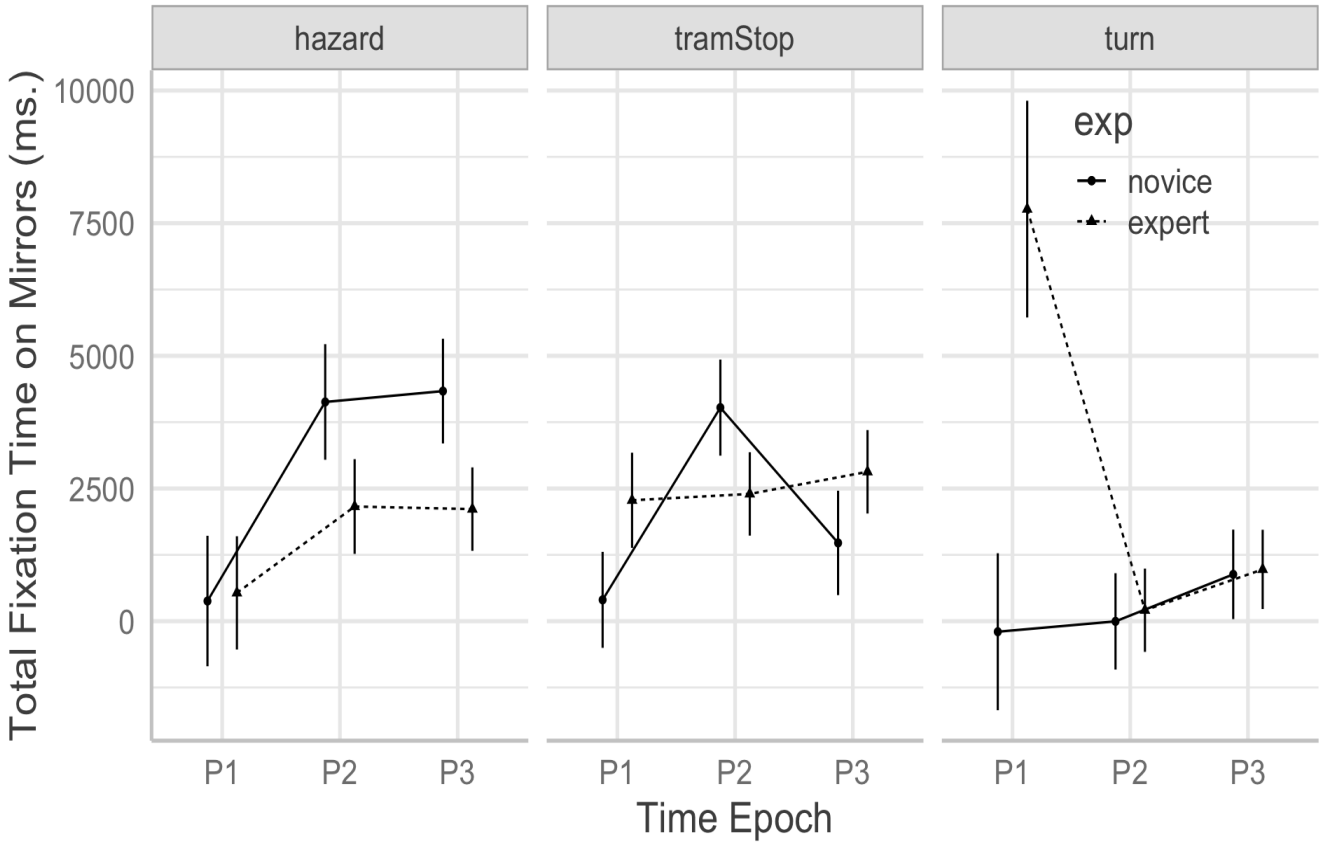
200 Hz mobile eye-tracker

Present study: ambient - focal attention



Ambient-focal attention dynamics depending on expertise, task type, and time.
Note: P1, P2, P3 - time periods; error bars represent +/-1SE for estimated means

Present study: areas of interest



Total fixation time on mirrors depending on expertise, task, and time.
Note: P1, P2, P3 represent the time periods of each task

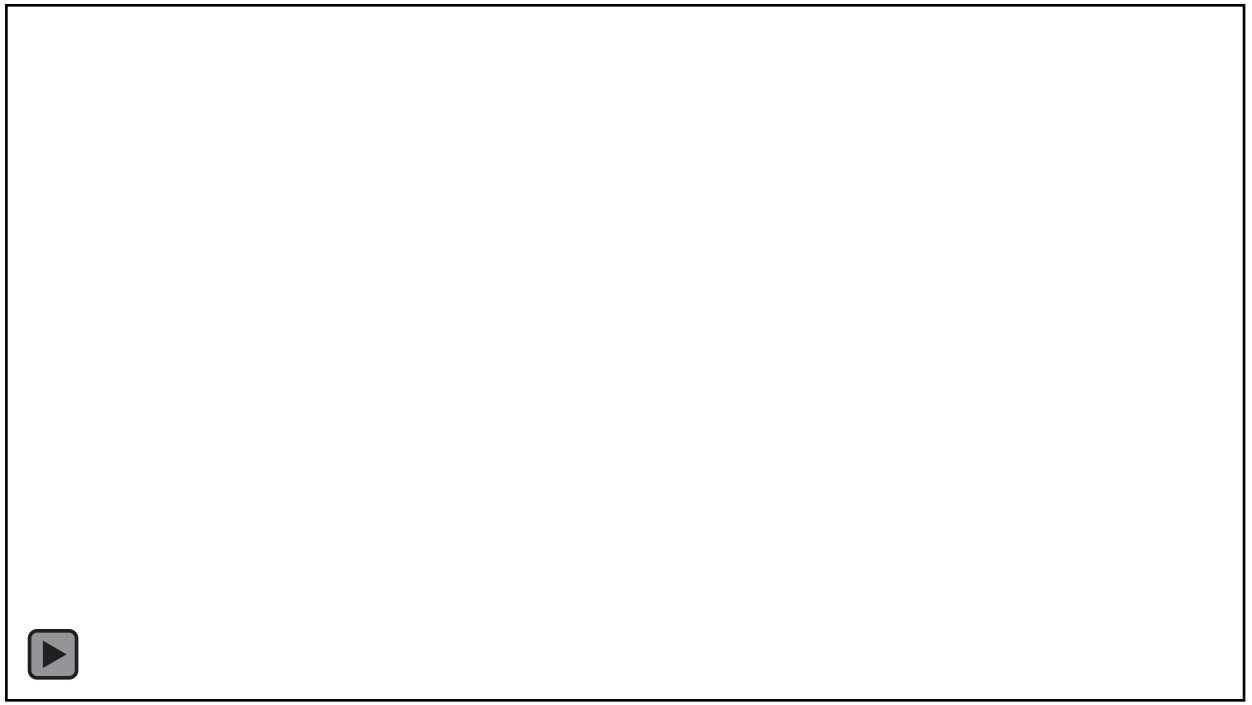
Summary

Analysis of visual attention distribution gives new insights into visual field scanning skills - equally important for training novices (developing important scanning skills) and experts (expanding knowledge about one's behavior) (Muehlethaler and Knecht 2016).

Scanning patterns can be a valuable source of information to adjust the training of novices to guide their attention toward key elements of their visual field during tram driving.

Our studies will lead to design a gaze-based training for novice tram drivers.

The Training Ideas



EYE TRACKING RESEARCH CENTER
SWPS University

TRAMWAJE WARSZAWSKIE
Przyjazne ludziom i miastu