



Pedestrians' Understanding of a Fully Autonomous Vehicle's (FAV) Intent to Stop: Utilizing Video-based Crossing Scenarios

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Presentation at the RSS 2022 conference,
8-10, June. Athens, Greece



Scientific Background

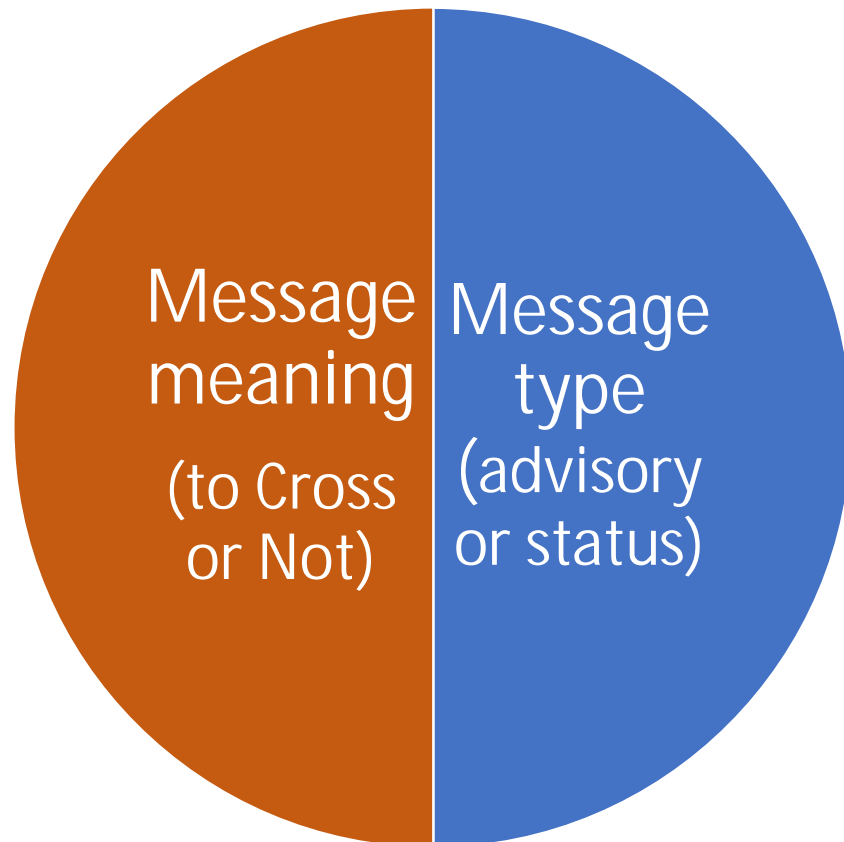
- External Human Machine Interface (eHMI) **improves interaction**, initial **trust, understanding**. (Clamann et al., 2017; Ackermans et al., 2020; Kaleefathullah et al., 2020; Deb, et al. 2018)
- **Pedestrians tend to look** at the eHMI before making the crossing decision, however they do not necessarily comply. (Hochman et al., 2020)
- Pedestrians' decisions to cross depend on the **eHMI** suggestion and **crossing conditions**, e.g., vehicles' distance from the crossing place. (Mahadevan, Somanath, & Sharlin 2018; Tabone et al., 2021)



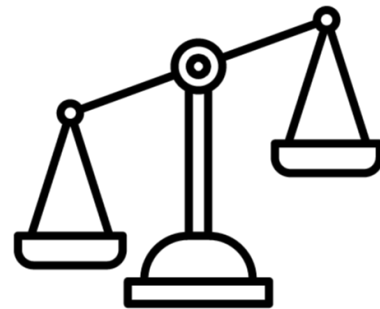
Motivation

What affects pedestrians understanding and behavior?

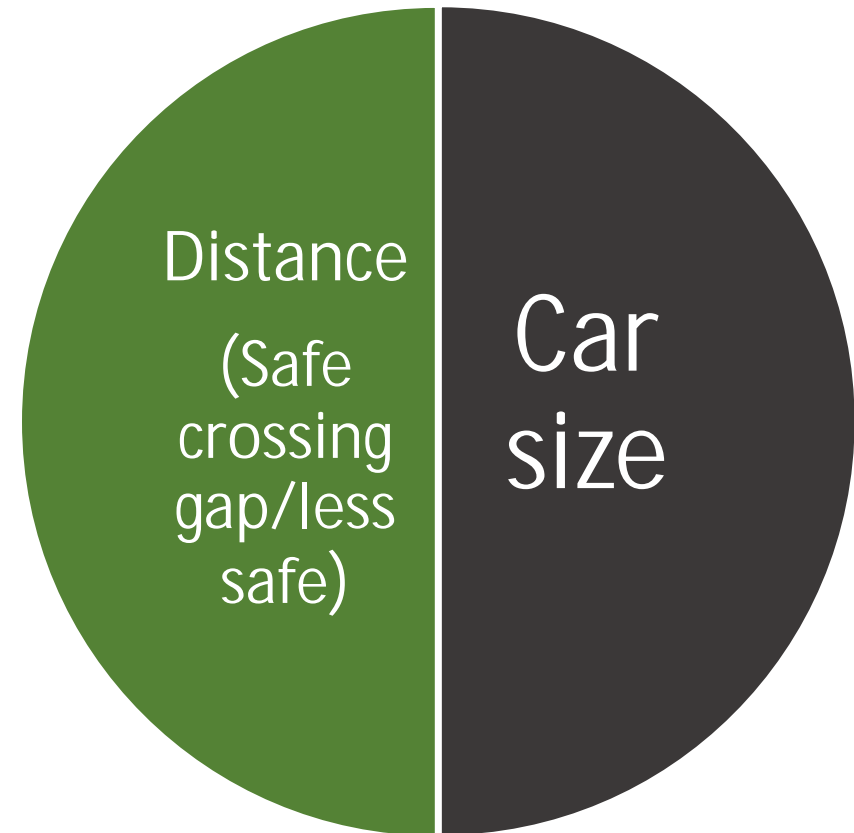
eHMI content



(Deb et al., 2018; Ackermann et al., 2019)



Crossing context



(Clamann et al., 2017)

The Goal

Examine the influence of factors related to the crossing context (distance, car size) and to the eHMI content (message meaning, message type), on pedestrian understanding & behavior in dynamic situations.

Method – Dynamic situations - Video based scenarios

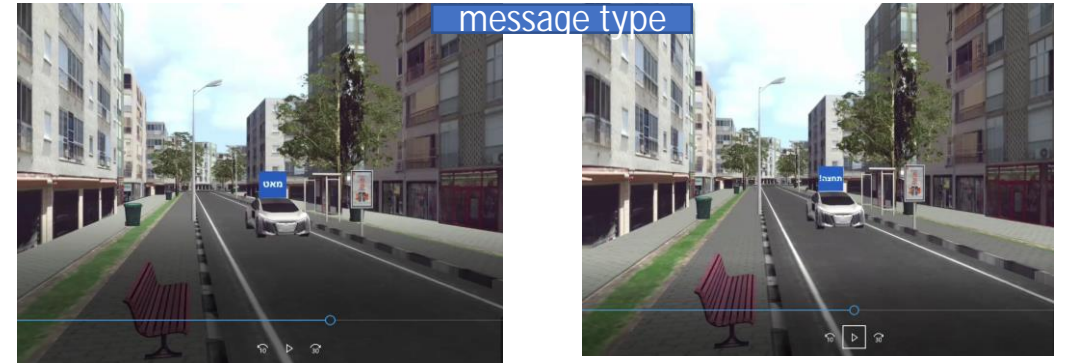
In-Person Experiments



34
participants

56 crossing
scenarios

Crossing
decision



message meaning

car size



Method – The intermediate questionnaire

Did you understand the FAV message? (yes/no)
How confident are you in your decision? (On 10-point rating scale)
To what extent did you experience the situation as dangerous?
What was the FAV's intention? (short free text answer)

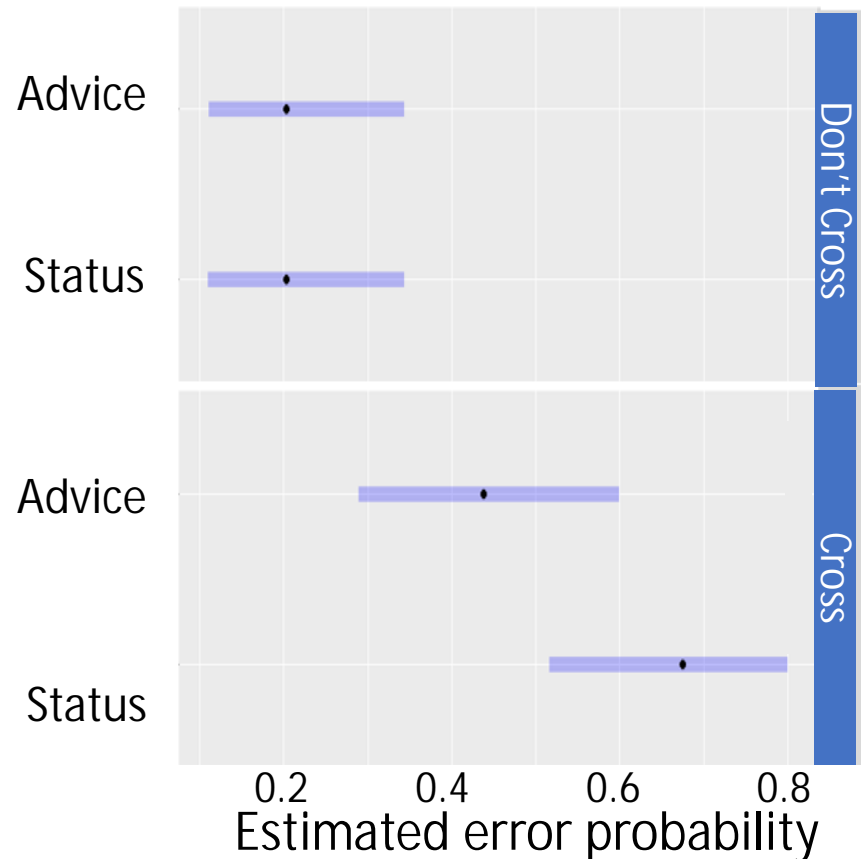
Measuring Understanding

- **Error probability**- was defined as the incompatibility of the participant's crossing decision (whether to cross or not) with the eHMI recommendations. (Ackermann et al., 2019)
- **Response time** - the time from the moment the video was initiated until the participant pressed a decision button. (Hochman et al., 2020)
- **Subjective questionnaires** – subjective questionnaires. (Deb, Carruth, and Strawderman, 2020; Tabone et al., 2021)
- **Eye-tracking measures** - Total fixations duration, the total number of fixations on the e-HMI, Gaze distribution. (Hochman et al., 2020; Liu et al., 2020)

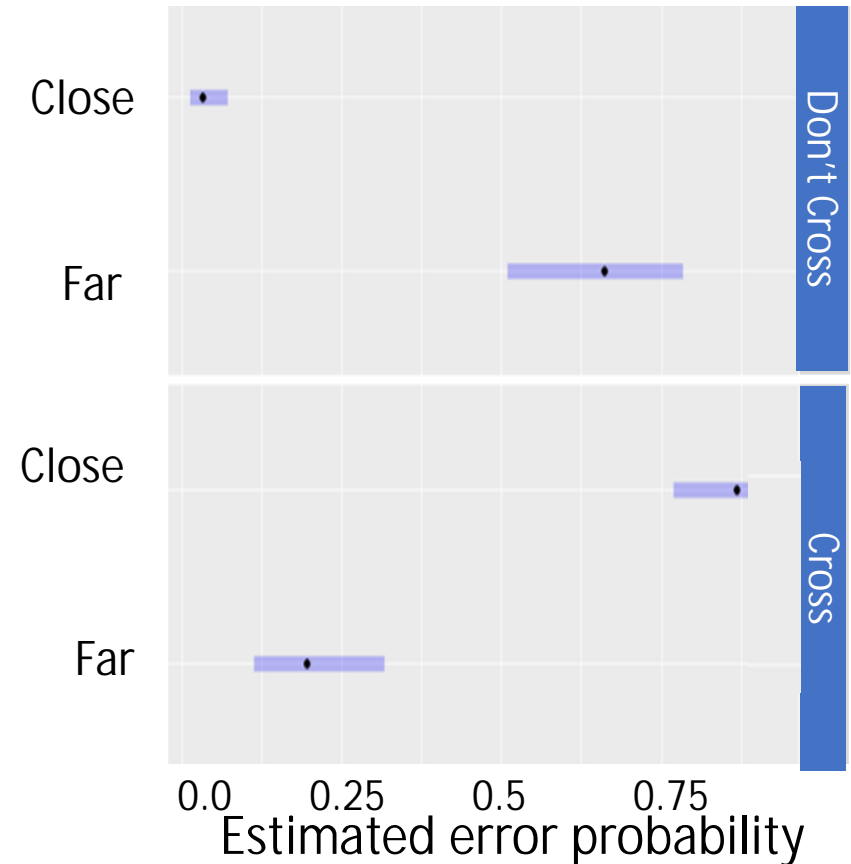
Results - Error probability

incompatible -47 % , compatible- 53 %

by message type
and message meaning

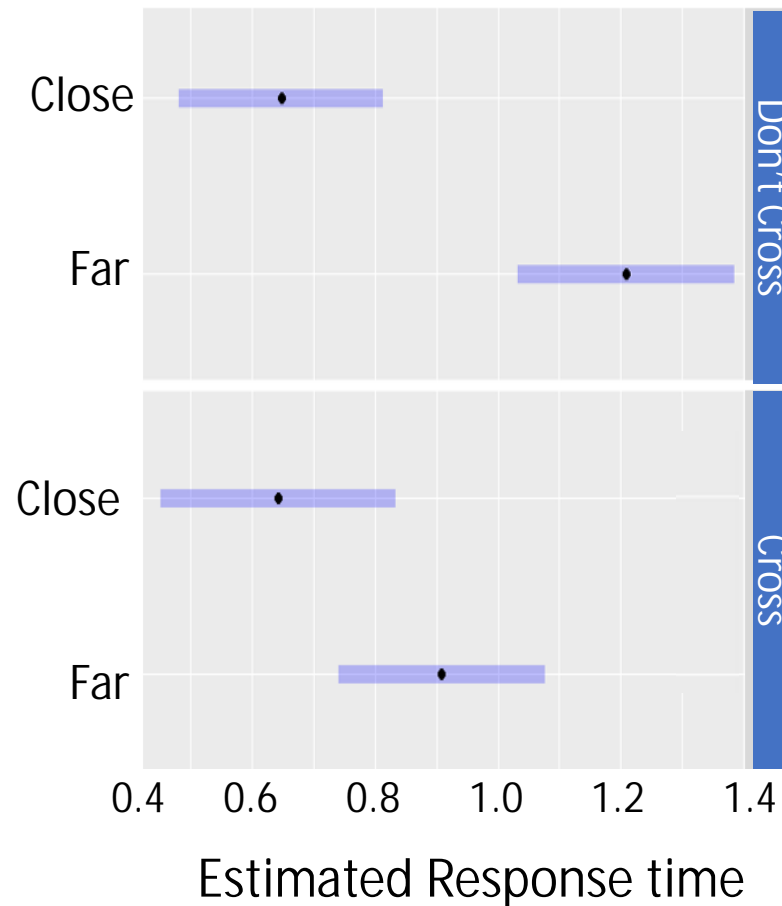


by distance
and message meaning



Results – Response time

By distance
and message meaning

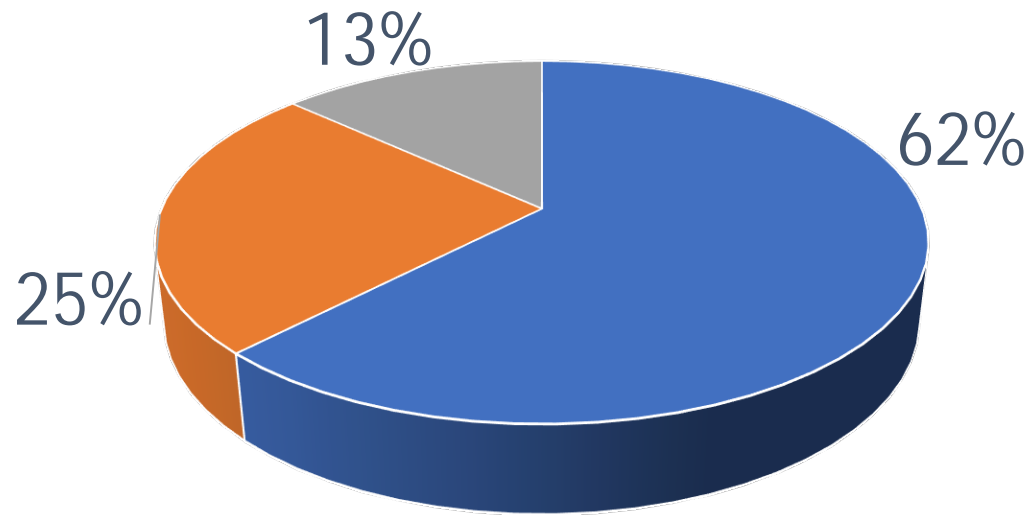


RT was analyzed only for
the compatible responses

Results - Pedestrian's subjective Understanding

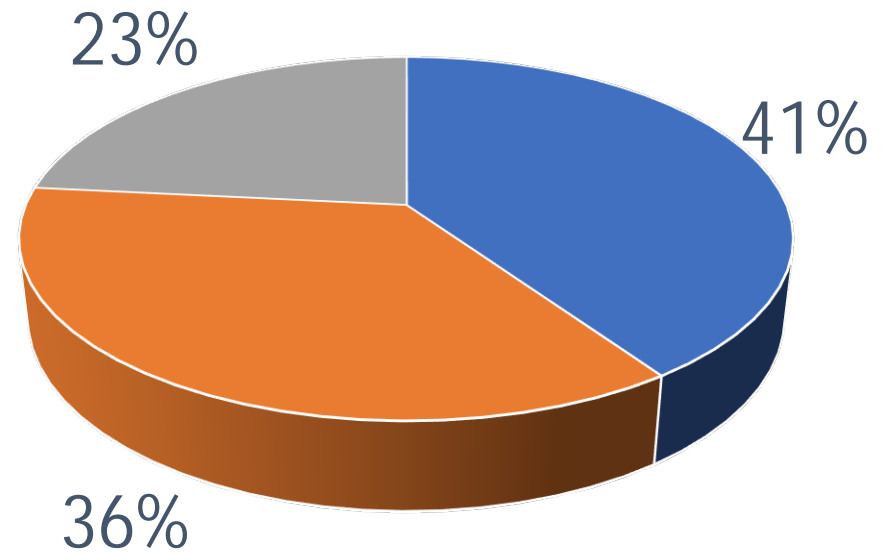
Compatible responses

(53%)



Incompatible responses

(47%)

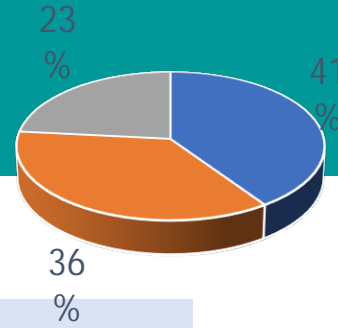


■ Understanding fits message meaning

■ Understanding doesn't fit message meaning

■ Pedestrian declare They did not understand

Incompatible responses



Incompatible responses when pedestrian **understood** occurred :

- FAV was **Close** and the suggestion was to **Cross** (78%).
- FAV was **Far** and the suggestion was **Not to cross** (92%).

When pedestrians **did not understand** they mainly decided:

- **Not to cross** in the **Close distance** when suggested **to cross** (77%).
- **To Cross** in the **Far distance** when suggested **not cross** (95%).

Discussion



FAV was **Close**
suggestion was
CROSS

FAV was **Far**
suggestion was
STOP

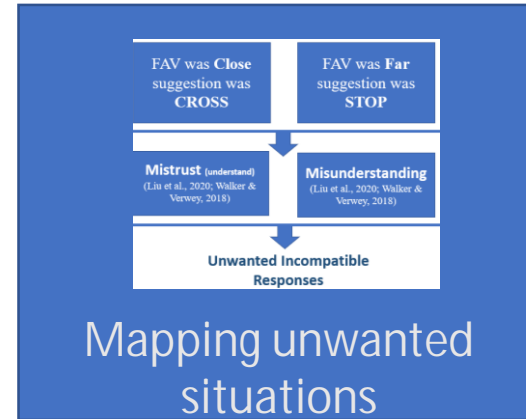


Mistrust (understand)
(Liu et al., 2020; Walker &
Verwey, 2018)

Misunderstanding
(Liu et al., 2020; Walker &
Verwey, 2018)

Unwanted Incompatible
Responses

Practical implementation



Increase Understanding through design



Provide e-HMI design that encourage higher compatible decisions and provide fast RT, and minimize number of fixations on the e-HMI



Increase trust by providing pedestrian information about the FAV reliability

Ongoing & Future Work

Ongoing work

- Examine **Few FAVs** at a certain time.
- Investigate the effect of **time pressure**.



Future work

- Increase trust by **providing pedestrian information** about FAV reliability.
- Explore effect of **sounds of eHMI** on pedestrians estimate the FAV distance, increase awareness of its intentions.
- Examine more **complex crossing opportunities** (more lanes, two-way streets, various car distances, speeds, etc.).





Questions?



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The first author, Michal Hochman, was funded by The Israeli Smart Transportation Research Center (ISTRC) via a doctoral student grant.

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