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INSTITUT FÜR INFORMATIK
ARBEITSGRUPPEN MEDIENINFORMATIK UND MENSCH-MASCHINE-INTERAKTION

Passenger Reroute: Phone-Based Intervention In Self-Driving Cars

Bachelor Thesis

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Presentation Outline

1. Introduction
2. Related Work
3. Research Questions
4. Concept
5. Implementation
6. Main Study
7. Results
8. Conclusion

1. Introduction

In **autonomous vehicles** (**AV**) passengers could…

- …engage in **non-driving related activities** (**NDRA**)
- …react to **non-critital spontaneous situations** (**NCSS**)

Papersource: https://link.springer.com/article/10.1007/s42154-019-00087-9
Terken, 2020; Toward Shared Control Between Automated Vehides and Users

Papersource: https://doi-org.emedien.ub.uni-muenchen.de/10.1145/3409120.3410652
Wang, 2020; "Watch out!": Prediction-Level Intervention for Automated Driving

Source: https://s3-prod-europe.autonews.com/s3fs-public/Volvo%20AV.jpg

1. Introduction

- Travel with **AVs**
  - **No driver**/ steeringwheel
  - New IT-> **Trust issues**
  - **Individual expectations** for information displayment
  - Need for **safety**, **autonomy**

Pony.ai Car: https://static.cdn.xiaomazhixing.com/images/home/car_1615998576.png

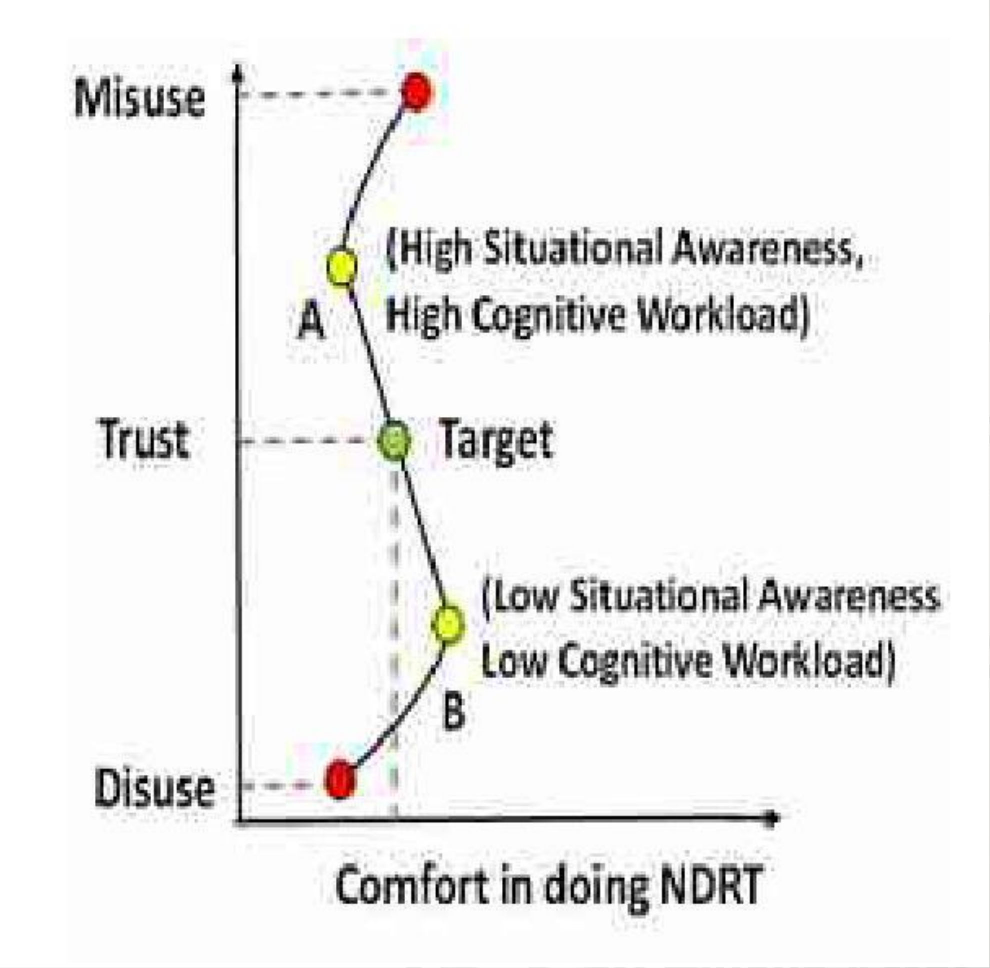
Waymo Sensors and Camera: https://static.cdn.xiaomazhixing.com/images/home/car_1615998576.png

Mercedes LVL 3 source: https://auto.hindustantimes.com/auto/news/mercedesbenz-becomes-world-s-first-to-get-level-3-autonomous-driving-approval-41639196499051.html

2. Related Work – NDRA vs. Trust

- **Tradeoff** in AVs: comfortability of **NDRA** and the perceived **trustworthiness** of the car

- Imbalanced UIs might cause **Mis-** or even **Disuse**



Paper source: https://dl.acm.org/doi/10.1145/3004323.3004331
Miglani, Diels - Compatibility between Trust and Non - Driving Related Tasks in UI Design for Highly and Fully Automated Driving

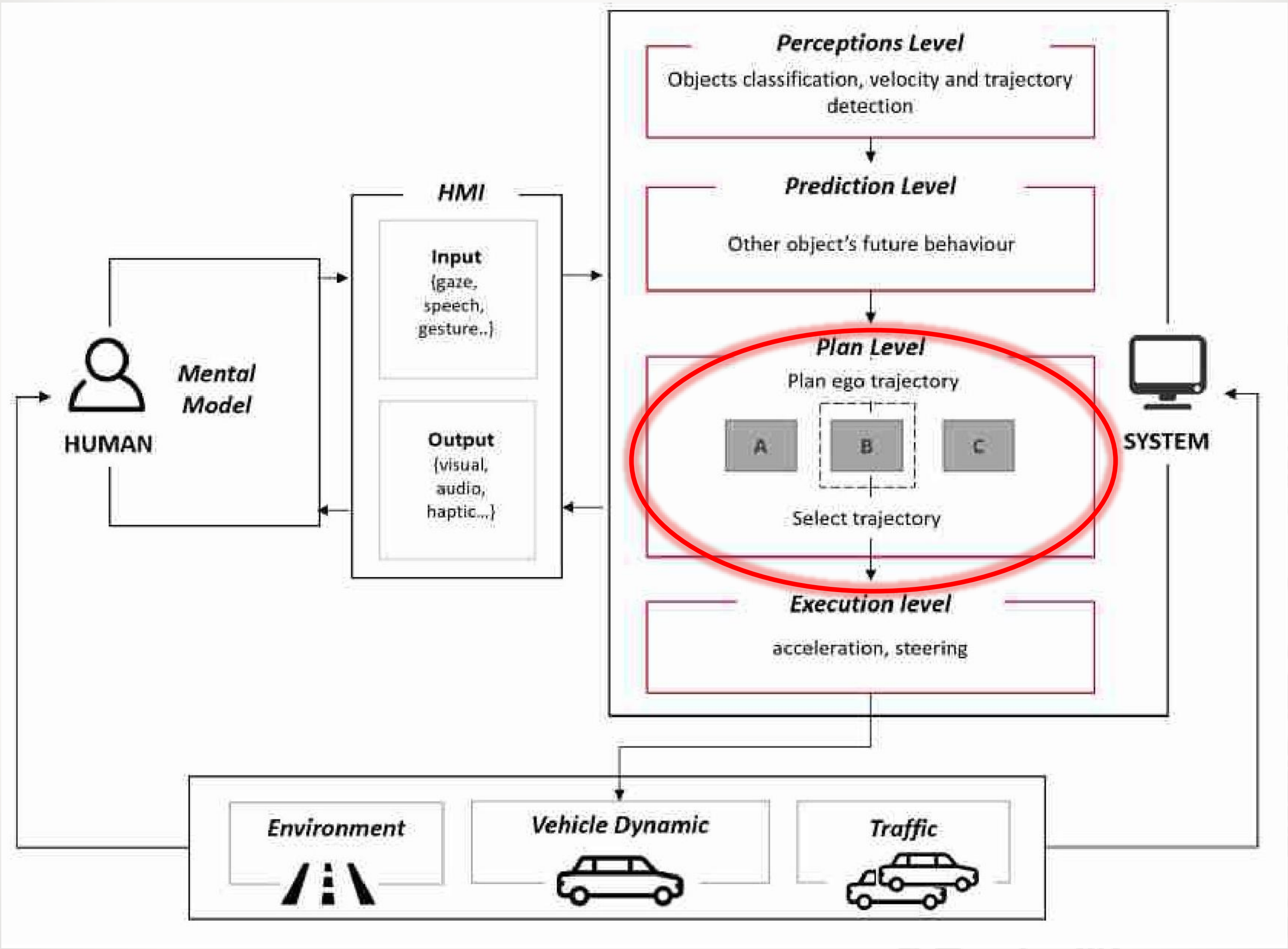
2. Related Work– Use cases

Table 1 Requirements emerging from the use case analysis

A	It should be possible to influence the planned route and tell the system to take a different route
B	It should be possible to help the ACC and tell the vehicle to accelerate more strongly
C	It should be possible to tell the system to initiate a takeover maneuver
D, E	It should be possible to tell the system to violate the speed limit
F	It should be possible for the user to tell the system to slowly and gently push into the pedestrian flow, even if the pedestrians have right of way
G	It should be possible to tell the system to start moving
H	It should be possible to adjust the driving style to one's own preferences
I	It should be possible to tell the vehicle to wait and let another vehicle enter or leave a drive before starting to move
J	It should be possible to tell the vehicle to slow down or stop, and yield to a pedestrian, satisfying the user's desire for courtesy
K	It should be possible to tell the vehicle to wait and yield to a bicyclist, satisfying the user's desire for courtesy

Papersource: https://link.springer.com/article/10.1007/s42154-019-00087-9
Terken, 2020; Toward Shared Control Between Automated Vehicles and Users

2. Related Work– AV Framework



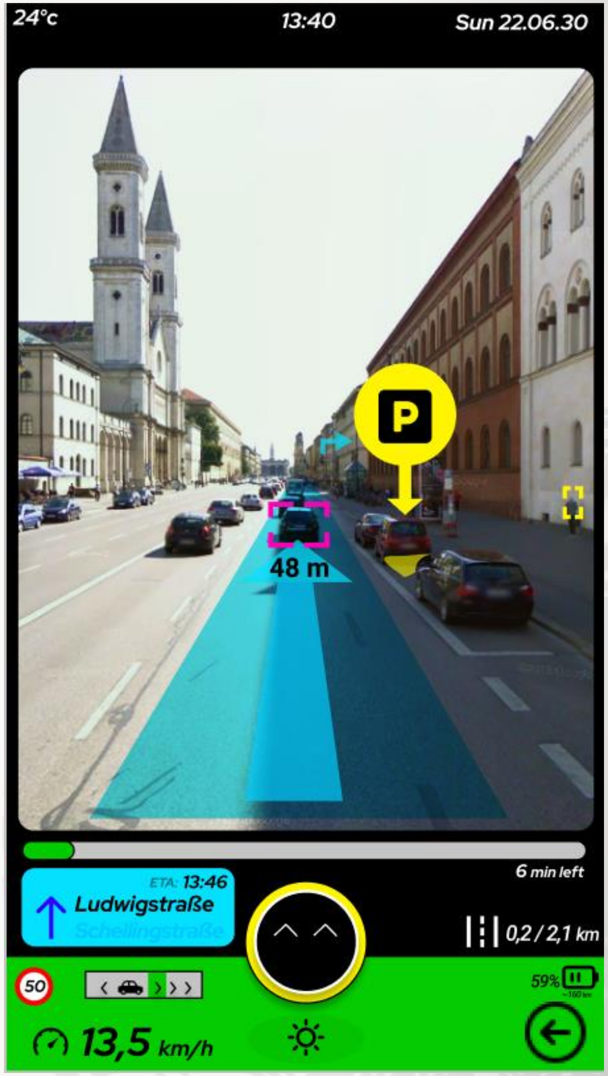
Papersource: https://doi-org.emedien.ub.uni-muenchen.de/10.1145/3409120.3410652
Wang, 2020; “Watch out!”: Prediction-Level Intervention for Automated Driving

2. Related Work – Measurement

What factors establish trust?

Important factors of UIs fostering user trust

1. Anthropomorphism
2. Transparency
3. System perceived as an expert (by neatness/ aesthetics)
4. Customization of noncritical information
5. Brand reputation
6. System knowledge and experience



Early design , all information
Source

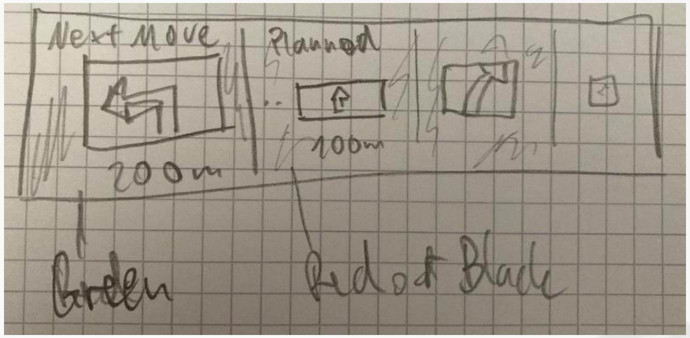
Paper source: https://dl.acm.org/doi/abs/10.1145/3004323.3004331,
Diels, Migliani 2016 - Compatibility between Trust and Non - Driving Related Tasks in UI Design for Highly and Fully Automated Driving

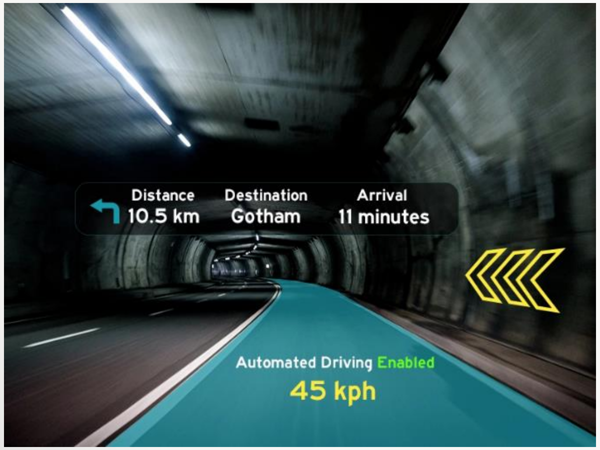
3. Research Questions

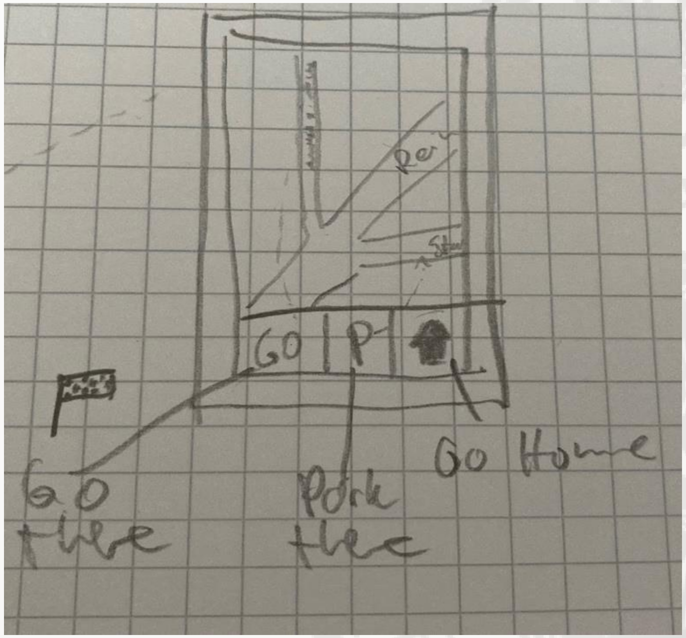
- **RQ1:** How do **varying** amounts of **information** in an AV navigation UI **affect passenger‘s UX**, **cooperative performance** and **trust** in the system?
  Is the **time restraint** relevant?

- **RQ2:** **How much information** is adequate for navigation level AV UIs?

4. Concept - Inspiration

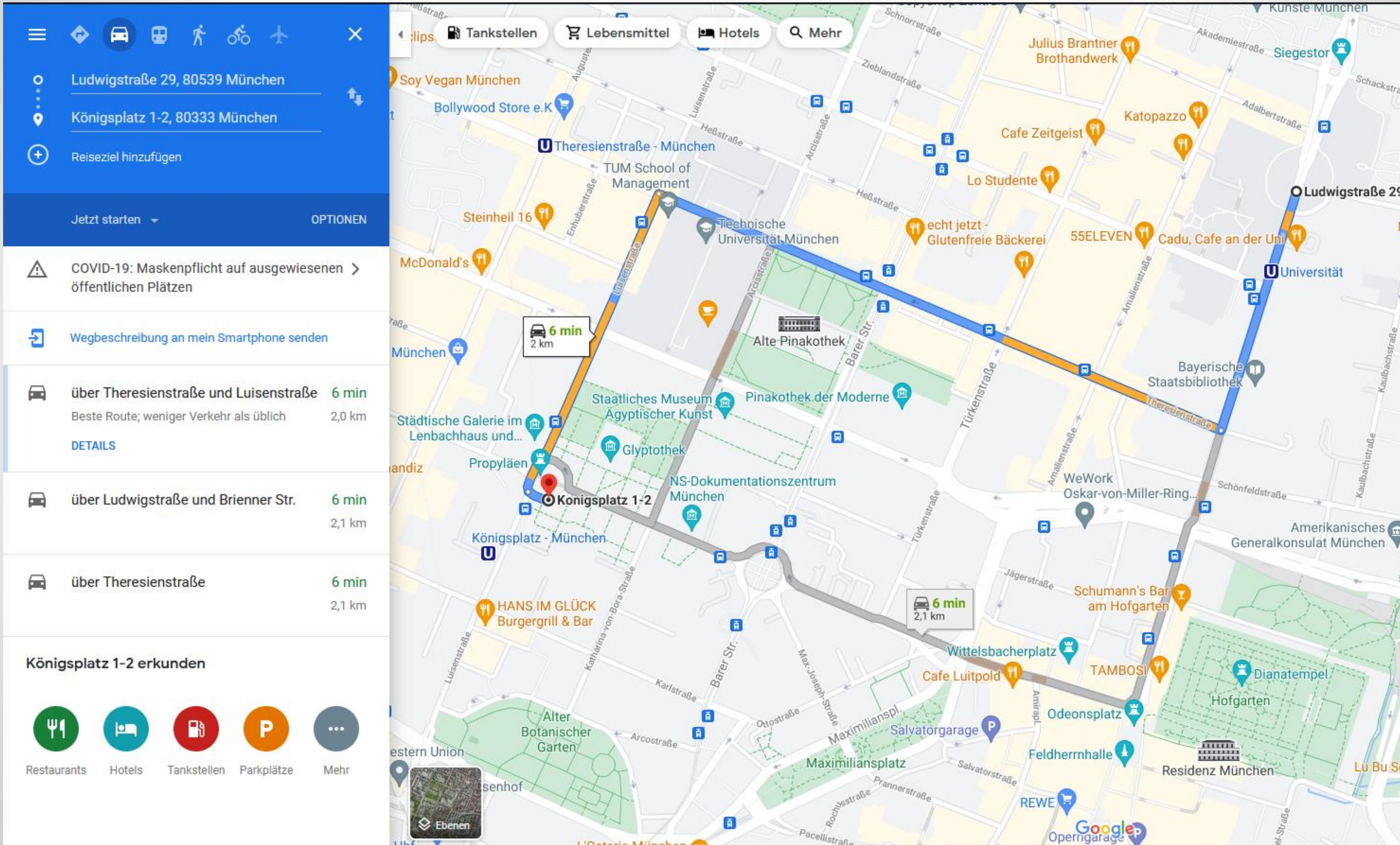






Source: top left: https://www.pinterest.com/pin/27795722678420817/
Source: top right: https://dribbble.com/shots/14803142-Self-driving-Taxi-App
Source: bottom: https://dribbble.com/shots/4012484-Automated-Driving-UI

4. Concept – Preset Route



Source: https://www.google.de/maps/dir/48.1504449,11.5812516/48.1457715,11.5642941/@48.1475748,11.5681677,16z/data=!3m1!4b1!4m2!4m1!3e0

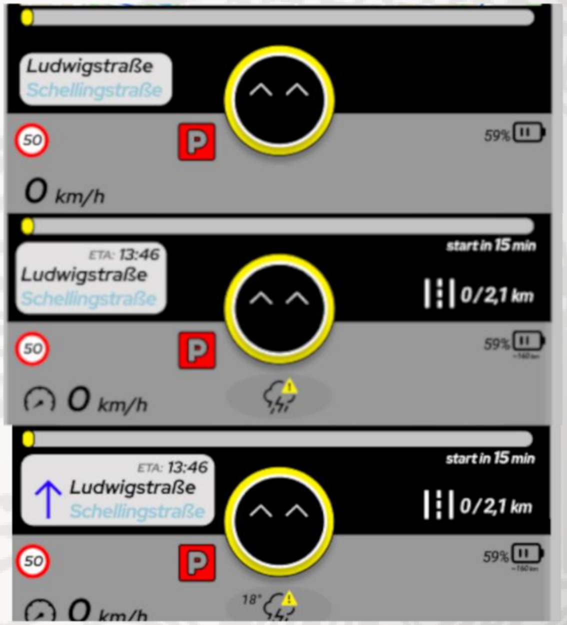
4. Concept – Pilot Study

Purpose:

- **Test design frames for viability**
- **Functionalities** and **aesthetics, useful** and **necessary**?
    - Is any **information missing**?
    - Can something be left out?

Details:

- N=11 participants
- Limesurvey
- Personal interview



Bottom menu

4. Concept – Pilot Study

Result:

- Deletion of notification screen
- Integrated **restaurant information** (address, menu with top dishes)
- Integrated **route information** (varying across levels)
- Demand to display the **traffic situation** (picture-in-picture **live camera view,** situational awareness)

4. Concept – Pilot Study

→ **Next Step:**

- **2 videos** of starting point

Within-subject

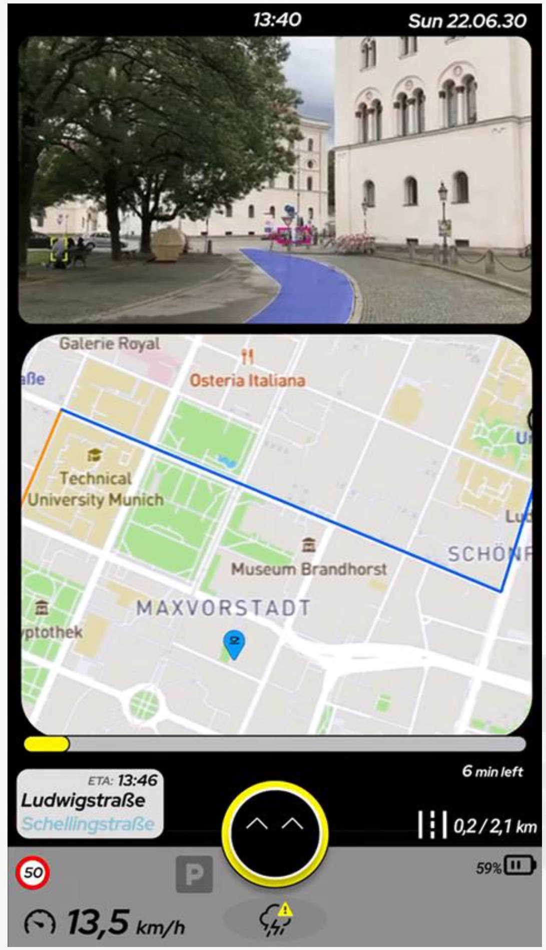
	thinking fast	thinking slow
Level Simple	condition 1	condition 2
Level Medium	condition 3	condition 4
Level Complex	condition 5	condition 6

- **Parked car** = Slow Thinking
- Implementation of **6** Levels
  - FT1, FT2, FT3
  - ST1, ST2, ST3

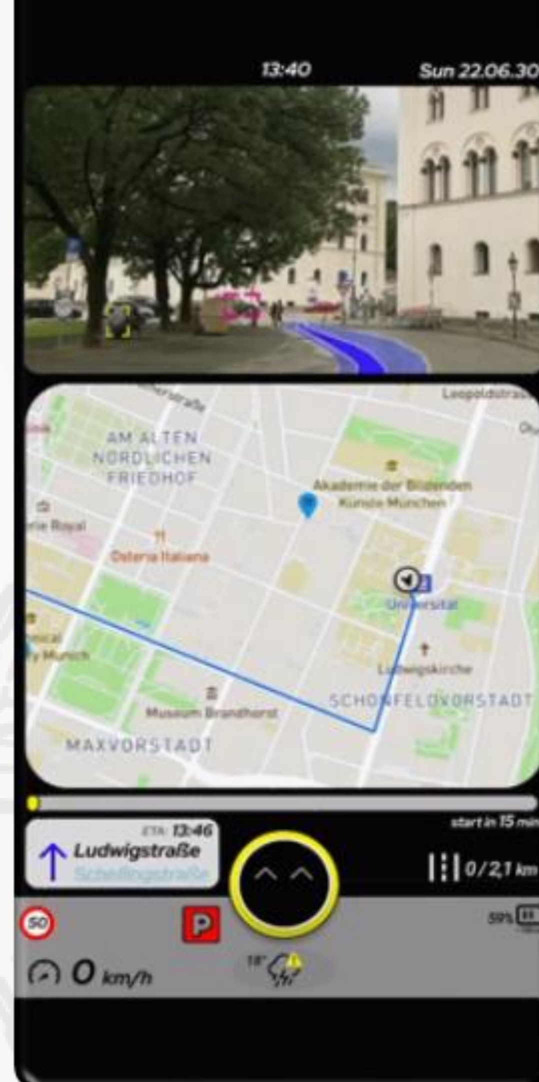
5. Implementation - Interaction

FT1

FT2



ST3



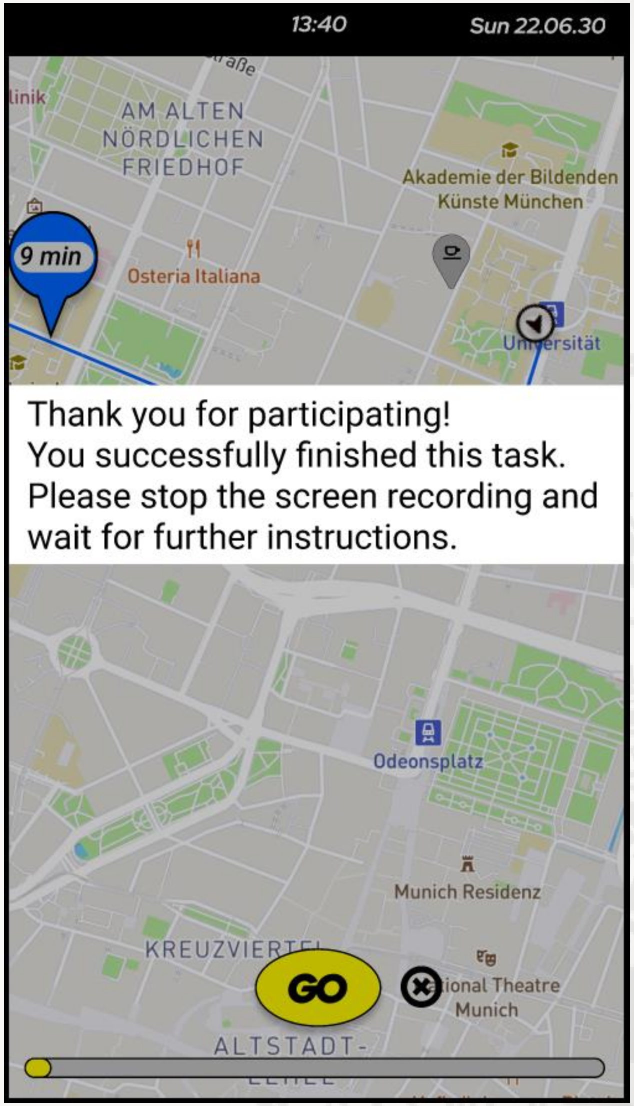
5. Implementation – Aid tools

UX design:

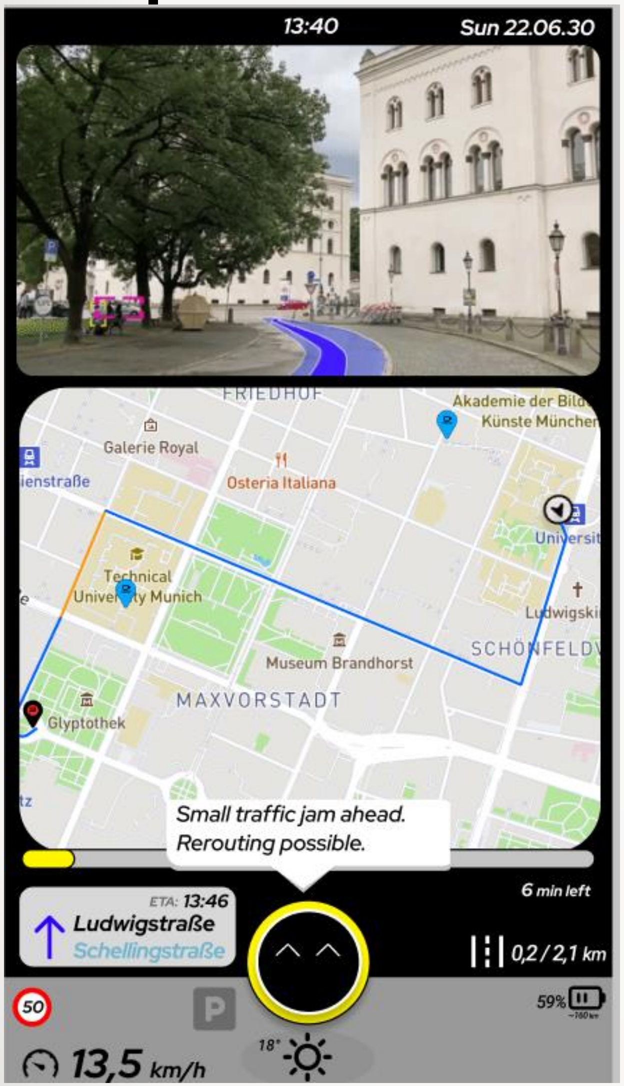
- Design tool: “Figma”
- Android/IOS application: “Figma Mirror” (**remote testing**)
- Plan-level application
  - add stopover to route

Online Study:

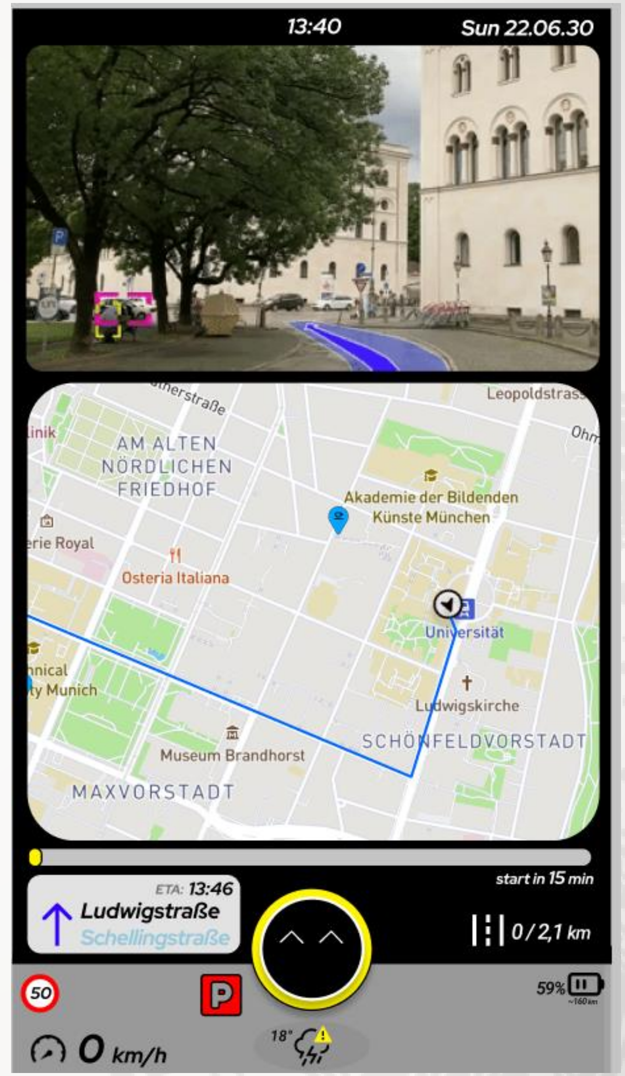
- Zoom conference & screen share
- Limesurvey questionnaire
- **Mobile screen capture**



5. Implementation – Homescreen



FT3

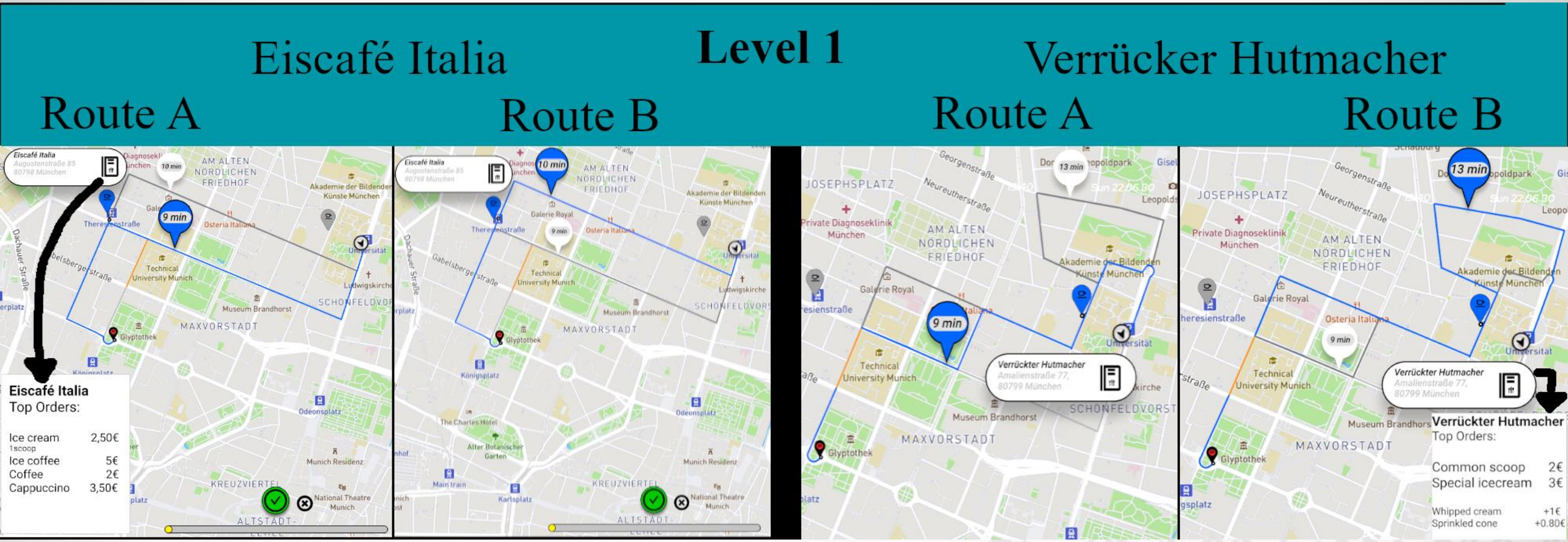


ST3

5. Implementation – Navigation

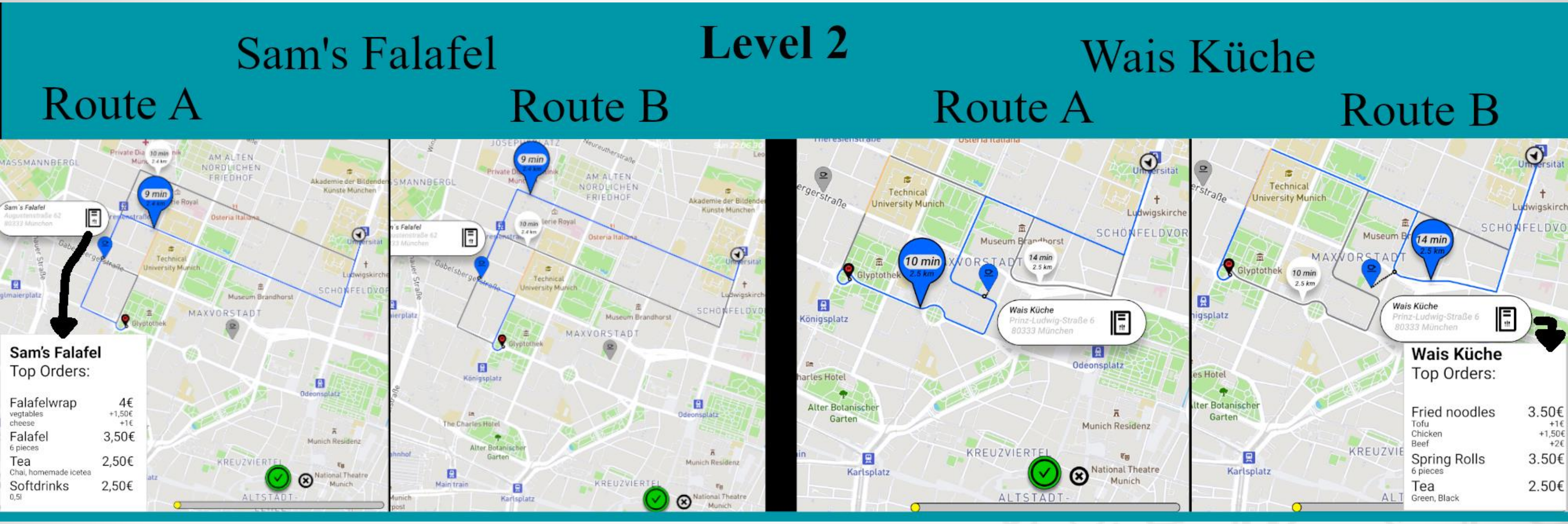
Slow Thinking Overview

5. Implementation – Level 1



- **Level 1**: Ice cream
- 2 shops
- 2 routes for each shop (new **time of arrival (TOA)**)
- Menu for selected shop

5. Implementation – Level 2



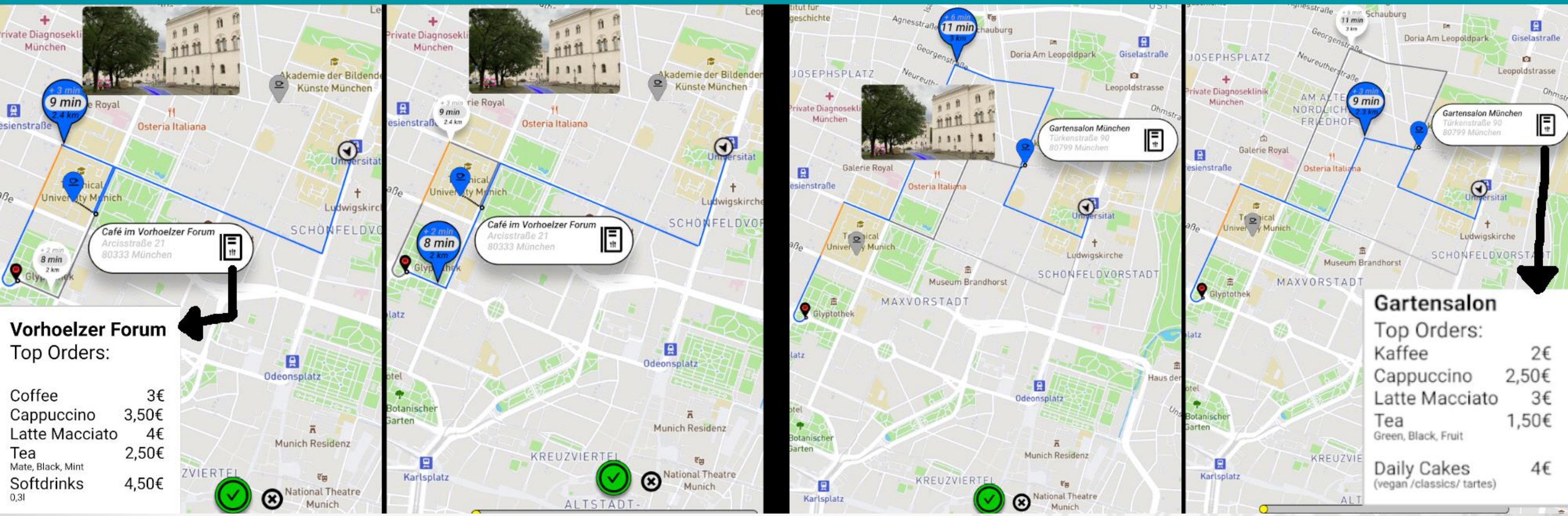
- **Level 2**: Quick Snack
- Route Information for Selection: ToA, **Mins added**

5. Implementation– Level 3

Level 3

Café im Vorhoelzer Forum — Route A | Route B

Gartensalon München — Route A | Route B



- **Level 3**: Coffee
- Route Information for Selection: ToA, Mins added, **Distance in km**

5. Implementation – Confirmation

- **Confirm** shop and route selection by pressing „**GO**“
- **X- Button** to **undo** previous step
- Participant notifies about finished task

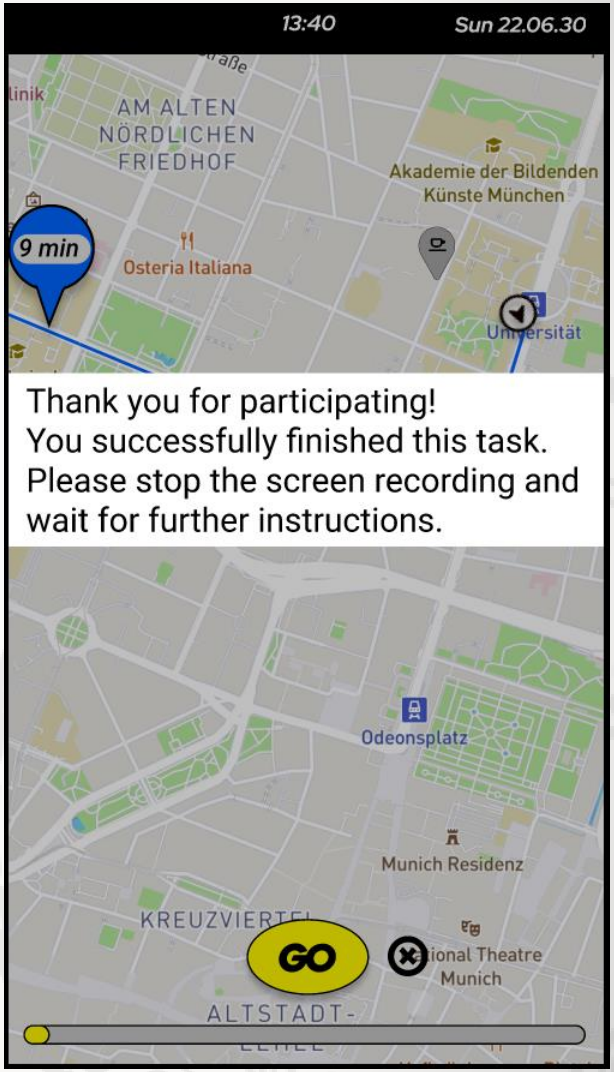
Recordings contains:

Time measured

Chosen **location**

Interaction **steps**

*After all Levels, **upload** of recordings to matching **ID Folder** on Google Drive*



6. Main Study – Introduction

Details:

- Guided **online-study** on **Zoom**
  - Limesurvey **questionnaire** (Demographics, T0)
  - For each of the **3 levels**:
    - Figma Mirror **screen capture**
    - Limesurvey **questionnaire** (T1, SUS, UX)

  - Final **interview**
  - Google drive **upload**

- N=30 participants [9 = F, 20 = M, 1 undisclosed]
  - Fast Thinking (**FT**)
  - Slow Thinking (**ST**)
- Time: 1 hour

6. Concept – Measurement

Situational Trust Scale **(STS) – rephrased for AV rerouting situations**

- Comparison between base trust **T0** vs. trust after prototype **T1**

Section 0: Base trust for rerouting in AV

1. I trust the automated vehicle in rerouting situations.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)
2. I would perform better than an automated vehicle in rerouting situations.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)
3. Rerouting situations are risky.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)
4. Automated vehicles make unsafe judgements in rerouting situations.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)
5. Automated vehicles react appropriately to the rerouting environment.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)

Situational Trust Factor	Item Abbreviation
Type of system System complexity	Trust
Self-confidence Subject matter expertise	Performance
~~Perceived benefits~~ ~~Workload~~ ~~Task difficulty~~	~~NDRT~~
Perceived risks	Risky
Perceived risks	Judgement
Perceived risks Perceived benefits	Reaction

- System Usability Scale (**SUS**)
  - 10 questions to get system usablity reference
  - Answer after every level

Paper source: https://doi-org.emedien.ub.uni-muenchen.de/10.1145/3409120.3410637,
Holthausen, Wintersberger 2020 – Situational Trust Scale for Automated Driving (STS-AD)

6. Concept – Measurement

- 3 self defined questions
- Considered separately
- Get rough picture if prototype fullfilled pilot study information demands

Control (**C**), Shop information (**SI**), Time (**T**)

Section C: Experience

How would you agree/disagree with the following statements after this rear-seat experience? Please rate the following items and specify the reasons for your choices.

a. I felt like I was in control.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)

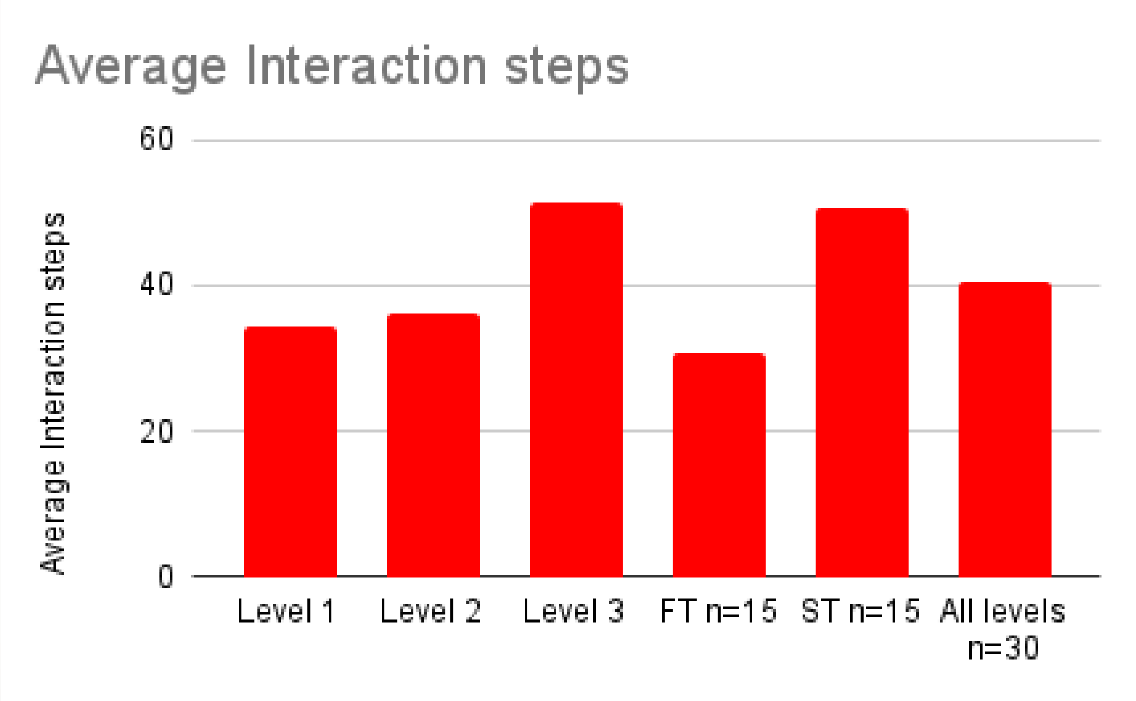
b. I got enough information about the shops to make a good decision.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)

c. I had enough time to make a considerate decision.
   (strongly disagree=1, 2, 3, 4, 5, 6, 7=strongly agree)

- Final semi-structured interview (10 Mins)

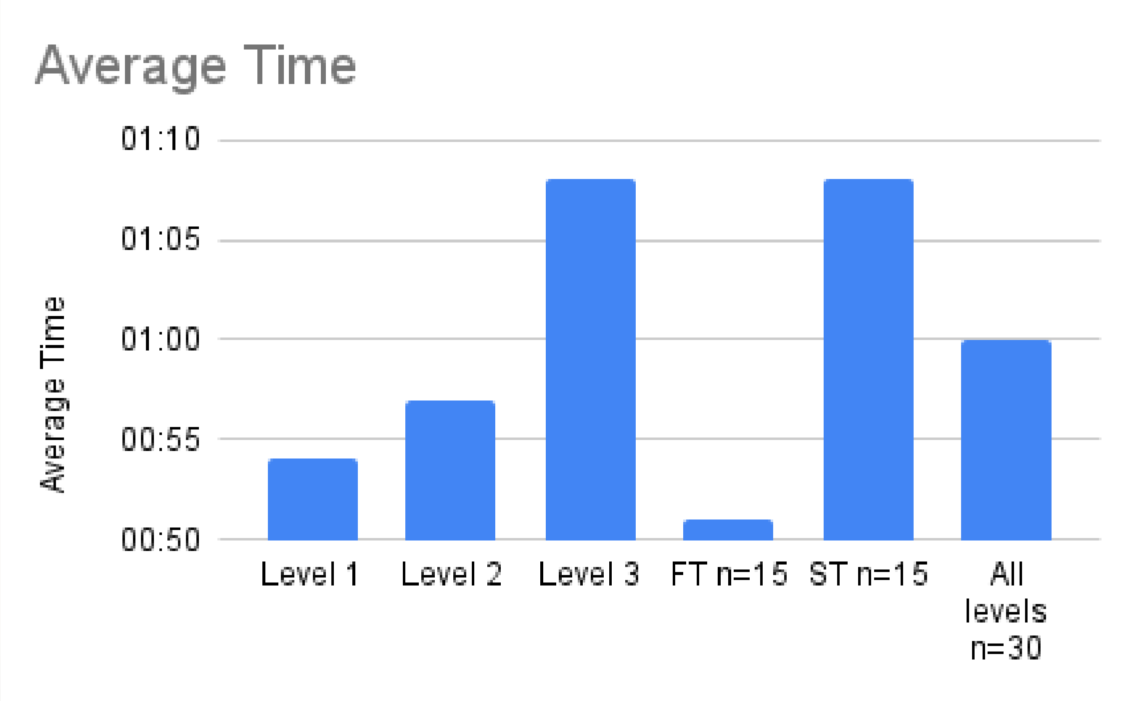
7. Results – Interaction Steps

- **FT** group finished Task with **less interaction steps** than **ST**
  - **FT123** Mean = **30.78**, StdDev = 20.133;
  - **ST123** Mean = **50.56**, StdDev: 81.457;
  - [N=30] Mean = **40.67**, StdDev = 59.830



7. Results – Average Time

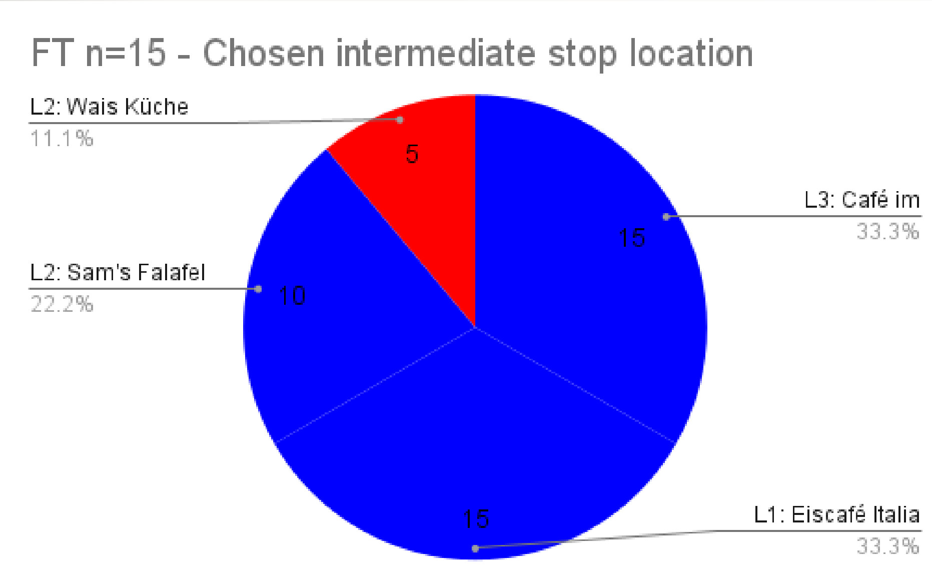
- **FT** group tend to finish the tasks **more quickly** than **ST**
  - **FT123** Mean = **00:51**, StdDev: 20.134;
  - **ST123** Mean = **01:08**, StdDev: 81.457;
  - [N=30] Mean = **01:00**, StdDev: 59.830.

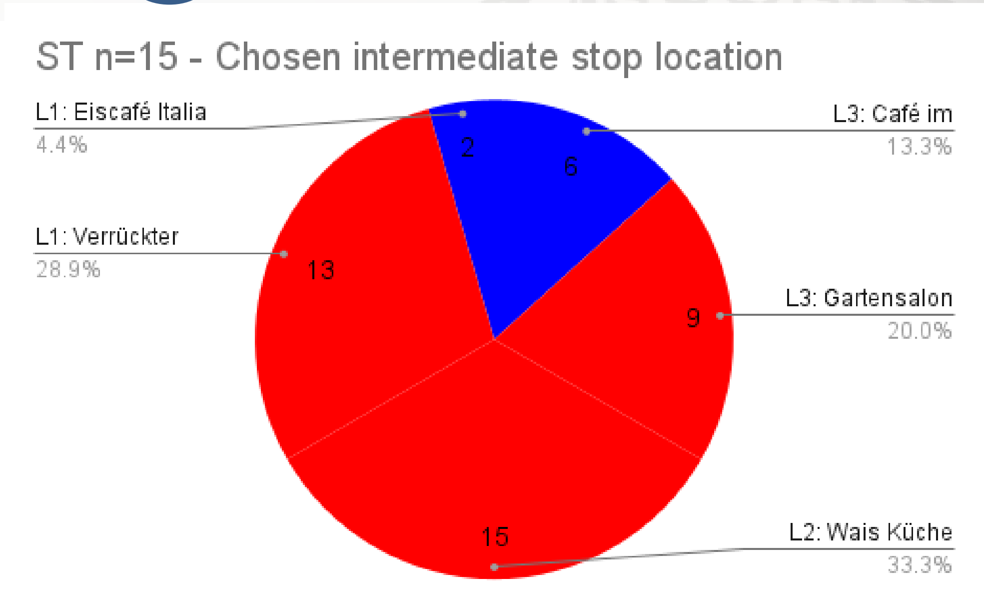


7. Results – Selected Shop

- **(N=21, 70%)** opted for detour to **level 3** shop **"Café im Vorhoelzer Forum„** (closest to the destination address, route is mostly identical)
- **FT** predominantly chose the **further** shop
- **ST** predominantly chose the **closer** shop

= closer = further





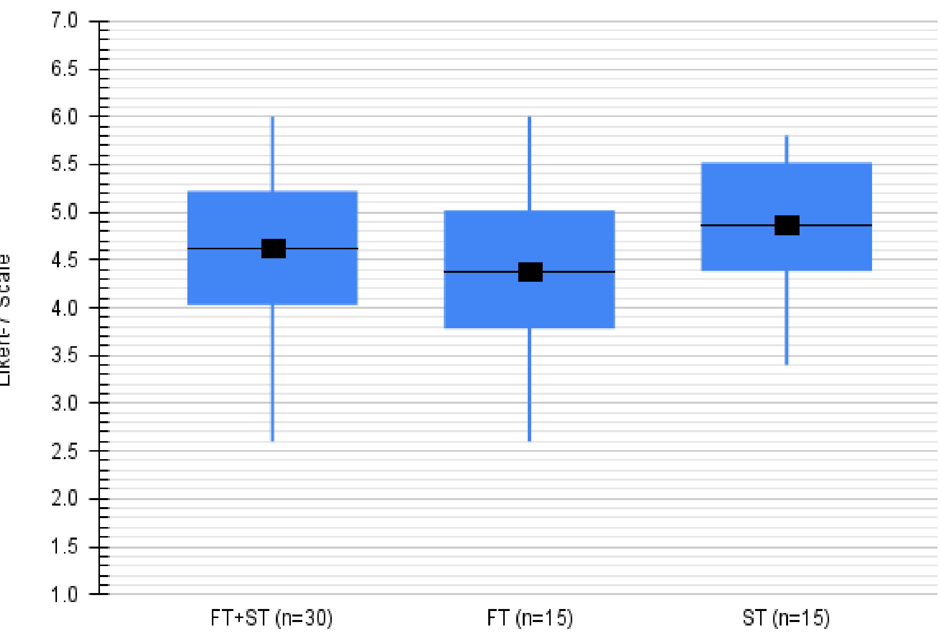
7. Results - Trust

FT-T0: Mean = **4.37**, StdDev = 0.965
FT-T1: Mean = **5.83**, StdDev = 0.748

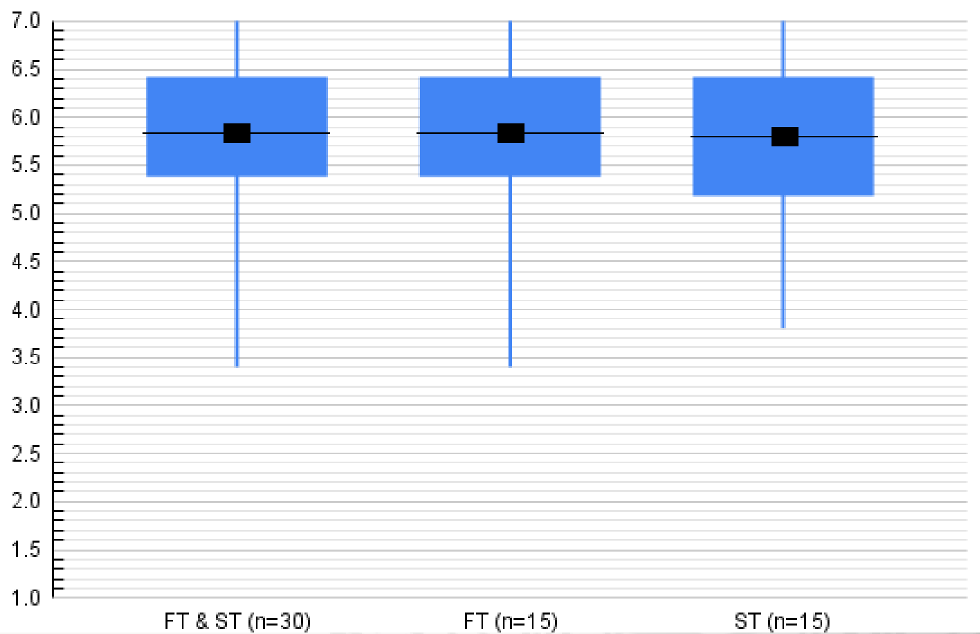
ST-T0: Mean = **4.88**,StdDev = 0.724
ST-T1: Mean= **5.8**, StdDev = 0.752

T0-[n=30]: Mean = **4.63**, StdDev = 0.877
T1-[n=30]: Mean = **5.82**, StdDev = 0.746

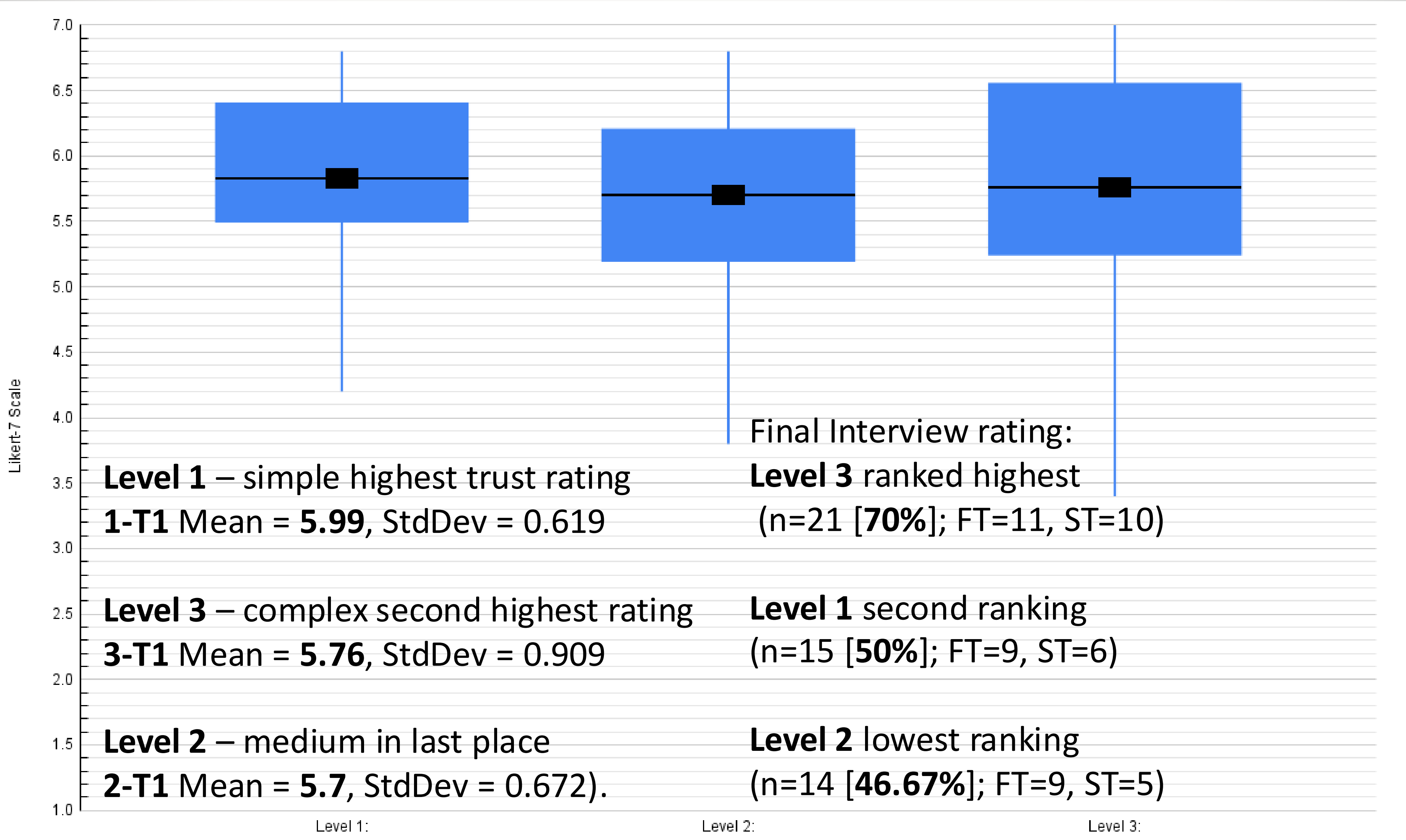
Baseline Trust T0



Trust T1



7. Results - Trust



Level 1 – simple highest trust rating
1-T1 Mean = **5.99**, StdDev = 0.619

Level 3 – complex second highest rating
3-T1 Mean = **5.76**, StdDev = 0.909

Level 2 – medium in last place
2-T1 Mean = **5.7**, StdDev = 0.672).

Final Interview rating:
Level 3 ranked highest
(n=21 [**70%**]; FT=11, ST=10)

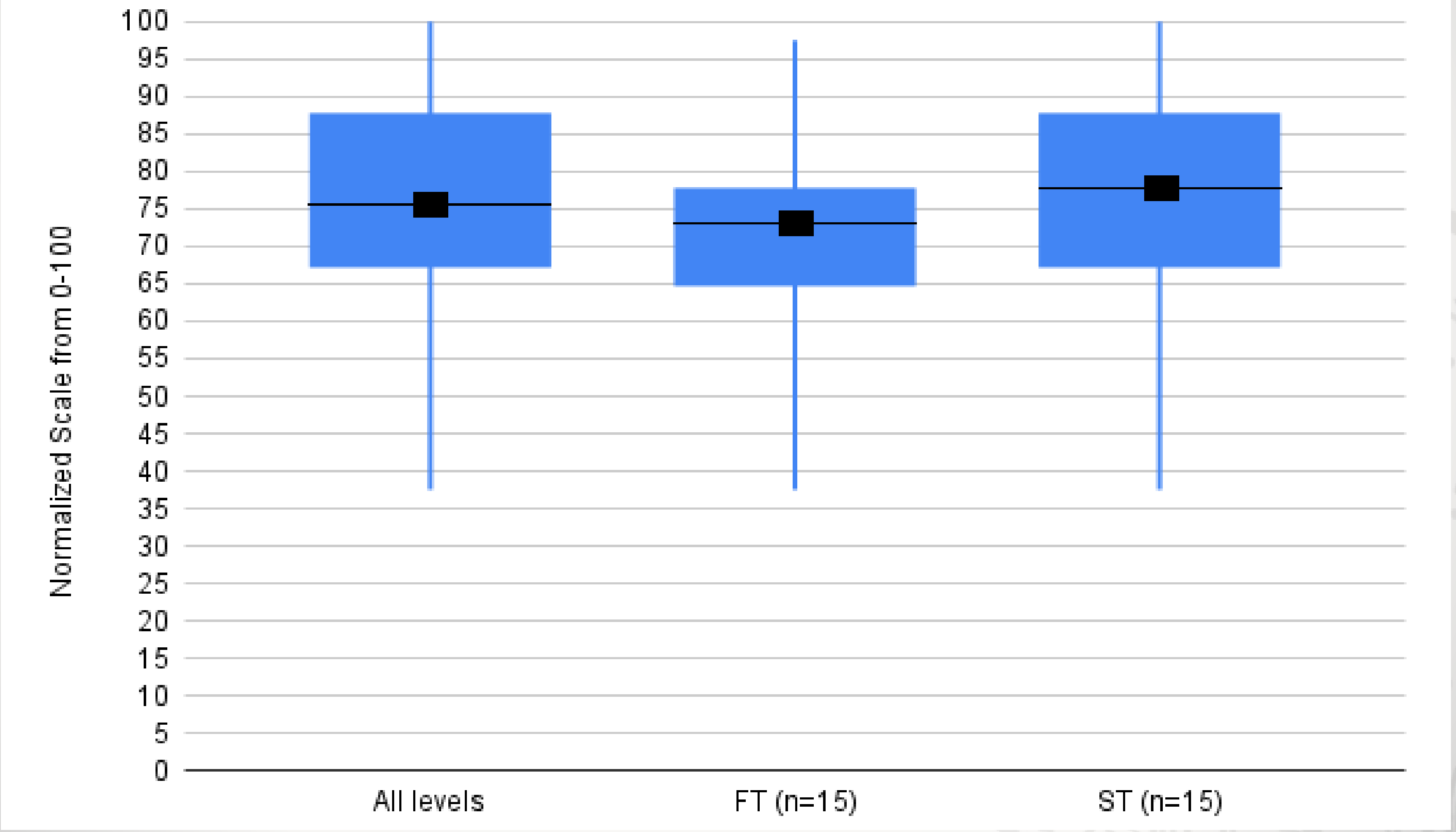
Level 1 second ranking
(n=15 [**50%**]; FT=9, ST=6)

Level 2 lowest ranking
(n=14 [**46.67%**]; FT=9, ST=5)

7. Results - Usability

Overall score = **75.38** on a scale of 100, r=0.7538, StdDev = 15.619)

Normalised **rating > 68**; adjectives "**good**" and "**excellent**"

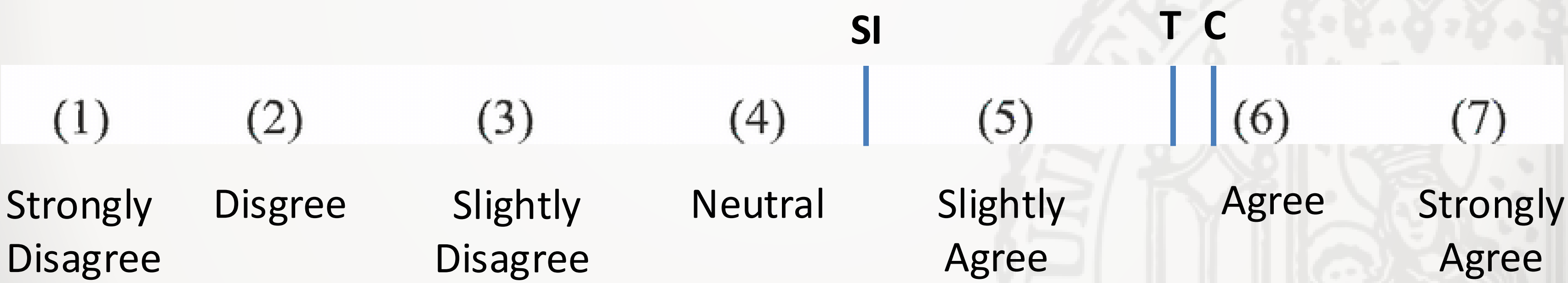


Paper source: Kortum Bangor 2009 - Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale

7. Results - Experience

Likert 7 scalar questions:

- **Control (C)** = mean = **5.93**, StdDev-C = 1.261
- **Shop Information (SI)** = mean = **4.42**, StdDev-SI= 1.761
- **Enough time to reroute (T)** = mean = **5.79**, StdDev-T =1.222



- Shop information: not sufficient
- Percieved control: OK
- Time for NCSS: OK

7. Results – Semi-Structured Interview

AV Control Interface: Hand-Held Device vs. Built-In

- N=**16** (53.33%) would like to interact with a **built-in interface**
- N=**14** (46.67%) would prefer to have a **mobile interface**

Shop filter for simpler reroute under time restraint:

Likelihood of use**:** Mean = **6.4**, StdDev = 0.724

Comment:

Useful tool under time pressure, but room for improvement

7. Results – Semi-Structured Interview

- **Traffic camera on trust** (Mostly positive, some negative)
- Learning effect (**Levels similar** in their structure)
- Too similar information split (Level 2 & 3 too similar)
- Still some concerns about IT security and
- Complications with mobile phones (i.e. low battery, no internet, slow-response times, device receives a call)

Improvement:

- **Trusted Sound Landscape**
  - Sound cues for warnings [N=9 (30%)]
  - Voice control [N=7 (23.33%)]
- Placement of smiley away from center (no actual help)
- **Shop Symbols** do not always correspond to shop

8. Conclusion

- **UI: Raise in trust level** towards the AV in participants, especially FT
- Level 3 complex first in user rank
- Level 1 simple had best survey score
- Time frame influences the decision making process (Interaction steps, time, location)

- Time limit for reroute can result in stress
→ Indecisive behavior, discomfort
- **Shop filter** supports time sensitive reroutes

Bachelor Thesis Bibliography

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Future work:

- Soundscape for subtle but meaningful notification
- Voice control/ assistance
- Shop filter questions
- In-car or simulator testing
- Better shop information

Limitations:

- Hardly realistic (online study)
- Figma functionalities (no zoom in, no sound, no haptic feedback)
- Mostly young participants with technological preknowledge and trust

Participants car usage

- 13 participants (43.33%) reported travelling weekly as a passenger in a car
- 1 (36.67 %) reported monthly
- 4 (13.33%) daily
- 2 (6.67 %) rarely

- 11 (36,67%) participants average trip duration of 1-2 hours
- 8 (26,67 %) a duration of 30 minutes-1 hour
- 7 (23,33 %) a duration of less than 30minutes
- 4 (13,33 %) a duration of 3-5 hours per trip

- Not all participants wanted to disclose their travel behaviour