A large-scale survey for assessing the influence of modern mobility services and automated driving on the willingness to use park-and-ride

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INTRODUCTION

Climate change presents a pressing challenge for decisive actions in the transportation sector as it is one of the fastest-growing CO2 emitters (European Environment Agency, 2023). Transitioning from individual vehicle transport to sustainable, integrated mobility solutions such as public transport and shared services is seen as a key element for climate-friendly and resource-efficient mobility systems. Moreover, the future integration of automated driving systems will heavily influence daily traffic patterns. Identifying interchange points between highways and urban or rural areas presents pivotal opportunities to promote this shift from individual to public transportation. Automated shuttles offer increased frequency in public transport, a service not economically feasible with conventional buses. Automatic valet parking enhances transfer efficiency from individual to public transport by optimizing parking, reducing congestion, and providing greater convenience by eliminating the need for drivers to search or park their vehicles. Shared options like e-bikes and e-scooters further incentivize last-mile travel in sustainable modes, particularly for longer distances than the typical footpath.

To better understand the potential implications on the mobility landscape, for instance, (Horschutz Nemoto, et al., 2023) analyzed the role and impacts of automated minibuses deployed as a public micro-transit through the perspective of different stakeholder groups and citizens. In contrast to querying acceptance of sustainable mobility services using a static survey, the main contribution of this paper is that each participant was presented with customized route suggestions for one of their own trips, using one of these mobility services for their actual trips. This not only allows better visualization of the alternative to the user, but also assess which of the alternatives are suitable for real-world mobility demand considering factors such as cost, time efficiency and personal preferences to identify the most viable mobility service for promoting sustainable transport within urban areas. Results are evaluated for five homogenous social groups which share similar mobility behavior.

MOBILITY SURVEY

To assess the impact of modern mobility services on mode choice, an online survey involving 995 participants was conducted in Carinthia, Austria. Choice experiments were a key part of the survey, revealing users' preferences for transitioning from cars to other transportation modes when entering the city under varied conditions. The survey assumed availability of four mobility services: (1) automated shuttles connecting a technology park to a commuter train station in 10-minute intervals, (2) automated valet parking at Park-and-Ride facilities in Klagenfurt West (depicted with a P+R logo in Figure 1), allowing *any* vehicle to utilize the automated parking service to save time, (3) e-bike sharing and (4) e-scooter sharing.

In this study, *MyTrips* serves as an online mobility survey tool designed for mode and route choice decision modeling, aimed at mitigating hypothetical bias (Rudloff & Straub, 2021). It was utilized for collecting Stated Preferences (SP) data regarding users' potential shifts in transportation modes. Additionally, Revealed Preferences (RP) were gathered through trip diaries, where respondents entered details, such as start and end locations, departure and arrival times, and chosen mode of transport. In an SP-off-RP setup, up to six choice pairs – each featuring two routes with identical start and end points – were generated via an intermodal routing service (see Figure 1). Attributes such as travel times per mode for each alternative were then computed from the resulting routes and presented to respondents, who selected their preferred route from each choice set. In addition, factors such as parking fees, limited parking availability and longer parking search times or traffic congestions were added as constraints.

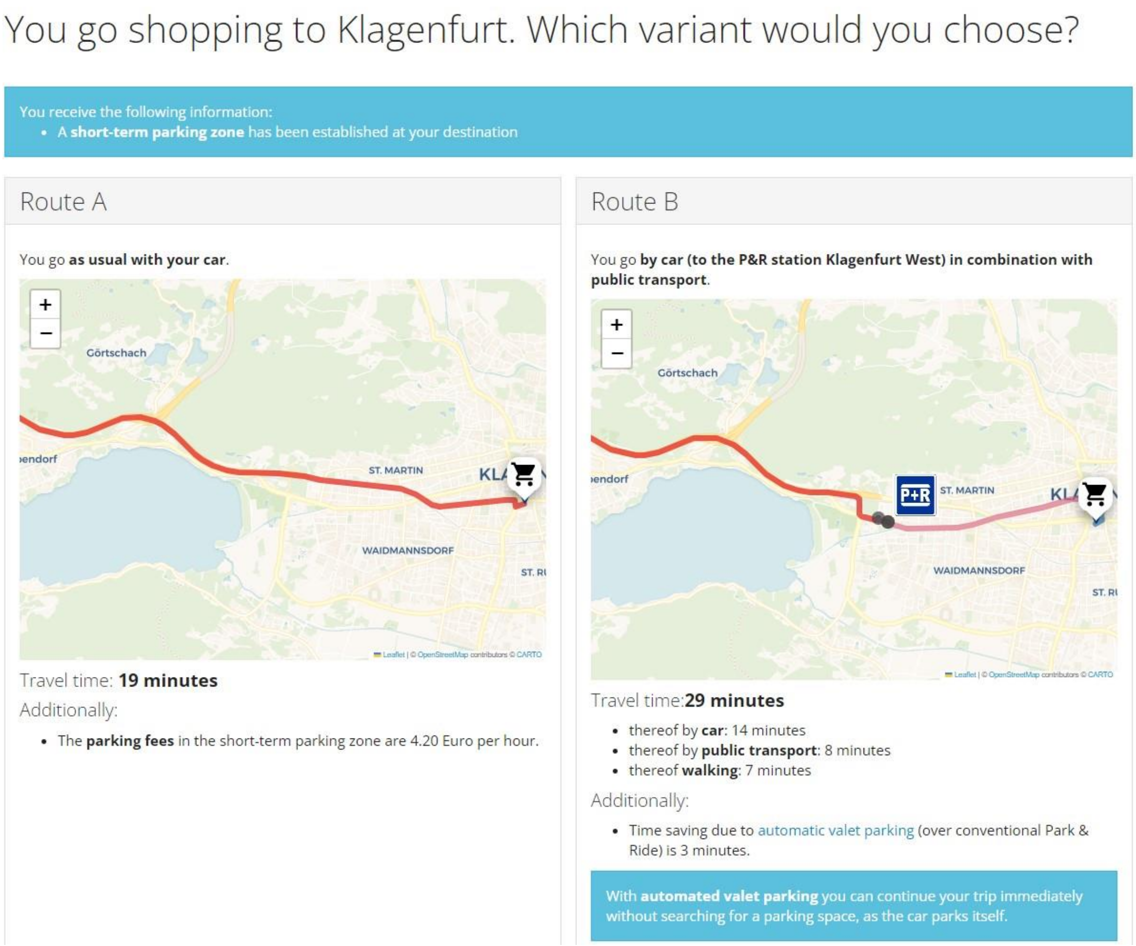

Figure 1: Tailored travel questions with personalized alternatives in an SP-off-RP setting. Each user receives customized suggestions based on their individual mobility diary.

RESULTS

The analysis of survey results is based on user groups that have homogeneous mobility behavior patterns or respond particularly to specific arguments for behavioral change (e.g. health, environment, costs, image, experience). In analogy to (Markvica, et al., 2020), a typology comprising five social groups were used to map the general willingness of individuals to change their habitual travel behavior under specific conditions (Figure 2).

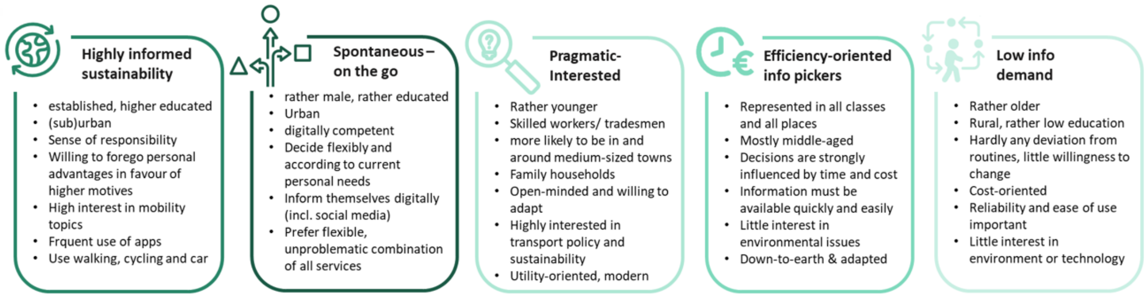

Figure 2: Five social groups used for evaluation.

Figure 3 shows the stated preferences indicating the level of interest each group has in the proposed services. Overall, participants expressed high interest for using automated shuttles as well as shared e-bikes. Interest for automated valet parking and e-scooter sharing was notably lower. The data underscores the importance of segmenting individuals, as preferences vary significantly across groups. Particularly, those categorized as *"efficiency oriented"* and having *"low information need"* displayed considerably less interest in these services.

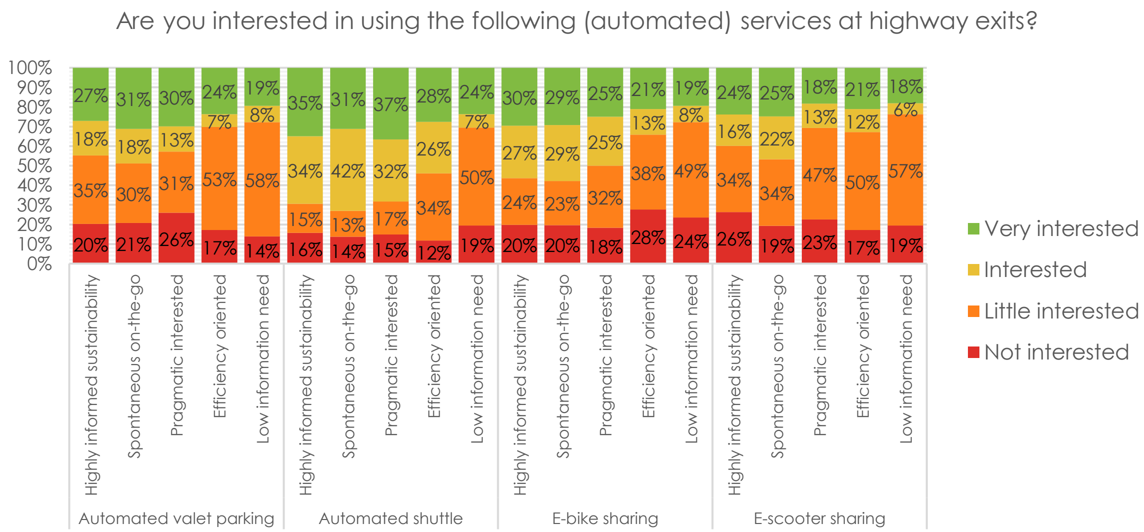

Figure 3: Interest in (automated) mobility services, categorized by social groups.

Furthermore, using the SP-off-RP approach, specific travel-related questions were tailored individually for each participant based on their home location and destination (see Figure 1). The primary route typically involved the originally stated mode of travel (often by car), while the alternative route entailed parking the car at the highway exit and utilizing one of the alternative mobility services. Table 1 shows that the acceptance of alternatives is highly influenced by the social group.

Figure 4 presents the primary factors influencing the choice between the original and alternative routes. Comfort and time emerged as the main drivers for adhering to the original route, while considerations of environment and costs were the main reasons for opting for alternative routes.

Table 1: Frequency of alternative selections (left: by service, right: by social group).

Service	Original route	Alternative route
Automated shuttle	54%	46%
E-bike sharing	59%	41%
E-scooter sharing	78%	22%
Public transport	57%	43%
Grand Total	**62%**	**38%**

Social group	Original route	Alternative route
Highly informed sustainability	54%	46%
Spontaneous on-the-go	53%	47%
Pragmatic interested	74%	26%
Efficiency oriented	72%	28%
Low information need	82%	18%
Grand Total	**62%**	**38%**

Notably, the distribution of these reasons remains constant and does not vary based on the selected modes of transport or social group. Future research will focus on the influence of parking, as the route-choice questions often included variations of increased parking costs and/or restrictions.

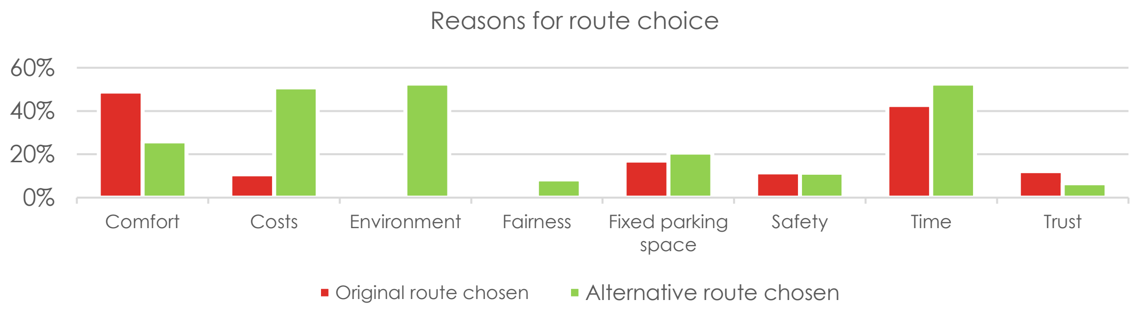

Figure 4: Factors influencing the choice of travel alternative (multiple reasons possible, therefore total sum > 100%).

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