# E-scooters on the Ground:
# Lessons for Redesigning Urban Micro-Mobility

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## ABSTRACT

The worldwide deployment of rental electric scooters has generated new opportunities for urban mobility, but also intensified conflict over public space. This article reports on an ethnographic study of both rental and privately-owned e-scooters, mapping out the main problems and potentials around this new form of 'micro-mobility'. While it suffers from problems of reliability and conflict, user experience is an important part of e-scooters' appeal, an enjoyable way of 'hacking the city'. E-scooters have a hybrid character: weaving through the city, riders can switch between riding as a pedestrian, a car or a bicycle. Building on these results, we discuss how e-scooters, ridesharing services, and their apps could develop further, alongside the role for HCI in re-thinking urban transport and vehicle design.

## Author Keywords

Electric scooters; Micro-mobility; User experience; Co-ordination in mobile interactions; Intermodal mobility; Vehicle design

## CSS Concepts

• Human-centered computing~Human computer interaction (HCI)~HCI design and evaluation methods~ User studies
• Human-centered computing~Human computer interaction (HCI)~HCI design and evaluation methods~Field studies

## INTRODUCTION

While digital technology has had a broad impact on transit (through real time transit times, for example [5]), the creation of a whole new mode of transport in itself is rare. Electric scooters (e-scooters) are small, single-user, electric vehicles, part of the global boom of urban 'micro-mobility' [17], which includes a variety of light, individual vehicles, often enabled by technological innovations, such as rental e-bicycles, folding bicycles, hoverboards, or monowheels [53]. They have recently grown in popularity and use worldwide as on-demand rental e-scooters have been deployed (by companies such as Lime and Bird), in the form of dockless (or free-floating) network-connected rental e-scooters [17]. Each vehicle can be unlocked through the app and left anywhere within a perimeter at the end of the journey. Building on this success, e-scooters are also being purchased by private users, creating a new form of single user transit that fits in and expands upon cities' existing infrastructure for bicycles and pedestrians. While this offers new opportunities for less invasive and polluting transit than cars, it also causes considerable debate regarding safety, use of public space, and environmental damage. But it is exceptional that a new transport mode be adopted so quickly, and in addition to their unique affordances in use, this makes e-scooters an interesting case of innovative mobility design.

In this paper, we investigate these developments drawing on an ethnographic study conducted in Paris, including five weeks of fieldwork observations; interviews with shop owners, city representatives and e-scooter renters and owners; video recordings of e-scooter use; and an unsystematic survey of media reports. We explore how these vehicles support a 'hybrid' form of mobility that combines practices from existing forms of transit in a dynamic way. They can also be part of rental services, dependent upon apps and smartphones as much as electric motors and tires. Our data then lets us document users' new experiences in both domains of riding and renting, and how they adopt and make use of micro-mobility alongside existing transport modes. We contrast the use of rental e-scooters, which offers great spontaneity but also suffers from problems of unreliability, with privately-owned e-scooters. Using videos of e-scooters' interactions with pedestrians in traffic, we document some emergent conflicts and co-ordination. This gives us a window on how bustling urban spaces change with the introduction of a new transport mode.

In our discussion, we look at e-scooters not simply as a new transport mode, but rather as the start of a potential new wave of innovations that blend mobility, electric motors, apps and mobile devices in new ways. For HCI, this gives us an opportunity to reflect upon the design of urban mobility systems, the possibility of inventing new and hybrid systems, and the impact future systems may have on their users and public space. This presents an interesting new role for HCI to take part in the design of future mobility solutions.

## BACKGROUND

While there have been many technology changes 'under the hood', in the last 100 years or so our cities' transport modes have stayed more or less the same [54]. Public transit (light rail, metro, bus) and private transit (car, bicycle and foot) are stable technologies, and with the exception of buses replacing streetcars after the second world war, city transport in most industrialised countries has remained essentially unchanged. Yet the pressing urgency of reducing carbon emissions requires radical change in how we use energy, particularly in high carbon producing economies. Transport produces 27% of European carbon emissions [23], the majority of which comes from road vehicles. While more efficient batteries and electric motors present the possibility of moving to cleaner sources of energy, simply placing these motors in cars replicates the existing inefficiencies of the current system. In urban areas in France, where our case study is located, 4 car trips out of 10 are shorter than 3km [76]. In terms of energy efficiency, it is hard to see how use of single occupancy vehicles weighing many times the weight of the passenger is sustainable, not to mention the ongoing problems of urban congestion. One hoped-for development has been ridesharing services (such as Uber), apps that support greater shared vehicle use [33]. While ridesharing has transformed the taxi cab business worldwide, recent research suggests this has actually if anything made city congestion worse – with users shifting from public transit to ridesharing in private cars [39].

### Electric vehicles

At least since the 1980s, there have been a number of attempts to innovate with the use of electric motors and vehicle design – in particular the Sinclair C5 and the Segway electric vehicle [64]. But these efforts suffered from low sales, and at times a less than serious reception. One area of success for electric motors has been electrically-assisted bicycles, augmented bicycles with small electric motors, support bicycling with less physical exertion, to increase speed and give assistance on hills [14]. This offers a mode of transport with both health and environmental benefits [26], with research showing that e-bike owners use them more than conventional bike users, with greater health benefits [16]. Around the same time as e-bikes were growing in popularity, a number of cities worldwide have also launched bike rental systems, from fixed locations where bikes are parked when not being used [55], with e-bikes increasingly being deployed [36]. Despite these efforts, bicycle usage broadly is still low when contrasted with other modes of transport [25], particularly in the US and Europe.

Building on much of the same technology, e-scooters use electric motors, but add this to a folding 'kick scooter' (*not* a moped), rather than bicycle. This makes e-scooters affordable, compact, and transportable on other transport modes when folded. However, it is their recent popularity as part of rental services that has perhaps been most striking. In 2017, Bird launched a rental service for e-scooters in Santa Monica, USA [48], and these services have expanded massively worldwide. Using a companion app, users can find, rent, and pay for e-scooters, to use them for short journeys. Rental e-scooters have been dockless from the beginning, they can be parked and rented from anywhere within a particular zone instead of hosted at fixed stations.

Because they are relatively new, there is little research on e-scooters. Rental companies and research institutes, using questionnaires or users' data, produce reports and surveys [12,19,59] comprising useful statistical views on this developing form of mobility (e.g. [51]) and on users' profiles. Scientists have also calculated the environmental advantages of e-scooters. They prove to help save carbon emission only when they replace automobile travel, which seems seldom the case; and their impact is heavily dependent on the lifetime of each scooter [40]. The safety of riders has also been discussed [4] and the problem of scooters obstructing public space [49].

### Transportation Research

While automotive HCI is an established subfield [21], other modes of transport, in particular public transport, have attracted less attention. There have been a number of well-received innovative experiments such as "UbiGreen" [30] and "Tiramisu" [75], yet HCI research has perhaps neglected transport beyond the car (with notable exceptions [47,60,71]). While there has been considerable research into ridesharing and app-enabled private transport services, they focus mainly on the changes to the driver/labour part [32,62]. HCI research has also engaged with ways of improving the bicycling experience [3,24,72].

Outside HCI, transport studies is of course a large field covering issues of transport and transport policy [13,63]. Two interesting topics here, in relation to our study, are the role of shared modes of transport to reduce spatial inequalities and environmental damage [22], and that of digitalisation to develop intermodal practices [15]. These perspectives tend to look at systems overall, and end users' perspectives are relatively absent in transport studies. Social science research on mobility, on the other hand, has documented travellers' perspectives [68]. This work attempts to capture the complex interplay between movement, its representation, and the embodied experience, bringing together different experiences of mobility [52]. Cycling has been a particular focus of this work [70], looking at cyclists' interactions with other road users [15], their perceptions of safety and the relationship between accident rates and exposure to motorised traffic [1], the influence of urban infrastructure on the prevalence of urban cycling [2,43], shared mobilities schemes [27,29] and their relation to intermodal mobility [57].

### Conflicts and public debate around e-scooters

E-scooters have already incited considerable public debate in the general media. The introduction of a new mode of transport has an impact on others users of public space, for transport and other uses, and thus changes the very character of that public space. As scholarly debate is still emergent on

this topic, we gained perspective and balanced our study's focus on first-person experiences of e-scooter use by reviewing general media discussions. Here we bring in media reports so as to give an overview of public debates about the social, spatial, and technological challenges e-scooters pose to non-users and to society at large.

Initial media reports about e-scooter, and in particular e-scooter rental schemes, were predominantly positive, referring to the opportunities in a new transit service as well as a form of entertainment, for inhabitants and tourists [80]. These early reports compared e-scooters to bicycles and bicycle rental schemes, sometimes through a history of other transport innovations [48]. Soon after e-scooters' deployment, however, complaints came from non-users, especially pedestrians feeling yet another infringement on their public space. Public complaints and acts of vandalism, drew attention to the problematic consequences of rental vehicles [50,78] – unused scooters are left out in the street, and users drive irresponsibly. This led to demands that authorities restrict or even ban these services. The main public response has been legal measures, such as creating a new category of vehicle for e-scooters in traffic rules to be able to ban them from pavements [77]; or negotiating settled codes of conduct with the companies who in turn commit to communicate good practices to their users [81]. But legal efforts have also progressed in the other direction, with Germany recently legalising e-scooters and the UK contemplating a similar change [73].

Once problems over the use of public space emerge, the media also begin to question other aspects of e-scooters. They report on safety, rising accident rates, medical experts' experience [83], and the insurance schemes available. Second, criticism of e-scooters' environmental impact and the companies' environmental friendliness [42]. Rental e-scooters are said to be less environmentally-friendly than companies claim, mainly because of their short life-span and the use of motorised vehicles to pick them up and recharge their batteries every day [40] (although most recently some companies have responded either by using only electric vehicles for pick-up, or installing swappable batteries). The main environmental cost of e-scooters as vehicles comes from their lithium batteries [40]. Rental companies respond by improving vehicle design and industrial processes so as to extend their lifespan and improve the technology. The media also have reported on experiences with e-scooter usage: while the use of *rental* e-scooters replaces more walking than car trips, *personal* e-scooters have a potential to replace car trips, especially by enabling intermodal mobility [57] and thus encouraging the use of public transit even for longer journeys.

Rental e-scooters are also an emergent industry and a market, with the ever fastest growing start-ups whose business strategies and success stories are commented on as role models [82]. However, their reliance on on-demand workers to recharge their vehicles at night and their contribution to the growing gig-economy have been pointed at for increasing social inequalities [79].

This brief review of media reports exposes the main problem concerning rental e-scooters: use of public space, environmental impact, and reliance on gig-economy workers. Yet this is balanced by the acknowledgement that rental schemes bring a widely appreciated service, and this is why authorities try to regulate rather than ban their use.

## METHODS

While there is much public discussion on e-scooters, there is somewhat less data on how they are actually used. Understanding user's experiences can also help improving the design of e-scooters, their related apps, and rental services. Accordingly, we conducted a video-ethnographic study of e-scooter use in Paris. We chose Paris as a case study since it was one of the earliest European cities to have rental e-scooters. They had been deployed in Paris for four months at the time of our fieldwork, and they were extremely popular also because October 2018 was particularly warm, making riding an e-scooter particularly pleasant. This success also showed that Parisians and tourists found in e-scooters something different from the many and variegated existing transportation modes there. Paris also has a dense population and dense traffic including cars, bicycles, pedestrians, mopeds, and so on. The city is not particularly hilly, and has a particularly dense urban core, making it a suitable city for e-scooter use.

As is typical in HCI we drew upon a mix of ethnographic and qualitative methods with a mix of interviews, observations video recordings and first-hand experiences. Our data comprise 5 weeks of observation in the streets of Paris, 10 interviews with e-scooter owners, 10 interviews with users of rental e-scooters, informal interviews with 10 shop owners, several days observing the work of sales persons in an e-scooter shop and their interactions with customers, documentary research on media coverage, survey reports and analyst reports. We recruited our interview participants by approaching customers of e-scooter shops and rental users in the street, asking them to make a latter appointment for an interview. Sixteen out of twenty of our interviewees lived in Paris or in the near suburbs, four of them were visiting either as tourists or for work. Men are overrepresented: 18 men and 2 women, an imbalance perhaps increased by our recruitment method, but in line with what reports find [12]. Our age distribution was 11 participants between 25 and 35 years old, with only 1 below, and 8 above. All the interviews were conducted in French, except for three in English. We also video-recorded three e-scooter rides with the main user wearing a head-mounted camera, and one researcher following them on another e-scooter wearing a chest-mounted camera. Participants for the video-recordings were recruited as a follow-up on their being interviewed as users. This video data gives us some view on *in situ* negotiations for public space, 'in real time'. All the participants gave their written consent to be audio- or video-recorded, and for

anonymised transcripts of the data to be reported in scientific publications.

In this data, we were not looking for statistically generalisable points, seeking instead to generate concepts and understandings of the phenomena, as well as get a grip on the problems and practices of those being studied. We used thematic analysis for the interviews [9]. For video data, we drew on the perspective of ethnomethodology and conversation analysis [20,31,74]. Ethnomethodology focuses on members' practices, offering a different perspective on mobility in that it focuses on the 'how and what' or 'ethno-methods' of choosing mobility mode, and of how we move and coordinate with other (mobile) public space users. Thus, ethnomethodological, video-based studies provide a unique view on mobility practices and interactions in mobility (e.g., [46,69]).

## RESULTS
First, drawing mainly from interview data, we focus on the first-person perspective to discuss the experience of riding an e-scooter: how it relates to and contrasts with cycling, the vehicle's affordances, the main characteristics of rental use, and the changes in mobility e-scooters enable. For the last two sections, we focus on the video data to show how e-scooters are used as a form of hybrid transportation, and we move on to an interactional perspective to show how e-scooters and other public space users coordinate.

### Enjoying and re-discovering the city
The main experience of scooters is riding through the city. The enjoyable [11] nature of this form of transport was mentioned as a major motivation to use e-scooters. There are many aspects to it: fun, a feeling of freedom and continuous movement, a mix of low effort and the joy of quickly travelling through the city, at times going around other road users. There is the bodily experience of enjoying the outdoors and feeling the air, unlike in public transport or cars:

*I wanted to try one just to avoid taking the metro, to avoid being confined, or taking the car, I wanted to be outdoors. […] Honestly when I get out of work I want to be in the open air, not to be confined in the underground.* (rental user, Paris resident)

*Coming from my hotel, it was either sitting in the back of an Uber, and the traffic I saw was very bad on the road that runs parallel to the Seine, or this* [the e-scooter]. *That's so much more enjoyable because you're outside, weather is fairly nice today, and you just get to kind of cruise and relax.* (rental user, London resident visiting for work)

Because they allow much longer distances than by foot and reach places where no motorized vehicle is allowed, e-scooters are also an opportunity to discover the city in unprecedented ways, both for tourists and veteran Parisians:

*Wandering on an e-scooter in Paris is another way of strolling, actually. You're certainly a little faster than on foot, but you still have time to appreciate, you're relaxed, you're being carried by the scooter […] It's super pleasant. It's another way of strolling, to discover Paris anew actually.* (owner, Paris resident)

Besides enjoyment, optimising journey time was a major motivation, to use this form of transport especially for e-scooter owners:

*But we save time anyway.* [With the e-scooter, commuting] *takes me about the same time* [as previously with the moped], *considering I do not use the same route, because I use streets usable by non-motorised two-wheelers. In Paris they even created cycle paths going in the opposite direction in one-way streets, so it allows me to cut through, or if I cannot cut through, I use the sidewalk, and there I drive more slowly.* (owner, Paris resident)

None of our rental users used a helmet, they felt both that it was the norm and that it would be absurd to carry one around. On the other hand, most of e-scooter owners did claim to wear a helmet. Helmet use is a complex topic – some studies suggesting that the advantages of wearing a helmet, at least for cyclists, are moderated by other road users treating cyclists with helmets more aggressively (the 'pleltzman' effect) [54,72].

### Cycling and e-scooters
The lack of effort required in driving an e-scooter makes for much easier usage in contrast to a bicycle, which makes e-scooter a more viable mode of transport.

*The e-scooter carries you. You have nothing to do. It takes you uphill. I overtake bicycles.* (owner, Paris resident)

This also means that riders do not sweat, they can ride with office dress. E-scooters were described as particularly manoeuvrable vehicles, which also enhances the feeling of safety:

*Because the e-scooter is smaller* [than a bicycle]*, you can weave in without being looked upon in ways that wouldn't work with a bicycle.* (rental user, Paris resident)

*I feel much more responsive than on a bicycle in case of an accident. On a bicycle you're one body with your bicycle, you can't jump away easily, whereas if something happen you can throw away you scooter, you can get rid of it just by jumping off.* (rental user, visitor)

This said, e-scooters and cycling share the need to navigate the city in an environment that is more or less designed to prioritise motor vehicles on the road, with some sections leaving little space for other road users. Our participants reported that travelling through the city could at times be unpleasant, and dangerous. Motor vehicles often drive fast and sometimes unpredictably, making it difficult and scary for e-scooter riders and cyclists. Moreover, e-scooter users are unprotected, there is no 'crumple zone', meaning that in a collision with a motor vehicle they are likely to be seriously harmed. Most of our e-scooter users said this was the reason

why they regularly rode on the pavements – which was still in a legal grey area at the time of our study, and is now illegal in Paris.

### Rental scooters: Spontaneous use, unreliability

Part of the huge attention e-scooters have attracted has been because of the visibility of their use through rental systems, using apps combined with cellular GPS units built into the scooters. A number of companies have used this technology to deploy thousands of scooters (up to 40,000 in Paris in 2019 [84]) and in many more cities. With this system, one can travel short distances without owning a scooter oneself, and without a concern for logistics or maintenance.

The location of scooters in a city during the day is more or less determined by the movement of users – users drop off scooters when they approach a destination, or when they encounter a technical problem with the scooter. This means that scooters move around the city as they are hired, and are sometimes left inoperable. Scooters are charged at night by self-employed workers hired by the scooter company, in a 'gig-economy' arrangement where they are paid per scooter charged (again, at the time of our study). The daily collection of scooters also allows maintenance since the broken ones can be kept for repairing.

Our participants described their use of rental e-scooters as mostly opportunistic during their travels around the city:

*It's really a matter of spontaneity, they're everywhere you know.* (Paris resident)

*I don't plan this sort of things, I'm more improvising. I improvise, so if there's one, all the better, and if I feel like using one I take it, otherwise it's not a big deal, I go on foot.* (Paris resident)

E-scooter use was not planned in advance and therefore rarely used for commuting, but in situations with little time pressure it could be considered in anticipation as an option besides public transport:

*On longer trips I actually plan to take a scooter and for example when I'm in a pub, before leaving the pub I look where the scooters are to see if I can do it on a scooter or if I do it by metro.* (Paris visitor)

This usage was shaped by the unpredictability and lack of reliability of rental e-scooters. Since e-scooters continuously moved across the city, one could never be sure to find one where and when needed. Second, if one could be seen close by through the app, sometimes it was not there at all. The map could be inaccurate, or the e-scooter impossible to find because the previous user had hidden it or taken it into their courtyard or flat:

*It has happened to us several times to walk about thirty minutes and there was nothing. Really it was there, and in fact we realised that the person had taken it straight to her balcony. We could see above the Lime up on the guy's balcony.* (Paris resident)

Or the e-scooter could be gone just a few minutes later:

*You never know where they are. They move so fast, sometimes even you get out of the café, you think you're going to fetch one which is two streets away, and when you get there it's no longer there. So I never plan in advance, thinking that there's no point anyway since it will be gone by the time I get there.* (Paris visitor)

This means that when considering using a scooter, users have to decide how long they want to spend looking before giving up. Even once found and unlocked, scooters themselves could have low charge or not work, creating another source of frustration and reason not to rely on rental scooters:

*I've been willing to try several times and actually it never worked. Either there was no battery left, or I don't know there was a problem with the e-scooter, it didn't work.* (Paris resident, about a particular rental company)

This partly explains why their use was 'opportunistic' – on seeing a scooter while walking, users would hire it and use it to get to their destination, if it worked. Sometimes this destination would be another public transport site, or their final destination. At other times having a working scooter would cause the user to reconfigure their journey – changing what public transport they took, or taking the e-scooter all the way to the destination. This opportunistic use was not entirely random; often users would try and take small detours to come across an e-scooter they saw on the map, or in identified places. Indeed, e-scooters are often deployed in clusters which become reliable points participants would walk past to find a scooter, as part of a plan. But these clusters were not stable throughout the day.

This reliability problem was balanced with e-scooters' ease of use, cost advantage (at least initially when compared to purchasing a e-scooter) and lack of concern for maintenance, repair, and even charging. Users can just pick up one and use it. This lowered 'barrier to use' also meant that users got a sense of how suitable a scooter would be for purchase. All of our shop owners said that their e-scooter sales boomed with rental users deciding to buy one after trial. Most users admitted that renting was relatively expensive, counterbalanced with the joy of riding:

*I think it ends up being more expensive for me than if I used the metro, but I don't care, I accept to sacrifice this money to be able to move around on e-scooters because the pleasure is there.* (rental user, Paris visitor)

On the other hand, while the influence of renting on driving practices remains understudied, some rental users admitted to driving faster because rental was paid by the minute:

*Most of the time I use the road. I feel more comfortable on the road, I can go faster, there are many people on pavements, all the more considering that you pay by the minute, it's metering system, so you have to be quite fast.* (rental user, Paris resident)

While our interviews lead us to take a user perspective, it is important to point out that rental e-scooters, at the time of our study and onwards, suffered from major problems of parking, with mis-parked scooters having a particularly negative effect on the accessibility of public space.

**Intermodal transport: "hacking the city"**
Discussion around new transit methods often focuses on whether its use substitutes for an existing mode (such as taking a taxi rather than a bus) or transforms practices in more depth [37]. Some of our participants, e-scooter owners, exclusively travelled around the city with the scooter almost completely replacing their reliance on public transport. But around half of them combined e-scooter with other transport modes. E-scooter use then 'reshuffled' their transportation practices in a variety of ways, enabling new types of 'intermodal' transport [66] – the combination of different transport modes in one journey. This opened up new routes and journeys that would have been inefficient or impracticable without e-scooters.

A simple but important feature of e-scooters is that they can be folded up through a hinge, which made them relatively compact and portable. Users could then carry their vehicle onto public transport:

*So I fold it. When I get to the metro, I get off, I still don't use it, I keep it folded, I take the RER [Paris railway network], RER, I still keep it folded. At Châtelet I take the RER B, then I get off at Cité Universitaire. From there on I have nothing to do apart from going downhill. I switch off the engine because it's useless, On the way back very often there are problems on the RER B, on evenings it's very recurrent. So then sometimes I have to go to the 14th to try and get as fast as possible to a metro station that will take me as close as possible to Châtelet. Then I take the metro, I get to Mairie des Lilas, and there if the bus comes and it's not packed, no need to turn on the e-scooter, I get home with the bus. If the bus is packed, if I have to wait 14 to 20 minutes for the next one, I leave* [using the e-scooter].

Rental users described how they created new, intermodal routes, for example using a faster train line that was usually too far away from their destination or starting point. They used the rental scheme for the first or last kilometres or hundreds of meters:

*I use the scooters to make connections to the subway. Basically it's line 13, but I try to take it as late as possible. Is use the scooter to shorten the metro trip as much as possible, to avoid connections.* (rental user, Paris resident).

E-scooters were mentioned as a successor of bike-sharing schemes:

*I used to walk to line 13 directly. Then I did it with the Vélib [Paris' public docked rental bicycle scheme], then I did it with the free-floating bikes, and now I do it with the scooters.* (rental user, Paris resident)

Another interesting comment about e-scooters concerns their utility in a very congested city. At rush hour, many large cities are saturated in all their forms of transport – car, bus, train. Because of because of the high demands put on transit and the problems of an 'at capacity' system, breakdowns happen very frequently, causing cascading delays for users. For these reasons, travelling around Paris not always smooth or easy, so that using an e-scooter allows a sort of 'hack' by squeezing between the existing saturated transport methods. While the city is saturated with various modes of transport, this one manages to squeeze itself inside:

*But the nice thing with the scooter is when you're in time pressure and you're in an Uber and you get stuck in traffic because there's something you don't know up ahead, it gets very stressful cause you can't do anything. Whereas on that, you're pretty much sure, you're like OK cool, that's gonna take me this amount of time and there won't be many detours.* (rental user, Paris visitor)

For some of our more enthusiastic users, their scooter completely replaced their reliance on a personal, motorised vehicle. While it seems fair that we found only few cases of scooters replacing car travel (considering the existing heavy constraints on car travel in Paris already) one participant gave up on using the moped when hers broke, and now uses only her e-scooter to travel inside Paris. Another participant avoided buying a new car by riding his e-scooter to the station which, by foot, used to be too far from his home:

*I don't own a car anymore, because now that I have the scooter, since the RER or the Transilien are in general quite punctual, it works for me. Since I've had it, I leave a little later and I arrive at work on time, so that's quite an advantage.* (owner, resident in the suburbs)

Lastly, an additional advantage of e-scooters being foldable, besides enabling intermodal transport, is that they can be easily carried up stairs, and kept indoors even in small flats. Stored indoors, e-scooters can be plugged and left to charge with no cost other than electricity itself; and they are preserved from theft or vandalism:

*You can fold it, put it at home in a cupboard, a cellar, anywhere. It really is a considerable advantage, when you think about it. Because bicycles in Paris are a hassle, a real hassle, they get stolen all the time, and if not the bicycle, pieces of the bicycle, all the time.* (owner, Paris resident)

**Scooter as hybrid transport: Pedestrian, car or bicycle**
Our participants would often compare riding the e-scooter to other forms of transport: they can be ridden in bicycle lanes like bicycles, on the road in traffic like cars; they can be pushed alongside to walk on pavements with pedestrians, and they can be folded and carried on foot to take public transportations. In terms of design, e-scooters indeed combine aspects of these: their top speed is close to that of a car in traffic, their size and shape resemble those of a bicycle, and they can be walked with as a pedestrian. This led us to characterise e-scooter as 'hybrid': they combine features of

other transport modes, and, relying on the former, they can be used in different ways according to the situation. In other words, users can 'transform' from one mode to another as they adjust to the situation, through road positioning (driving close to the curb or more in the road), folding up the scooter and carrying it, or getting off the scooter and pushing the scooter alongside.

One example of this 'hybridity' is in jumping red lights or using the pavement. We observed in our video data that e-scooter users approaching a red light, instead of stopping or simply go through the red light, could jump off their scooter and push it through the crossing. Dismounting exactly when they cross the red light boundary, they become pedestrians, albeit pushing a scooter. At some point, when the way is clear, they jump back on the scooter and drive off again.

In Figure 1, we follow Christine (a pseudonym) on her morning commute, a route she knows in every detail. Driving on the right side of the road like a bicycle, she approaches a red light (Figure 1.1). Christine slows down as she approaches the red light, and exactly as she reaches the boundary, she sets her left foot off the platform while turning her head to the right. In an uninterrupted movement, she sets her right foot off the board too and starts walking, pushing the e-scooter alongside. With her head turned to the right, she monitors the potential coming of cars, showing that she may still have to give way, and is ready to. Shortly after, having secured the way as cleared and safe, she turns her head to the road ahead and continues walking. As she gets near the end of the intersection, she climbs on the scooter again and resumes her motorised journey.



**Figure 1: from scooter to pedestrian at the red light**

Unlike bicycles, e-scooters are stable at low speed, and therefore Christine does not *need* to dismount, she could simply slide through the red light slowly as bicycles sometimes do. But what matters and why she dismounts is how she appears to others present around her – cars stopped at the traffic light, bystanders on the porch a few meters away, or even the researcher following and filming her. Through her conduct, she orients to the accountability of her actions [65]: public space is one of constant visibility where

one's actions can be scrutinised and judged by others. That is to say, actions are 'accountable' to others [34]. When she walks and pushes her e-scooter along, Christine is visible not as a road user going through a red light, but as a pedestrian walking across the road. Goffman called this "body gloss" – the embodied, visible way in which we convey certain information in public, where we control how we are seen by others. In this case Christine's movements are seen as 'like a pedestrian', not 'like a car' obligation not to convey other impressions [35]. With this change of body gloss, Christine is no longer accountable as a road user but as a pedestrian, and thus she is not really breaking the rules.

Figure 2 involves a similar practice, but for different purposes and with a lesser concern for appearance. Vincent is using the bus lane which is also the cycle-lane, driving in the centre of Paris. He approaches a red traffic light while pedestrians for whom the light is green are crossing the road (the coincidental presence of two other scooters reflects their popularity in Paris at the time).



**Figure 2: from scooter to pedestrian to walk on pavement**

Vincent slows down as he approaches the red light and dismounts. Like Christine, with no pause whatsoever, he starts walking pushing his vehicle along. But instead of walking past the zebra crossing to continue on the road the way Christine did, he swerves to the left, and walks along the zebra crossing with the crossing pedestrians. As he reaches the other side of the road, he climbs on the pavement and mingles among pedestrians. In the interview, Vincent explained he did it in order to take a route impossible as a road user. In our discussions about travelling on the pavement, nearly all our e-scooter users admitted resorting to driving on the pavement to make their way around obstructions. Since this is less common for bicyclists, one possibility might be that a scooter on the pavement is closer in form to a pedestrian. As one participant put it:

*On an e-scooter you're not exactly a pedestrian, and you're not exactly motorised. You end up in a grey area, and in the absence of a strict legislation, you allow yourself some things you [wouldn't normally]. When you stop at a traffic light on an e-scooter, you wonder why you're stopping (Owner)*

E-scooters could also emphasise their similarity to other types of road user. Our participants tended to take a similar position as bicycles – either in a cycle-lane if it was available, or over to the side of the road near the pavement. But in both cases, they would encounter cyclists and sometimes overtook them, being faster than them. To do so when driving on the right side of the road, they could swing themselves out into the road and thereby take the position where a car would normally drive. In these situations, therefore, they could be said to be taking on the position of a car. Even when they were not overtaking, e-scooter users could drive into the centre of a lane like cars again, when they felt at risk driving on the side of the road. This was especially the case when they felt pedestrians could step down unpredictably, when people from parked cars could open their doors without looking behind; or in order to block cars coming from behind from overtaking them because it felt dangerous.

In sum, these 'transformations' captured the hybrid nature of e-scooters, their flexibility, from motorised vehicle to pedestrian and from bicycle-like to car-like vehicle in under a second, according to road conditions and travelling speed.

**Negotiating the way with other public space users**
As we discussed above when reviewing media reports of e-scooter use, one area of considerable controversy is their conduct in public space. The media has extensively reported on pedestrians disgruntled by e-scooters jostling them on pavements or going through lights and zebra crossings at full speed. One can also see this major conflict as 'normal troubles' when a new technology enters the field - growing pains, of a sort. Since e-scooters are relatively recent, other road users may not have good expectations of how and where they would move; and second, because they are not identified as a particular type of vehicle, other road users have no prior code of conduct to refer to, they don't know which sets of rights and obligations should apply:

*We are less visible, also, to pedestrians […] as something which doesn't make noise, moving forward, vertical, like a stick moving forward, I think we're much less visible than bicycles. […] Pedestrians just see another pedestrian coming. In the corner of their eyes, in their field of vision, they see someone standing, they don't necessarily see someone standing and moving forward.* (Rental user)

Several of our participants talked about pedestrians' prejudice against them, and the gratuitous attacks they faced:

*I was not going anywhere, just strolling really [on the pavement] at 7km/h or so. And there, an old woman ahead of me as she sees me come to her raises her cane in the air blocking my way. I don't say anything, and the moment I go by she pushes me. She pushes me, you know! So I look at her,*

*and she says "You have nothing to do on the pavement."* (e-scooter owner)

Our videos of scooter users give us some insight into cases where e-scooter's and pedestrians' trajectories coincide, and how they quickly negotiate ways. In Figure 3, a pedestrian is speaking on their phone and starts to cross the road from the opposite pavement, in front of our e-scooter rider. When he is about two meters away from the rider (in the cycle-lane), and walking directly towards him, the man still looks down. The rider slows down even more, visibly expecting that the man on the phone might simply continue, and giving him way. But while he takes one more step, the pedestrian raises his gaze and then stops dead with his left foot on the cycle-lane marking. During this step, as the angle of the camera shows, the rider turns his head to the man, with the pedestrian maintaining his gaze. The combination of stopping and looking is responded to as giving way, and the scooter rider takes the offer by accelerating and passing on the right.



**Figure 3: pedestrian giving way to e-scooter**

There is a sort of 'double take' where the pedestrian notices the scooter and stops walking and stares. This makes visible that the pedestrian has now seen the rider, but also that his first concern is to avoid any collisions. Our rider takes this as a sign he can proceed to the right of the pedestrian (crossing his path) making use of the pedestrians' stop to 'go first'.

In Figure 4, the same rider, still in the cycle-lane, is turning round a corner. As he does so, a pedestrian coming from the opposite pavement enters a zebra crossing, walking slowly and looking down. The e-scooter rider slows down. As they are about 4 meters from each other, the pedestrian stares at the scooter, marking not only his surprise but also appreciating the situation as potentially dangerous, towards imminent collision. But shortly after, he resumes walking as before and turns his head away. As he walks past the cycle-lane marking, he visibly hurries his steps to get out of the scooter's way. Through his "moral quickstep" [69], a way of accelerating the pace as a public demonstration more than a

practical purpose, the pedestrian shows he appreciates the offer, does not take advantage of it, and somehow reciprocates [44]. In Figure 4, Vincent had slowed down almost to the point of stopping, but he can accelerate once the pedestrian has jumped on the pavement. These two clips capture some of the emergent negotiations that take place between pedestrians and scooter users on the road. In both cases there is an element of conflict, in at least the sense of a shared stare between road users, a suspension of 'civil inattention' [34] usually given between road users.



Figure 4: pedestrian taking rights of way

DISCUSSION

Our study has reported on both privately-owned and rental e-scooter use. After discussing the enjoyment of e-scooter riding, we reviewed how e-scooters support new forms of intermodal transport, and how owned and rental scooters are used in different ways. Focusing on the videos, we then reported on the 'hybrid' nature of e-scooters, where they can combine the properties of other modes of transport; and we considered some of the potential conflicts between e-scooters users and other road users.

In discussion, we consider two areas of relevance for HCI. The first is to consider how HCI can contribute to designing new transport systems, in particular through inventing new mobility services. While this has not been traditionally an area of much HCI research, pressing environmental issues promote the urgency of finding new solutions here. Moreover, as discussed above, the experience of complex transport networks is increasingly produced as much through app-based systems as the transport means itself.

Second, we discuss the potential of HCI to contribute to vehicle design. One exciting development in micro-mobility is how it opens up the physical design of transport systems, aspects that have long been closed [6]. These aspects of design are not only tied to efficiency or practicality, but also to how vehicles are seen in traffic with others, as well as more broadly how they engage with users' practices – points where HCI can productively engage. This underlies the importance of studying the 'user experience' of transport in different ways, and how HCI can shed light on the value of individual mobility experiences.

New opportunities around new mobilities

We urgently need to reduce our carbon dependency, and many authors have identified motor-vehicle dependency as a key part of this. While cars are likely to be part of our transport systems for some time, HCI has potential for an expanded role exploring mobility innovations that go beyond current transport offerings. As our study has documented (alongside similar work on app-based mobility services [33]) transport now depends upon apps and software as well as physical mobility. E-scooter rental requires apps and networked scooters to be able to work. This makes transportation an increasingly relevant HCI topic. Indeed, under the banner of 'urban infomatics', Foth and colleagues [28] have discussed a range of interesting new technological concepts around non-car transport, city design and software. This connects directly with the increasing interest in an HCI that can work with broader 'matters of concern' and digital civics [7,62].

One aligned concept here is that of 'mobility as a service' [41], which has gained considerable traction amongst public transport providers, promoting idea about how apps, payment and systems can work to better combine different transport modes. A number of app-based services have attempted to combine various transport providers, transport information, calculations of optimal intermodal journeys adjusted in real-time, and payment, merging data from various providers [ibid].

Our data suggests that introducing e-scooters to these services could create interesting new opportunities. For example, scooters could let users jump between different transport modes more effectively. Existing transport networks often suffer from 'gaps', such as when two train stations are close but there is no easy public transport between them, and e-scooters might be one way of filling in these gaps at a massively lower cost than building physical infrastructure. Such systems could also help in cases of transport failure, potentially adapting to actual conditions in real time, for example by quickly deploying e-scooters to alleviate disrupted transit connections.

With regard to e-scooter rental, there are also interesting new possibilities. Different payment solutions could support commuters who need to use e-scooters regularly (such as integrating with existing public transit passes). There may also be intermediate arrangements between purchasing a scooter and renting a scooter that could be offered. It is also worth considering how sharing schemes (rather than rental) could work. Communities of neighbours, for example, could own scooters together and benefit from specific software assisting them to organise timetables and manage vehicle maintenance, thus supporting innovative, sustainable forms of shared micro-mobility.

**Vehicle design and opportunities for HCI**

It is important to think of the e-scooter not as an 'end point' but as something still developing. Commercially there is still considerable experimentation with new types of e-scooter design [38,56]. There are, for examples, vehicles that can carry cargo more than one person, or support those with disabilities better. Ongoing improvements in the technology are also likely to answer some of the criticisms over obsolescence and sustainability. So, while e-scooters are interesting in their own right, they should be seen as part of a quickly developing family of technological innovations around individual electric transportation. E-scooters 'open up' a new design space around personal vehicles that has been closed for a very long time [6].

From this we can draw a host of interesting directions and ways in which HCI can contribute. We do not have the space here for a full design process around micro-mobility, rather the contribution of our work is to provide an understanding of the user impact of different electric vehicles on those travelling, and the decisions they make. Individual electric vehicles – be it scooters, e-bikes, single person electric cars – have interactional (between road users) as well as practical (effort, manoeuvrability, foldability) impacts. An important HCI contribution then is to provide an empirical background to inform design processes seeking to develop this in different ways. For example, one could try and expand on e-scooters' ergonomic, practical and social features; combine them with features of electric bicycles; or try to transfer their hybrid nature to other forms of transport. This gives a distinctly HCI contribution to understanding user values and perspectives in the design process of creating new hybrid transport forms.

Alongside the design of the vehicle itself, there are also ongoing debates about how to reshape public space: e-scooter use could make a positive contribution to ongoing innovations around the planning and design of public space [32,67]. Adapting cycle-lanes and pedestrian spaces more broadly to the use of e-scooters would promote the use of light electric vehicles, and 'soft' transportation modes in general. If cycle lanes are seen as 'personal vehicle lanes', perhaps they do not need to be separated from other road users, and could even be integrated with spaces for pedestrians. As we discussed above, our e-scooter users did admit to making extensive use of pavements (something that some cities are making illegal). There is increasing worry about how at peak times different cycle lane users who have different speeds and space considerations are causing congestion. In the Netherlands, one country with a prominent cycling culture [8], new micro-mobility vehicles are already causing traffic congestions and accidents on saturated cycle-lanes. Here, a pressing but also delicate problem is the amount of space dedicated to cars. A straightforward solution to the competition for both parking and driving space in dense urban ecologies is to re-allocate the space currently given to cars to lighter forms of mobility.

More broadly, we would argue for HCI's role in understanding user experience of transport over the viewpoints of infrastructure providers. HCI has a powerful design research role to play here in bringing the user into the transit design process more broadly. This connects with the growing importance of sustainability. For example, while transport route choice is a complex issue, it may increasingly become forced because of environmental urgency. One research direction here is to question how route choice is presented, and how different techniques might encourage more carbon-friendly modes of transport. One connection point that can help these discussions is social science field of mobility studies, a field that shares HCI interest in user experiences, although one so far with few overlaps (cf [45,58]).

## CONCLUSION

This paper has taken an ethnographic approach to understand e-scooters as a novel vehicle with the potential to reshape cities and everyday transport. An exploration of users' experience confronted with the controversy occasioned by rental schemes point to an opportunity for HCI to not only design interfaces at an individual level, but also contribute to larger societal change by re-designing transportation modes. More broadly, we are hopeful for the opportunity to think about HCI's role in contributing to new mobilities and new ways of designing, and travelling through, urban spaces.

## ACKNOWLEDGEMENTS

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