Exploring Human - eBike Interaction to Support Rider Autonomy

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Figure 1: Ava the eBike.

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Abstract
eBikes contribute to the future of personal transport while offering physical activity and wellbeing benefits. However, there has been little exploration of the way eBikes interact with humans within the field of human-computer interaction (HCI). In exploring this opportunity we augmented existing eBike functionality to create "Ava, the eBike", a prototype aiming to support a playful eBike riding experience by supporting the rider's autonomy. We used inherent cycling body movement to playfully interface with the eBike's functionality and fuse the rider's body to Ava's, as a way of harmonising bodily interaction with the eBike in a continuous expression. Through this offering playful bodily interactions while reducing interaction obstacles. Furthermore, we leveraged LEDs and multiple sounds creating a flexible environment in which the rider can choose the emitting sound when accelerating. Our work will contribute to designing playful interactive technology that supports users' autonomy while augmenting their bodily capabilities, and expanding the field of human-eBike interaction.

Author Keywords
eBikes; Physical activity; Autonomy; Interactive Technology; Play; Body.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

eBikes are defined as "bicycles that are fitted with an electric motor to provide the rider with power assistance" [1]. eBike adoption has increased across the world: in the Netherlands approximately 1 in 20 Dutch citizens owns an eBike [2], in China over 200 million eBikes are regularly used [3, 4], while in Switzerland eBikes are promoted as a greener transport option [5]. A potential challenge with eBikes is that they often have a controller interface with signals, buttons, levels and throttles which require learning and operation while in motion, increasing the attentional load. According to various eBike research, this is a factor that can detract from the cycling experience, as it reduces engagement with cycling and has led to a decrease in cycling safety [6-8]; and beyond eBikes, we know that interaction while in motion is a difficult challenge [9, 10]. These insights suggest to us that there is a lot of potential in exploring more natural interactions with eBikes; rather than providing interactions which detract from the cycling experience, we focus on how interactions can support the experience that cycling affords, celebrating whole body engagement and physical activity through playful human-eBike interaction.

There have been works on helping people ride bikes faster using technology, these works are characterised by focusing on performance [11, 12]. Other studies have explored the social aspect: for example, systems can connect riders online, and riders can comment on one another's rides through their GPS recordings, as well as discover new routes [11, 13]; we learn from Johnson et al. [14] that "eBikes are offering riding opportunities to new segments, such as people who rarely or never cycled as an adult, they frequently ride their eBike, particularly for casual trips (e.g. to the shops, visit friends)." This suggests that eBike riders are riders who enjoy the experience that cycling affords, and appear to ride for pleasure and enjoyment. eBike riders appear to appreciate the assistive electric engine since it can help them to go further and faster while still experiencing the enjoyment of cycling. As such, with our work, we aim to support and enhance the pleasure inherent in eBike riders' cycling experience from a playful perspective.

Bikes and technology

In HCI, research has previously focused on bikes; for example Dancu et al. [15] explored the use of projections while cycling in urban environments to make people more aware of moving vehicles. They found that a gesture-projection system was considered easier to use than an off-the-shelf turn signalling system and allowed the user to be more attentive to the route. Walmink et al. [16] experimented with a head motion controlled LED helmet to increase awareness and safety when turning and braking. In the research and development of bike products new ideas have been developed: for example Smarthalo functions as a GPS and night light, and shows mobile phone call notifications [17]. Rowland et al. [18] have explored designing mobile experiences for cyclists: they created two experiments using GPS, concentrating on the enjoyment of the cycling experience. Their conclusion is that "design has to respect the distinctive nature of cycling as a mode of transport and needs to carefully interweave moments of interaction with it."

Bikes and play

We are inspired by works that combined play and cycling, for example the 'iron horse' makes horse-like

sounds when cycling to facilitate a playful riding experience [19]. Riding an eBike can be seen as a form of play [19], hence we look at cycling from theories of play, such as Self Determination Theory (SDT), in particular with its three core elements "competence", "relatedness" and "autonomy" [20]. "Competence" appears to not play as much a role for eBike riders as bike riders [2, 14], while "relatedness" has been previously explored [11, 13]. Here we focus on the third intrinsic human need, "autonomy". Prior research explains that "Autonomy means, you are behaving in accord with your own body values, you are able to act in a way that matches your interest and your deep values" [21], and "we can define an autonomous person as one who has an independent capacity to make and carry out the choices which govern his or her actions." [22]. Supporting autonomy can contribute to users' experience and enjoyment. In sports and video games it can improve users' performance and motivation [23, 24], while in education, healthcare and work, it enhances self-directive efforts [22, 25-27]. We believe that supporting users' autonomy contributes to supporting positive experiences that are more complete and desirable for the user.

We find that eBike riding offers qualities that support autonomy, such as providing meaningful choices that the rider can pursue (riding faster and further than a normal bike and providing engine power that serves as an extension of the rider's power), which augments their bodily capabilities. The eBike riding experience facilitates riding in a manner that encourages self expression and a sense of wonder, and we know that when people are in a play like state is when they are most autonomous [23].

We are interested in how else we can support eBike riders' autonomy to contribute to their cycling experience. This is important because we believe that the interactions that emerge with the increased popularity of eBikes need to support and augment the cycling experience, rather than interfering with and detracting from it. To explore this opportunity we have created a prototype that opens up questions towards its effect on the cycling experience. We wonder what our prototype would elicit from riders; what riders' feedback would be on their perceived autonomy support from our eBike prototype; and what the learnings would offer towards the design of eBikes and human-eBike interaction. We find that much of the eBike's functionality is designed with a utilitarian approach in mind, such as getting from A to B, rather than to support the playful experience that eBike riding can afford. As a result we formulate the following research question: "How do we design for eBike riders' autonomy to support the cycling experience?". With this knowledge, interactive technology designers as well as HCI and transport researchers can design better eBikes that contribute to the riders' autonomy while leading to a playful, active and healthy community.

Opportunities when designing autonomy-supportive playful interactive technology

Calvo et al. [28] state that autonomy in technology design can be aimed to target four dimensions, to which we have added labels below.

- Experience: *In impacting users' motivation and engagement with a technology.*

Figure 2: Bodily acceleration posture present in various human powered sports activities. Source: Luca Longboards, TexasTailwind Blog, Unsplash surf, skiing.

Figure 3: Images captured during observations - the wobbly state, resuming riding from a stop position.

- Assistance: *In removing obstacles, enhancing capabilities, and allowing people to pursue self-determined goals more fluently.*

- Empowerment: *In supporting users in designing their own technologies, based on their unique and evolving needs and contexts.*

- Personal growth: *In technologies that foster autonomy as an overarching characteristic of psychological development and flourishing.*

In this investigation we focus on 'Experience', and 'Assistance'. In focusing on Experience and Assistance we build on Friedman et al. [29], from whom we learn that "autonomy is protected when users are given control over the right things at the right time. Of course, the hard work is to decide these whats and whens".

Experience Design for eBike riding

To gain an understanding of the eBike riding experience, and to imagine what features an autonomy-supportive eBike might have, we employed an "Experience Design" approach [30] creating a story map based on observations. 1) One of the authors became an "undercover" eBike rider at an eBike group where people meet and ride, and participated in a weekend ride. 2) One of our researchers conducted observations at an intersection that is the gateway to the city from the suburbs, from 7:30 am - 9:00 am on Tuesday, and from 4:00 pm - 5:30 pm on Wednesday (both days during that week were weather friendly). From these observations approximately 75 eBike riders were observed. This is what we found:

- Most riders stop pedalling when accelerating with the eBike's throttle, often leaning forward as if getting ready to maximise the acceleration; this posture is also recurrent in other human-powered experiences (Figure 2).

- Riders often resume riding from a stop position by standing up while pedalling to speed quickly; although this facilitates power to the pedal, it also causes a wobbly state (Figure 3).

- Some riders seem to take pride in decorating their eBikes; some have custom sounds for their bell or horn. This appears to be part of self-expression and may add to their enjoyment of cycling.

We captured these observations with photos, notes, and sketches to create our story. The story assisted us in refining the scope for our prototype.

Introducing Ava, the eBike

We present Ava, the eBike, an autonomy-supportive ride. Ava focuses on supporting the rider's experience by removing interaction obstacles and offering bodily playful choices that the rider can explore through human-eBike interactions. More precisely, we extend the cycling experience by using inherent cycling body movement as a way of harmonising bodily interaction with the eBike in a continuous expression, to playfully interface with the eBike's engine. We use LEDs that pulse to increase visibility, similar to a car's hazard lights, and offer three sounds that the rider can choose from. Ava focuses on augmenting the experience that eBike riding affords through applying autonomy in the design of playful interactive technology, while fostering enjoyment of eBike riding and physical activity.

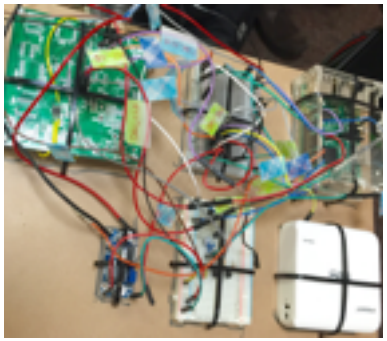

Figure 5: Ava electronics.

Figure 6: LED, colour RGB, waterproof with 540-600 Lumens/M were used for Ava's body.

Figure 7: Four different sounds for the rider: silent, dreamy, futuristic, and a turbo.

Figure 4: Ava the eBike, bodily-acceleration in action.

Ava's objective is to support the rider's autonomy in their cycling experience. We gave our prototype a human-like name, to help riders relate to it; as Ryan [21] notes: "one of the most autonomous things people do is to relate to others; through this, others support our autonomy".

Ava's extended functionality

In order to use the engine's power, users need to interpret levers, lights and gauges. We know from literature on eBikes and in HCI that designing interfaces to operate while in motion can cause extra attentional load [2, 18]. With this in mind we have explored ways of exploiting inherent cycling body movement to playfully interface with the eBike's functionality and fuse the rider's body to Ava's, as a way of harmonising bodily interaction with the eBike in a continuous expression. This offers the use of playful bodily interactions to the rider, such as leaning the body forward to accelerate, as observed in the experience design approach (Figure 2). By doing so, we explore more natural interactions with eBikes, aiming to reduce interaction obstacles. We call this leaning forward "bodily-acceleration". This is inspired by what Rowland calls "deeply physical connection" in his description of cycling: cycling "involves an intimate and deeply physical connection with the world that can stimulate engaging and even profound experiences [18]".

Ava is built around an original "Dillinger" brand eBike, model OspreyLight, with 250W nominal power [31]. We used a Raspberry Pie3 B as a processor to augment Ava [32]. Riders can accelerate by a) using the traditional throttle or by b) leaning forward. The leaning posture angle determines the intensity of the power applied to the motor, the interaction is designed so riders bodily-accelerate momentarily, however if they choose to, they can remain in this posture to embrace acceleration to the fullest. The bodily-acceleration angle is calculated with a mobile's phone gyroscope sensor worn on the rider's chest, with a custom knit elastic pouch, in order to optimise the gyroscope sensitivity to the acceleration interaction. Orchestrating all the different parts requires careful electronic design (Figure 5).

In exploring the wobbly state a hall effect sensor was used [33] to detect when riders are resuming cycling from a stop position; Ava then was programmed to offer pedal assist at this point, lightly augmenting the rider's pedalling power. Ava has LED strips on each side, which pulse as hazard lights to increase visibility to vehicles nearby while in the wobbly state. Furthermore, the LED's pulse in a different pattern when the rider surpasses 25km per hour as an indicator of speed and to contribute to safety (Figure 6).

Ava's iterative evolution
We conducted a two-hour discussion and cycling test with our five lab peers who come from multiple backgrounds such as computer science, interaction design, exertion games and user experience. The discussion resulted in the following key points:

1) "Bodily-acceleration" should be disabled when a) in a stop position so Ava does not accelerate as the rider is reaching down, b) when taking a sharp turn, and c) the brakes should disable engine acceleration.

2) Three peers suggested adding sound to the prototype, as sound is present in other engine enabled experiences (motorbikes, eSkateboard, cars). This can contribute to the sense of speed and playfulness.

After implementing point one, we continued with point two, exploring how to deliver stereo sound, while maintaining a sleek and minimalist look. We selected the portable PolkBoom speaker [34], as it can be discreetly added to the handle bar. We then explored playful sounds that were complementary to the bodily acceleration interaction. Three sound states were selected, plus a silent state, to represent a dreamy, a futuristic, and a turbo state. A small knob without labels was added next to the speaker, as it provided the simplest sound switch, and serve to entice the rider to explore the sounds (Figure 7).

Proposed Future Study
We plan to recruit eBike riders to take on the 'perceived autonomy support questionnaire [35]' in relation to their current eBike experience. Next, we will conduct an in-the-wild study [36], deploying Ava to participants' homes for two weeks. Riders will be offered a diary to document their observations, and this will be followed with semi-structured interviews. After this, participants will re-take the 'perceived autonomy support questionnaire' in relation to their experience with Ava. We will analyse, visualise and compare the questionnaire responses, and use thematic analysis [37] for the qualitative data analysis.

The results will help us understand how to design for augmenting the quality that eBike riding affords by considering autonomy in playful technology design. We hope our work will contribute to designing playful interactive technology that supports users' autonomy while augmenting their bodily capabilities, and expanding the field of human-eBike interaction.

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