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The (digital) medium of mobility is the message: Examining the influence of e-scooter mobile app perceptions on e-scooter use intent

Rabindra Ratan [a,*], Kelsey Earle [b,**], Sonny Rosenthal [c], Vivian Hsueh Hua Chen [c], Andrew Gambino [d], Gerard Goggin [c], Hallam Stevens [e], Benjamin Li [c], Kwan Min Lee [c]

[a] Michigan State University, College of Communication Arts and Sciences, Department of Media and Information, 404 Wilson Road, East Lansing, MI, 44824, USA
[b] Michigan State University, College of Communication Arts and Sciences, Department of Communication, 404 Wilson Road, East Lansing, MI, 44824, USA
[c] Nanyang Technological University Singapore, Wee Kim Wee School of Communication and Information, 31 Nanyang Link, Singapore, 637718, Singapore
[d] Penn State University, Donald P. Bellisario College of Communications, 201 Carnegie Building, State College, PA, 16803, USA
[e] Nanyang Technological University Singapore, School of Humanities, 48 Nanyang Ave, Singapore, 639818, Singapore

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ABSTRACT

The present research examines how perceptions of e-scooter mobile apps (i.e., a communication technology) influence intent to use e-scooters (i.e., a transportation technology) while considering other perceptions specific to e-scooters (ease of use, usefulness, safety, environmental impact, and enjoyment), context of use (geographic landscape), and demographic factors (age and sex). Results suggest *mobile app perceived ease of use* is associated with *e-scooter use intent* and this effect is mediated by *e-scooter perceived usefulness,* even when controlling for *e-scooter perceived ease of use* as well as other influential elements of e-scooter use. In addition to illustrating the importance of user experiences with mobile apps within the e-scooter context, this interdisciplinary research furthers a fundamental argument that media technologies are an integral factor in the adoption of transportation technologies.

1. Introduction

Mobility technologies have long been platforms of communication, but this is becoming increasingly apparent as media technologies are more visibly embedded in transportation networks (Featherstone, 2004; Goggin, 2012). The present project focuses on electric scooter ("e-scooter") sharing, a relatively novel form of micromobility with growing adoption rates worldwide (Clewlow, 2019; McKenzie, 2019; Reck et al., 2020; Sandt, 2019; Seebauer, 2015; Yang, 2010) in both urban and suburban landscapes (Aartsma, 2020; Aguilera-García et al., 2020; Tyrinopoulos and Antoniou, 2020). In addition to serving as technologies of transportation, e-scooter sharing platforms are integrated into the media-technology landscape, given that using such e-scooters requires use of a digital media platform, often the e-scooter company's mobile application ("app") on a smart device. In other words, human interaction with a mobile app is an essential element of the interaction with e-scooters that potentially influences use intention. The influence of the mobile app has been studied in regard to other micrombility options (e.g., Lo et al., 2020), but not as thoroughly for e-scooters particularly when considering perceptions of the technology, demographic information, and individual factors that contribute to use intention.

The present research addresses this gap, focusing on how perceptions of e-scooter mobile apps (i.e., a communication technology) influence intent to use e-scooters (i.e., a transportation technology) while considering other perceptions specific to e-scooters (ease of use, usefulness, safety, environmental impact, enjoyment), context of use (i.e., geographic landscape), and individual factors (age and sex). In addition to illustrating the importance of user experiences with mobile apps within the e-scooter context, this study adds to the growing body of research that examines transportation technologies from a communication perspective (e.g., Dumitru et al., 2018; Ratan, 2019; Steinberger et al., 2017; Von Pape et al., 2019).

* Corresponding author. 404 Wilson Rd., Room 418, Communication Arts and Sciences Building Michigan State University, East Lansing, MI, 48824, USA.
** Corresponding author.
E-mail addresses: rar@msu.edu (R. Ratan), earlekel@msu.edu (K. Earle), sonnyrosenthal@ntu.edu (S. Rosenthal), ChenHH@ntu.edu.sg (V.H. Hua Chen), andrew.gambino@gmail.com (A. Gambino), gerard.goggin@ntu.edu.sg (G. Goggin), HStevens@ntu.edu.sg (H. Stevens), benjyli@ntu.edu.sg (B. Li), kwanminlee@ntu.edu.sg (K.M. Lee).

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1.1. E-scooters: mobile access to micromobility

E-scooters fall within a class of micromobility technologies, along with rentable bikes and other light-weight vehicles, that are transforming transportation practices around the world (Sunio et al., 2020; Tuncer and Brown, 2020). Usually, e-scooters are two-wheel devices used for short-distance ("last-mile") transportation that draw power from batteries which are recharged either by the user or e-scooter company (Hardt and Bogenberger, 2019). Use of e-scooters has grown exponentially in recent years (Bureau of Transportation Statistics, 2019) and there are a variety of brands that provide short-term rentals of their e-scooters, including Uber (https://www.uber.com/us/en/ride/scooters), Lime (https://www.li.me/electric-scooter), Bird (https://www.bird.co), and Gotcha (https://ridegotcha.com).

In most instances, the use of short-term-rental e-scooters for transportation requires the use of a mobile application provided by the e-scooter company (Tuncer and Brown, 2020). Such mobile applications function as the central hub for operating the scooter, allowing users to view scooter availability (e.g., location, battery status) on a local map, verify the user's eligibility for rental (e.g., by scanning a driver's license), store and use payment mechanisms (e.g., credit card), unlock a scooter (often by using the mobile-device camera to scan a QR code on the scooter), track current rental statistics (e.g., duration, charges), and end a rental and dock the scooter (e.g., by taking a picture of it in a safe location). In short, the e-scooter mobile app is a critical element of using this transportation technology.

The integration of media technologies is increasingly apparent across many transportation technologies, from large touchscreens in advanced automobiles (e.g., Teslas; Parkhurst et al., 2019) to mobile applications for automotive ride-sharing services (Siuhi and Mwakalonge, 2016). These media technologies are not a core physical element of the transportation technology, but they contribute significantly to the user's perception of the entire transportation experience. In other words, perceptions of the media technology are interconnected with perceptions of the transportation technology. One study found that perceptions of a virtual voice assistant offered in an autonomous driving context influenced intent to adopt autonomous vehicles (Lee et al., 2019). The voice assistant is clearly not the vehicle itself, but because this media technology represents the transportation technology, perceptions of the two are intrinsically linked. Similarly, in the context of e-scooters, the mobile application serves as a gateway to the transportation technology and thus perceptions of the mobile application should influence perceptions of the e-scooter itself.

1.2. Mobile applications and E-Scooter use intent

In addition to mobile applications, there are many other factors that likely contribute to the perceptions of e-scooters and thereby influence use intent. There is a long tradition of research on the factors that explain technology adoption, building on psychological models such as the theory of reasoned action (TRA) and theory of planned behavior (TPB) (Madden et al., 1992), leading to numerous models of technology acceptance (Rondan-Cataluña et al., 2015). Here, we focus on one of the most widely used approaches that builds? on TRA and TPB, the technology acceptance model (TAM; Davis, 1989).

This research focuses on the core TAM factors proposed as predictors of use intent, namely, perceived ease of use and perceived usefulness, which have been found to predict intent to use technologies with medium effect sizes across multiple meta-analyses (Hauk et al., 2018; Ma and Liu, 2004; Schepers and Wetzels, 2007; Yousafzai et al., 2007). Perceived ease of use is conceptualized as the perceived benefits and effort required in using the device, while perceived usefulness is conceptualized as the belief that the technology will help perform an action better (Davis, 1989). The TAM model prescribes that perceived ease of use and perceived usefulness both directly predict intent to use, and also that perceived ease of use predicts usefulness and thereby indirectly influences use intent as well. Our aim is not to add to the multiple extensions of TAM (e.g., Venkatesh et al., 2003, 2012), but instead to examine how these fundamental attitudes about a given technology (e.g., e-scooters) relate to attitudes about an integrated secondary technology (e.g., e-scooter mobile apps). This approach successfully led to valuable insights in previous studies, such as highlighting the influence of self-efficacy regarding mobile healthcare systems on use intent, as mediated by TAM variables (Wu et al., 2007).

Several studies have utilized TPB and TAM to examine individuals' intentions to use micromobility technologies. One such study examined the influence of perceived usefulness and perceived ease of use on intent to use ride sharing services. They found that perceived usefulness but not perceived ease of use was related to behavioral intent to use ride sharing services (Wang et al., 2020). Another study found that mobile app assessments can influence the purchasing intention and purchasing behavior of ride sharing services (Lo et al., 2020). The aforementioned studies discussed ride sharing services broadly (e.g., bikes, scooters for package delivery, carpooling, residence exchanging, etc.). However, e-scooters are one specific kind of ride sharing micromobility and are of interest to the present research. A study of Taiwanese individuals found that many of the TPB variables such as attitude, perceived behavioral control, and subjective norms all significantly predicted use intentions of e-scooters (Eccarius and Lu, 2020). Taken together, TPB and TAM have been used to examine the sharing economy, particularly micromobility technologies. However, no research of which we are aware has put all of these pieces together and focused on the role of mobile apps on use intentions for e-scooters.

Given the prior reasoning that media technologies integrated into transportation technologies likely influence the perception of the transportation technology itself, we expect that perceptions of e-scooter mobile applications will influence e-scooter use intent, even when taking into account essential e-scooter-specific perceptions which are very likely to influence use intent, such as e-scooter ease of use and usefulness. Hence, we posit the following:

Hypothesis 1. E-scooter use intent is positively predicted by perception of e-scooter mobile application ease of use, even when controlling for essential perceptions of e-scooters, such as e-scooter ease of use and e-scooter usefulness.

The technology acceptance model (TAM; Davis, 1989) does not predict that perceived usefulness and perceived ease of use independently influence technology use intent, but instead that perceived ease of use contributes to perceived usefulness and both influence use intent (Venkatesh and Davis, 2000). In other words, perceived usefulness mediates the influence of perceived ease of use on use intent. Other research on micromobility from multiple disciplines has examined the importance of mobile applications in this process. A recent study regarding the sharing economy found that app assessments drive purchasing intention and behaviors. Further, app assessment mediated the relationship from attitudes and beliefs to intention and behaviors (Lo et al., 2020).

In the present research, we examine whether the effect of perceptions of e-scooter mobile applications on e-scooter use intent follows similar mediation. Specifically, we focus on ease of use of e-scooter mobile applications, which, like usability, is a fundamental characteristic of user perceptions across media technologies (Coursaris and Kim, 2011; Norman, 2013). Applying the TAM model to ease-of-use perceptions of this related technology, the expected relationship between mobile application perceptions (i.e., app ease-of-use) and e-scooter use intent (i.e., Hypothesis 1) may be mediated by the perceived usefulness of the e-scooter. Hence, we hypothesize the following:

Hypothesis 2. E-scooter use intent is positively predicted by perceptions of e-scooter mobile applications, and this relationship is mediated by e-scooter usefulness.

In addition to focusing on perceptions of the mobile application, we are interested in e-scooters themselves. While e-scooters are not

communication technologies in a traditional sense, they are transportation technologies embedded in larger systems of communication that pervade modern society (e.g., mapping software, mobility accessibility, etc.). Just as automobiles are a noteworthy technology of inquiry from a communication perspective, especially given their increasing connectedness with media (Von Pape et al., 2019), so too are e-scooters. Hence, this research also examines additional factors that likely relate to e-scooter use, including technology-specific perceptions (i.e., safety, environmental implications, enjoyment), context of use (i.e., geographic landscape), and demographics (i.e., age, gender). Many of these factors have been previously studied within the micromobility context. Therefore, the following variables were included in the present research as important covariates that determine e-scooter use intent.

1.3. Covariates

1.3.1. Safety

Safety matters when using micromobility technology, including e-scooters. Indeed, e-scooters have been identified as a public health problem (Choron and Sakran, 2019). E-scooter injuries rose 222% between 2014 and 2018, coinciding with the time frame in which e-scooter rentals were introduced (Basky, 2020). Injuries have also been reported due to reckless driving or discarded e-scooters (Blomberg et al., 2019). Injuries to one's self or others are a potential hazard when using e-scooters.

Indeed, perceptions of these safety issues may encourage or discourage micromobility use. In terms of technology acceptance, safety may play various roles in intent to use and adoption of new technologies. Micromobility safety is often in regard to the *physical safety* of one's own or a pedestrian's body while using the mode of transportation or the *perceived risk* of using the particular mode of transportation (Wang et al., 2020). Much of the research on the perceived safety of new transportation technologies has been conducted in terms of autonomous vehicles (Madigan et al., 2017) or ride sharing services such as bicycles (Rosenthal et al., 2020; Wang et al., 2020) and have found that perceived safety influences use intent. As mentioned previously, e-scooters have a contentious history regarding the locations in which to ride or store rentable e-scooters (CDC, 2019; Holley, 2019; Sikka et al., 2019). If not properly ridden or stored, there is a greater risk of injury to the rider or pedestrians. Together, the previous evidence suggests that perceived safety of the e-scooter positively influences e-scooter use intent and thus is used as covariate in the analysis.

1.3.2. Environmental impact

Electric travel has been featured as a potentially environmentally friendly alternative to other energy sources such as fuel. In fact, researchers have found that when replacing other automobile travel, e-scooters may have a net reduction in environmental impacts (CO_2 emissions), especially if used in ways that maximize the e-scooter's lifespan beyond two years (Hollingsworth et al., 2019). Rather than taking a personal car, bus, or rideshare (e.g., Uber, Lyft or taxi), individuals have the option to rent an e-scooter to get to their destination (Glenn et al., 2020). This is particularly helpful for short distances that would be difficult to walk, but would be environmentally costly to drive (i.e., last mile transportation). For people who are environmentally conscious, an e-scooter ride could be a desirable transportation option.

Individuals may have more internal motivations for using e-scooters as environmentally friendly alternatives to transportation. Research has found that many people perceive e-scooters as having positive health benefits due to the reduction in air pollution (Glenn et al., 2020). In terms of technology acceptance, perceptions of environmental impact have been shown to strongly predict of intent to use transportation such as autonomous vehicles (Kwee-Meier et al., 2016). Previous analyses of e-scooters have speculated that advances in technology, economic changes, and social and environmental concerns are all factors that could lead to e-scooter use (Mathew et al., 2019). Additionally, "No matter how pronounced a respondent's environmental values are, they only lead to a positive intention to use [e-scooters] if its use is perceived as compatible with one's lifestyle or transportation needs and as being within the control of the respondent, or easy enough to perform" (Eccarius and Lu, 2020, p. 102327). As such, these studies suggest that perceptions of e-scooters as environmentally friendly positively influences e-scooter use intent and thus is used as covariate in the analysis.

1.3.3. Fun/enjoyment

Simply put, e-scooters are fun. In fact, studies have reported that a large portion of e-scooter riders use the scooters just for their own enjoyment (Glenn et al., 2020). While there are practical uses for the e-scooters (e.g., commuting), riding these devices also provides an enjoyable recreational activity.

Enjoyment is particularly important when adopting new technology (Song and Han, 2009). Perceived enjoyment has been shown to be influential in the technology adoption process in terms of internet adoption (T. Zhou, 2011), social media (Wirtz and Göttel, 2016), and mobile learning (Chao, 2019). Naturally, technology that is fun or enjoyable is more likely to be adopted or used (Viswanath et al., 2000). E-scooter adoption is no exception and thus was considered a covariate in the present study.

1.3.4. Geographic landscape

Geographic location likely influences e-scooter use intent given the influence of many geographic factors (e.g., density, infrastructure) on community members' lifestyle habits. Many of the first e-scooter rentals were available in larger cities such as Los Angeles and New York and this is not surprising considering the transportation needs of urban individuals. In a large city, owning a car comes with many costs such as parking, fuel, and maintenance which makes the cost-effective bike or e-scooter sharing services attractive to users (Aartsma, 2020; Aguiler-a-García et al., 2020; Tyrinopoulos and Antoniou, 2020). In fact, people in large cities often use personal transportation devices such as bikes or scooters as travel alternatives, particularly when traveling alone (J. Zhou, 2012). Lastly, larger cities have more infrastructural ability to accommodate micromobility options including the accessibility of charging stations (Y.-W. Chen et al., 2018; Nikiforiadis et al., 2019). On the other hand, in rural areas, people rely more on their personal vehicles. Commutes to work and school are longer, populations are smaller, access to adequate public transportation options are limited, and rideshare is less frequently used in rural areas (Henning-Smith et al., 2017; Jiang, 2019).

One interesting case to consider is the medium size "college town." Many large agricultural and land-grant universities are in rural or suburban areas that function like medium-size cities. Thousands of students live on or near a college or university campus and have varying transportation needs. Students without driver's licenses or personal vehicles may depend on public transportation, micromobility, or walking to meet their needs. In addition, international students face unique challenges related to transportation as they integrate into the campus community, particularly in less urban areas (Poyrazli and Grahame, 2007). A study focused on the student population in Taiwan compared students with different levels of use intention (Eccarius and Lu, 2020, p. 102327). They found that lack of perceived compatibility with personal values, mobility needs, and lifestyle drove students' use intention, particularly for those with low use intention and for those in the precontemplation stage. Knowledge of the sharing system and environmental values drove perception of use intention in indirect ways.

As a means of promoting external validity across geographic locations, the present research considers attitudes about e-scooters in both urban and college-town communities. As described above, geographic location likely influences e-scooter use intent, so in order to focus the present analysis on the central theoretical questions, geographic location is simply included as a covariate in the analysis.

1.3.5. Age

Just as demographic factors such as age have been shown to influence technology adoption in general (Hauk et al., 2018), there are several factors relating to age that might encourage or discourage individuals to ride an e-scooter. For one, older adults are less likely to use public transportation than younger adults, perhaps due to mobility challenges faced by older adults and the lack of accommodation by these transportation systems (Zwald et al., 2014). For micromobility options such as bikes and e-scooters, older adults may not have the balance required to operate the devices safely, especially given that proprioceptive control deteriorates with age (Faraldo-García et al., 2012; Riva et al., 2013). For another, the use of communication technology differs between older and younger adults, with the former group being less likely to have smartphones (Pew Research Center, 2018). As mentioned previously, the mobile phone application is required when renting an e-scooter. Age may also influence e-scooter use intention when considered alongside other factors such as geographic location. Younger adults are less likely to own their own personal vehicle, which means they are more likely to use micromobility (Nikiforiadis et al., 2019). Together, previous research suggests a negative effect of age on e-scooter use intent — given differences in balance, mobile phone use, and transportation accessibility — and thus age is included as a covariate in the present analysis.

1.3.6. Sex

Just as biological sex predicts differences in technology adoption (Padilla-Meléndez et al., 2013; Viswanath et al., 2000), it might also influence e-scooter use intent. Men report greater e-scooter use intent than women for a variety of reasons (Aguilera-García et al., 2020; Eccarius and Lu, 2020). Women tend to be more focused than men on the potential risks of micromobility use. One study showed that women were more likely than men to report safety-related concerns about e-scooter use (Sanders et al., 2020). Men on the other hand report engaging in more risky behaviors with personal transportation devices, such as leaving their bicycles unlocked while unattended and thus risking the costs of getting their bikes stolen or damaged (Cobey et al., 2013). Given the many factors related to biological sex that likely relate to e-scooter use intent, biological sex is included as a covariate in the present analyses.

2. Method

The present dataset is derived from a survey ($N = 398$) focused on attitudes about e-scooters. The survey was distributed to two different U.S. populations. The first population ("urban") included residents of New York, Los Angeles, and Chicago ($n = 176$; 77 male, 99 female; Age $M = 46.90$, SD = 14.91). The second population ("campus") included students at a Midwestern University ($n = 222$; 80 male, 141 female, and one who declined to report their sex; Age $M = 20.31$, $SD = 1.90$). The urban sample was recruited through the market research company Dynata, which provides samples with low sampling bias, fair compensation to participants, and high quality data (Ahler et al., 2019; Middleton et al., 2020; Milne et al., 2019). The campus sample was recruited through a student research participation pool (SONA) and students were given course credit upon completion.

2.1. Primary measures

Unless otherwise specified, all measures were constructed from means of responses on five-point Likert scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with reliability of these metrics indicated by Cronbach's alpha scores. Descriptive statistics for all measures appear in Table 1.

2.1.1. E-Scooter Use intent ($\alpha = 0.96$), the outcome variable of interest, was measured with four items, including, "I intend to use e-scooters in the future," "I will try to use e-scooters in the future," "I expect that I would use them in the future," and "I plan to use e-scooters in the future."

Table 1
Descriptive statistics for all measures.

	Campus Sample		Urban Sample		Full Sample	
	M	SD	M	SD	M	SD
Intent to Use	2.79	1.08	2.43	1.30	2.63	1.19
Mobile App Ease of Use	2.33	0.74	3.40	1.48	2.81	1.25
Scooter Ease of Use	3.36	0.86	2.86	1.18	3.14	1.04
Scooter Usefulness	3.08	0.95	2.51	1.23	2.83	1.12
Safety	2.97	0.72	2.95	0.80	2.96	0.76
Environmentalism	3.59	0.89	3.38	1.17	3.49	1.03
Enjoyment	3.61	1.05	2.97	1.19	3.33	1.16

2.1.2. (E-Scooter) Mobile Application Ease of Use ($\alpha = 0.90$) was measured with a single question asking respondents, "If you have seen or used the mobile app for any of these e-scooter companies, to what extent would you say that it is easy to use?" Respondents answered that question for multiple different e-scooter platforms (Gotcha, Lime, Scoot, Bird, Spin, Skip, or "other"). We took this approach because we could not be sure which e-scooter companies' respondents had used. Response options included: 1 = Don't remember/Didn't use; 2 = Very difficult; 3 = Slightly Difficult; 4 = Neither easy nor difficult; 5 = Slightly Easy; 6 = Very Easy. Only respondents who gave a response for at least one scooter company were included in the analysis (n = 152). The mean score for mobile app ease of use across platforms was used as the metric.

2.1.3. E-Scooter Ease of Use ($\alpha = 0.90$) was examined with five questions asking respondents to indicate to what extent they agree that e-scooters are "easy to use," "easy to operate," "intuitive," and "do not require a lot of mental effort," and to what extent "it would be easy to get e-scooters to do what you want." Items were adapted from several previous TAM scales (Davis, 1989; Venkatesh & Davis, 2000).

2.1.4. E-Scooter Perceived Usefulness ($\alpha = 0.90$) was measured using four questions asking respondents to indicate to what extent do they agree that e-scooters are "useful," "enhance your effectiveness," "enhance your productivity, and "would improve your performance." These items were also adapted from previous studies of TAM (Davis, 1989; Venkatesh & Davis, 2000).

2.2. Covariate measures

As described previously, these demographic and individual characteristic variables have been shown to influence use of these micromobility devices and thus are included here as covariates.

2.2.1. E-Scooter Environmental Friendliness ($\alpha = 0.91$) was measured using three items from (Y.-S. Chen et al., 2015) asking respondents to indicate to what extent they agree that e-scooters "are environmentally friendly," "can help reduce environmental impact," and "are more environmentally friendly compared to other transportation options."

2.2.2. E-Scooter Enjoyment ($\alpha = 0.96$) was examined using a scale adapted from (Davis et al., 1992; Yi and Hwang, 2003), which asked respondents to indicate to what extent they agree that e-scooters are "enjoyable," "fun, and "pleasant to use."

2.2.3. E-Scooter Safety ($\alpha = 0.89$) was measured with questions about the perceived safety of e-scooters for both oneself and for others, which asked respondents to indicate to what extent they agree that e-scooters are "safe," "secure," "risky," and "dangerous" to the people around them (latter two items reverse-coded). They also indicated to what extent they agree that if they were operating an e-scooter, they would feel like they were "safe," "secure," "at risk" and "in danger" (latter two reverse-coded).

2.2.4. Age, Sex, and Geographic Location were demographic variables utilized in this study. Participants were asked to report their age and their biological sex (the sex assigned at birth). Location was assessed based on whether participants came from the urban representative sample or the university-student sample as explained in the methods section.

3. Results

3.1. Use intent with TAM variables

We first ran a multiple regression test in SPSS v.27 with e-scooter use intent as the dependent variable, and e-scooter mobile app ease of use, e-scooter ease of use, and e-scooter usefulness as the predictor variables. Results (Table 2) suggest that e-scooter mobile app ease of use significantly predicts e-scooter use intent along with e-scooter ease of use and e-scooter usefulness, providing support for Hypothesis 1 (with the caveat that the subsequent analysis offers a test of H1 with additional covariates).

3.2. Mobile app ease of use as mediator

We next tested for mediation effects using Model 4 of the PROCESS macro for SPSS (Hayes, 2017) with 10,000 bootstrap samples. The model included e-scooter use intent as the dependent variable, e-scooter mobile app ease of use as the predictor, e-scooter usefulness as the mediator, and e-scooter ease of use as a covariate. Results (Fig. 1) suggest that the effect of mobile application ease of use on e-scooter use intent was mediated by e-scooter perceived usefulness, as indicated by a significant indirect effect ($\beta = 0.073$, 95% CI [0.032, 0.121]), even while controlling for the well-established covariate, e-scooter ease of use. The direct effect of mobile application ease of use on e-scooter use intent was also significant ($\beta = 0.139$, 95% CI [0.043, 0.234]). These results support Hypothesis 2.

3.3. Use intent with all predictors

Finally, in order to account for all the covariates identified in previous research we ran another multiple regression test in which e-scooter use intent as the dependent variable, and e-scooter mobile app ease of use, e-scooter ease of use, e-scooter usefulness, e-scooter perceived safety, e-scooter environmental friendliness, e-scooter enjoyment, geographic landscape, and respondent age and sex as the predictor variables. Parameter estimates (Table 3) suggest that e-scooter use intent was significantly predicted by all variables included in the model except e-scooter ease of use, providing additional support for Hypothesis 1.

4. Discussion

The integration of media technologies is apparent across many transportation technologies. The present research highlights the importance of considering such technology from a communication scholarship perspective. Results suggest perceived ease of use of e-scooter mobile apps is associated with e-scooter use intent and this effect is mediated by perceived usefulness of the e-scooter itself, even when controlling for perceived ease of use of the e-scooter as well as other influential elements of e-scooter use. In addition to illustrating the importance of user experiences with mobile apps in the e-scooter context, this research suggests that communication technology is an integral factor in the adoption and use of transportation technologies like e-scooters.

The first hypothesis examined the relationship between e-scooter mobile app ease of use, e-scooter ease of use, and e-scooter perceived usefulness on intent to use e-scooters. All three of these predictor variables significantly predicted use intent, supporting the importance of TAM variables in use behaviors (H1). However, these variables do not influence use intent in isolation. Consistent with previous TAM research, the effect of perceived ease of use on intent was mediated by perceived usefulness. However, notably, it was *mobile app* ease of use that indirectly influenced intent through perceived usefulness of the e-scooter (H2). Together, these findings support the claim that perceptions of e-scooter mobile apps (i.e., a communication technology) are an important component of perceptions of e-scooters (i.e., a transportation technology) as a whole.

We also anticipated that perceived safety, environmental friendliness, enjoyment, geographic landscape, age, and sex would function as covariates in our model (see Table 3). Perceived safety, enjoyment, age, and location were all significantly related to intent, while environmentalism was marginally significant ($p = .08$). Similar to previous studies (Glenn et al., 2020; Song and Han, 2009), enjoyment was the strongest predictor of intent to use the e-scooters ($\eta_p^2 = 0.10$). Perceived safety and age also significantly predicted intent in the expected direction. Younger individuals had stronger intent to use the e-scooters than older adults, and people who perceived the e-scooters as safe have stronger intent to use them. Lastly, individuals in larger urban cities showed more intent to use the e-scooters than individuals in a smaller less urban setting, as expected. Finally, the non-significant relationship between sex and intent was somewhat surprising, but makes sense given that the sample for this test only included respondents who had previously used an e-scooter (and thus had provided data on the mobile app ease of use measure). A post-hoc test with mobile app ease of use removed from the regression (thereby increasing the sample size to include non-users) found that men did indeed report greater use intent, $F(1, 394) = 5.63$, $p < .05$, $\eta_p^2 = 0.01$, but with a very weak effect size.

In the larger model, e-scooter ease of use was no longer a significant predictor of e-scooter use intent, but mobile application ease of use was significant. In other words, e-scooter mobile app ease of use seems to contribute more to e-scooter use intent than the ease of use of the e-scooter itself. This reflects the importance of media in the relationship between the user perceptions and intent to use micromobility such as e-scooters. Additionally, the effect sizes of other predictors, such as enjoyment, geographic landscape, perceptions of safety, and age were just slightly higher ($\eta_p^2 = 0.10$, 0.05, 0.04, and 0.04 respectively) than that of mobile app ease of use ($\eta_p^2 = 0.03$), further supporting the importance of media in micromobility perceptions.

Table 2
Multiple regression predicting e-scooter use intent.

	df	*F*	*B*	*β*		*p*	ηp^2
App Ease of Use	1	4.99	0.12	0.14	*	0.027	0.03
Scooter Ease of Use	1	4.60	0.22	0.20	*	0.034	0.03
Scooter Usefulness	1	16.38	0.39	0.40	***	0.000	0.10
Total	151						

*p < .05, **p < .01, ***p < .001, adj. $R^2 = 0.36$.

4.1. Implications

Taken together, these results imply that younger people seeing e-scooters as fun, safe, easy to use, and useful while living in a city does not tell the entire e-scooter adoption story. The perception of the e-scooter mobile application also plays an important role. Thus, these findings are interesting for the future of micromobility, but they are also important in terms of interactions with media. Renting an e-scooter presents a novel case in which a mobile app is required to operate the device. This paves the way for future researchers from a variety of disciplines including fields of transportation, advertising, and human-computer interaction to improve the usability of micromobility technologies. Future research may also explore particular affordances of the application that make using the e-scooter more appealing. As seen here, the media we use can influence our use of micromobility.

The present research also contributes to a broader understanding of the integration of media within transportation contexts. Transportation technologies are an increasingly noteworthy topic for communication and human-computer interaction research (e.g., Nikiforiadis et al., 2019; Lo et al., 2020). The increasing connectedness between media and transportation technologies in recent years is not only limited to automobiles (Goggin, 2012; Von Pape et al., 2019), but extends across all transportation contexts. The present research supports the claim that such media technologies — including mobile applications — are an important aspect of using transportation technologies, from e-scooters to

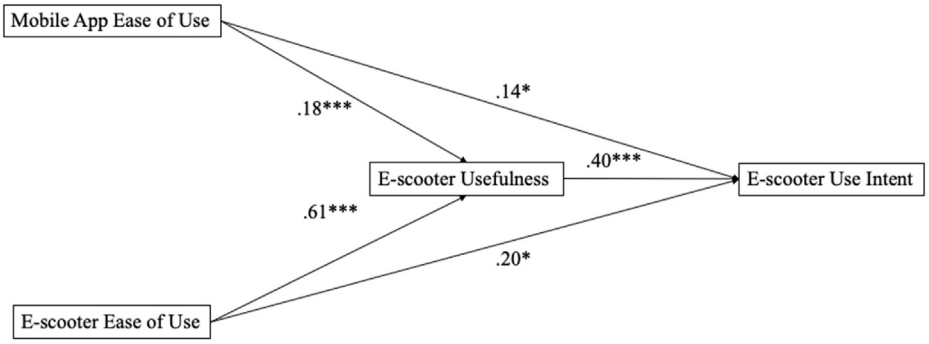

Fig. 1. Test of mobile app ease of use indirect effect on e-scooter use intent ($\beta = 0.069$, 95% CI [0.02, 0.12]) controlling for e-scooter ease of use. Note: ***$p < .001$, *$p < .05$.

Table 3
Multiple regression predicting e-scooter use intent with covariates.

	df	*F*	*B*	*β*		*p*	ηp^2
App Ease of Use	1	3.96	0.11	0.14	*	0.049	0.03
Scooter Ease of Use	1	0.48	−0.08	−0.07		0.490	0.00
Scooter Usefulness	1	4.38	0.20	0.20	*	0.038	0.03
Safety	1	6.17	0.24	0.17	*	0.014	0.04
Environmentalism	1	3.08	0.16	0.14	0.08	0.081	0.02
Enjoyment	1	16.01	0.38	0.36	***	0.000	0.10
Age	1	5.24	−0.02	−0.21	*	0.024	0.04
Location	1	7.00	−0.50	−0.26	**	0.009	0.05
Sex	1	0.57	0.09	0.05		0.451	0.00
Total	150						

*p < .05, **p < .01, ***p < .001, adj. $R^2 = 0.48$.

autonomous vehicles to public transportation. Media are integrated into all these technologies, be it on screens, in speakers, or even in haptic interfaces (e.g., steering wheel). A person's interaction with such technology is twofold: with the media application and with the transportation technology itself. Often, the media application provides a gateway or complement to using the transportation technologies. Hence, unlike other research that focuses on a direct outcome of a single technology, this research highlights the importance of considering the media and transportation technologies together.

As such, this study provides an example of the benefits of interdisciplinary research related to transportation and media technologies. A focus on transportation only (e.g., e-scooter design and distribution) might miss the importance of the related media technologies (e.g., e-scooter mobile applications). Similarly, scholars coming from a media-focused background (e.g., on mobile communication) may inadvertently neglect to address media technologies that are embedded in transportation processes (e.g., e-scooter applications) because they are otherwise focused on more visible media categories (e.g., social media and games). By considering both media and transportation-related factors, the present interdisciplinary project speaks across multiple communities of scholars and provides a multifaceted contribution of knowledge.

There are many facets of mobile applications related to micromobility to be explored in future research. For example, other sharing economy transportation options such as bicycles would be an interesting comparison with e-scooters. Some of the barriers to using an e-scooter (e.g., balance, safety, and accessibility issues) may not be present when using a bicycle. Additionally, bikes may have their own lane in which to ride while e-scooters have had a contentious history regarding where they are allowed to be ridden (Holley, 2019) particularly in regard to safety (Sikka et al., 2019). A comparison study between these two ride-sharing options would be an interesting avenue for future research, particularly considering the important role of app ease of use and perceptions of safety.

Additionally, researchers may consider how the sharing economy has expanded and the effect this has on mobile applications and perceived ease of use. For example, Uber has expanded their business models from rideshare services into markets such as e-scooters and food delivery (Bean et al., 2020). Such services can be conducted through the same mobile application, which likely impacts adoption along with factors more directly related to the service provided (e.g., food quality). This company is only one of the many diversifying their business ventures, while maintaining a single brand. As such, the flow of goods and services from mobile applications to micromobility provides a fruitful research context, particularly as e-services are becoming more prevalent.

4.2. Limitations

As with all survey research, this study has certain limitations, such as the inability to infer causality. While the results point to particularly interesting findings regarding mobile and micromobility use, the specific causal mechanisms promoting these use behaviors are currently unclear. At face value, attitudes about e-scooter mobile applications would seem to precede adoption of the e-scooters, given that the former must be used before the latter, but it is possible that experiences with the e-scooter might influence attitudes about the mobile application or that a third variable influences both. Future empirical research should seek to elucidate this process, possibly by using experimental research.

There may also be demographic concerns related to the samples. Although the urban sample was representative, the campus sample was based on a sampling pool within a specific college (of Communication). Perhaps students from other majors (engineering, computer science, history) have different attitudes. As can be seen in the demographic profile, students polled at this university were predominantly female and only biological sex was examined. Considerations regarding variances in samples should be considered in future research regarding micromobility media.

This study utilizes approaches from the technology acceptance model and draws upon the original research (e.g., Davis, 1989; Venkatesh and Davis, 2000). Many new and complex variations of TAM have been utilized in research with varying results (Venkatesh et al., 2003; Venkatesh

and Davis, 2000). That being said, it was not possible to include all of the variables of interest as outlined by these models and so important variables may have been missed. As such, researchers should explore other potential avenues of technology adoption or use that were not addressed here.

Relatedly, e-scooter mobile app ease of use was measured, but not usefulness. At the original conception of the study, mobile app ease of use was considered to vary significantly between e-scooter companies because the user interfaces are developed by entirely separate teams. In contrast, mobile app usefulness was assumed to be largely similar across companies because they all essentially provide the same base functionality (i.e., unlocking the scooter). However, this assumption should have been validated empirically and thus this omission represents a limitation that future research could address.

Further, the present approach to the e-scooter mobile app ease of use variable was limited because responses were averaged across multiple companies, despite the likelihood that their mobile apps differ significantly, and frequency of use was not taken into account. The original intent was to create a generalized metric across e-scooter companies because asking all the questions for all companies that participants had used did not seem feasible. Future research could remedy this issue by asking respondents to think about either the e-scooter mobile app they have used most recently or most frequently. In such a case, all measures related to the e-scooter should be focused on that one specific provider.

5. Conclusion

This study offers one of the first examinations of micromobility technology from a communication perspective supported by interdisciplinary research, focusing on the important facets of the technology related to the media portal to the technology, individual factors, and technological characteristics. In addition to illustrating the importance of user experiences with mobile apps within the e-scooter context, this research furthers a fundamental argument that media technologies influence our perception and thus adoption of transportation technologies. The present findings are interesting for the future of micromobility from a vast array of disciplines — including transportation, communication, advertising, and human-computer interaction — paving the way for such research to scoot toward a central lane in these fields of study.

Author contributions

Rabindra Ratan: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Supervision; Roles/Writing - original draft; Writing - review & editing.

Kelsey Earle: Data curation; Formal analysis; Investigation; Methodology; Project administration; Roles/Writing - original draft; Writing - review & editing.

Sonny Rosenthal: Conceptualization; Investigation; Methodology; Writing - review & editing.

Vivian Hsueh Hua Chen: Conceptualization; Investigation; Methodology; Writing - review & editing.

Andrew Gambino: Conceptualization; Investigation; Methodology; Writing - review & editing.

Gerard Goggin: Conceptualization; Investigation; Methodology.

Hallam Stevens: Conceptualization; Investigation; Methodology.

Benjamin Li: Conceptualization; Investigation; Methodology.

Kwan Min Lee: Conceptualization; Investigation; Methodology.

Declaration of competing interest

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