[PREPRINT] Exploring the Roles of Conformity, Hazard, and
Convenience in Risk Mitigation Decisions: An Observational
Study of Helmet Use Among Bicyclists and E-Scooter Riders
in Los Angeles During Two Natural Experiments

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Abstract

Despite the protection offered by bicycle helmets, their use varies substantially across populations of riders. Building on previous efforts to understand helmet use as reflecting tradeoffs between convenience and safety, we explore whether helmet use is influenced by conformity, that is, by a preference to make the same helmet use decision as other riders. If so, an experiment introducing more riders with or without helmets in a specific location might shift helmet use patterns among other nearby riders. We conducted an observational study of helmet use over eight months at five locations across two university campuses in Los Angeles, California, U.S.A. During this time, a bikeshare program and electronic scooter rental services were introduced in the local area. The low use of helmets among riders of these vehicles allow us to treat these as natural experiments testing the conformity hypothesis. Corresponding to the sudden appearance of numerous helmetless e-scooter riders, helmet use declined among riders of ordinary bicycles at the more hazardous study locations, a pattern we cautiously interpret as consistent with a conformity preference among ordinary cyclists traveling long distances along city streets among helmetless e-scooter riders. At the safer locations, helmet use rates increased among ordinary cyclists, which we suggest was driven by vehicle selection decisions, with the most convenience-oriented riders preferring to use e-scooters, leaving a more safety-oriented population of ordinary cyclists. The possibility that social conformity may influence risk mitigation decisions has important implications for designing and measuring the impact of public health interventions. Also of note are empirical demonstrations that helmet use patterns can vary substantially across seemingly similar populations and over short periods of time.

Keywords: Helmets, E-scooters, Bicycles, Risk-Taking, Risk Mitigation, Conformity

Introduction

Wearing a bicycle helmet reduces the likelihood of serious injury or death [1,2]. Where not legally mandated, helmet use varies dramatically across populations [3–5]. Understanding the psychological factors that contribute to such variation can help inform and evaluate public policy and health interventions regarding helmet use. More generally, wearing a helmet is an example of a risk mitigation strategy; understanding variation in risk mitigation decisions across individuals and contexts may have broad translational utility.

A functional cost-benefit analysis of helmet use decisions

The benefits of helmet use—reduced bodily injury in the case of a severe accident—come at some costs to the wearer. Helmets have a purchase price, requiring financial resources. They must be carried around or stored when not in use, entailing opportunity costs or access to secure storage. Even the best helmets can be uncomfortable in hot weather, and, hot or cold, helmets leave coiffed hair in disarray.

Phrased in the language of decision science, the choice not to wear a helmet can be said to be riskier than the choice to wear a helmet, because the former option involves more extreme outcome variance [6]. For the rider without a helmet, the difference between the best-case outcome (arriving safely at the destination without inconvenience) and the worst-case outcome (serious, even fatal head trauma in the event of an accident) is much greater than is true for the rider with a helmet, for whom there is less difference between the best-case outcome (arriving safely, albeit with the costs of minor inconvenience) and the worst-case outcome (a serious accident, albeit with the benefit of considerable protection from injury). Helmet use mitigates outcome variance, raising costs of good outcomes and

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33 lowering costs of bad outcomes. Risky

34 The various types of costs and benefits underlying specific risk mitigation decisions
35 can be valued differently as a function of individual ability and/or situational factors, leading
36 to different behavior [7,8]. Helmet use is less costly for a bald professor who can leave his
37 helmet in his office during the day, compared to his cash-strapped student who has to carry
38 her helmet – which ruins her carefully styled hair – from class to class. (Any similarity to
39 any authors is purely coincidental). Benefits of helmet use can vary as a function of personal
40 traits and/or situational circumstances that make the user more or less likely to suffer an
41 accident. For example, helmet use is more beneficial for an inexperienced cyclist or one
42 traveling a long distance in close proximity to cars, compared to an experienced cyclist or
43 one traveling a short distance on a dedicated bike path.

44 Aligning with this functional analysis, prior studies suggest that decisions regarding
45 helmet use often weigh safety (i.e., concern for the benefits of risk mitigation) against
46 convenience (i.e., concern for the costs of helmet use) [9–11]. Other types of costs and
47 benefits are possible, especially in the social realm. Where legally mandated, helmet use has
48 the social benefit of avoiding sanction. In some places, users of helmets might suffer costs of
49 being derided as cowardly or out of fashion. Wearing a specific kind of helmet might signal
50 group membership, with attending costs and benefits, etc.

51 **Conformity preference as a psychological mechanism underlying helmet use** 52 **decisions**

53 Complementing this functional analysis, we can consider how psychological mechanisms
54 might evaluate and execute decisions reflecting these and other functional considerations.

55 Towards assessing the benefits of helmet use, cyclists can draw on any personal history
56 of direct encounters with their current bicycling environment and its potential hazards or
57 social factors. Thus, helmet use decisions likely involve spacial navigation and memory
58 processes and their interaction with emotional states related to acute somatic or social threat
59 (e.g., the fear and pain from an accident; embarrassment from being mocked for helmet use).
60 Mechanisms involved in coping with resource constraints might influence one’s willingness to
61 bear the financial or time costs of risk mitigation. For example experiencing chronic hunger
62 might reduce willingness to pay resource costs of risk mitigation [12], or being in a hurry to
63 make a social appointment might reduce willingness to pay the time costs of risk mitigation.

64 Beyond those methods of using direct experience to inform risk mitigation decisions,
65 indirect information about the costs and benefits of helmet use is often available, implicit
66 in the helmet use decisions of other riders. One possible mechanism for exploiting such
67 information is a tendency towards *conformity* in helmet use decisions, that is, a preference
68 to make similar helmet use decisions as other riders. A conformity preference mechanism
69 would serve the function of using crowd-sourced information to refine one’s estimate of the
70 costs and benefits of a behavior. Individuals could be expected to vary in the extent to
71 which they weigh conformity among the influencing factors, with riders who are very familiar
72 with the hazard and convenience factors they face perhaps being the least likely to employ a
73 conformity preference.

Two natural experiments with potential to reveal population-level conformity in helmet use decisions

If riders do have some conformity preference, then riders who observe different rates of helmet use among others in otherwise identical environments should be expected to make different decisions. A controlled test of this under real world conditions could investigate whether helmet use patterns in specific areas change after an experimental introduction of confederates who frequently and conspicuously cycle through the area wearing helmets. (Ethics considerations preclude a no-helmet condition.) We might expect to be more likely to see a conformity effect, or to see a stronger effect, in an area where the bicycle rider population has a higher percentage of new riders who are less familiar with the local environment; lacking direct relevant experience, such riders might be expected to weigh indirect information more heavily and thus show more conformity bias.

In this paper, we treat two real world events as natural experiments that approximate such an experimental design, reporting results from an observational study of helmet use across an 8 month period during which these events occurred.

The first natural experiment began when the University of California, Los Angeles (UCLA) launched a bikeshare program. Individuals can either rent a bicycle by the hour, or purchase an inexpensive monthly or annual membership. Distribution docks were installed throughout the campus and neighboring community. A free helmet was offered to the first 1,000 members of the bikeshare program. If hundreds of new bikeshare customers would soon be cycling around the campus area wearing their free helmets, the conformity hypothesis would predict that helmet usage might increase among ordinary cyclists as the bikeshare program expanded. The areas around universities include many newly arrived students, and students and university workers who experience changing schedules across academic terms; the local bicycle rider population thus likely features a high rate of turnover, and thus might be especially prone to conformity bias.

Optimistic about the possibility of documenting increasing helmet use rates among ordinary cyclists as the bikeshare program rolled out, we initiated a longitudinal, observational study of helmet use at the start of the fall term in early October 2017, the day before the UCLA bikeshare program launched. The goal was to monitor helmet use trends over time, rather than to track individual riders. Accordingly, we simply counted all passing riders at specific locations, noting whether each rider wore a helmet and if they rode an ordinary bicycle or a bikeshare bicycle. (More methods details are below.)

The study did not proceed as expected. As we report in further detail below, despite the associated helmet giveaway, the bikeshare riders rarely wore helmets. This inverts the potential influence of conformity on helmet use decisions from what we had hoped: helmet use among ordinary cyclists might decline as a result of exposure to the bike share riders. However, the bike share program did not attract many users, limiting the opportunity for them to influence the far more numerous ordinary bike riders.

The second natural experiment was unanticipated. During our research, for the first time anywhere in the world, the nearby Bird company pioneered the commercial provision of rental e-scooters, a business soon imitated by competitors. E-scooters appeared on and

around the UCLA campus in January 2018, and became common within a few weeks. Responding to these events, in February 2018 we expanded our ongoing study of helmet use to include e-scooter riders. As we will report, e-scooter riders were far more numerous than bikeshare riders, and, like the latter, rarely wore helmets. Thus, a conformity-influenced population of ordinary cyclists might trend towards decreased helmet use as a result of exposure to e-scooter riders.

Challenges of interpreting data from these natural experiments

The potential to detect the influence of a conformity preference on the helmet use decisions of ordinary cyclists during these natural experiments is premised on the assumptions that ordinary cyclists would be encountering a changed social environment (i.e., a new rate of helmet use among all of the riders whom they observe), but that all else would remain equal. The latter assumption is violated if the introduction of two new transportation options directly changes the population of ordinary cyclists by attracting business from the existing population of riders of ordinary bicycles and/or from new arrivals who would previously have used an ordinary bike. If such vehicle choice is random with respect to whether the rider was (or would have been) a helmet user on an ordinary bicycle, the quasi-experimental design would not be compromised. But the potential for unmeasured factors that could influence both helmet use decisions and vehicle choice decisions complicates interpretation of the results. Any change in helmet use percentage among ordinary cyclists could be attributable to either or both of (1) conformity, via changing decisions by remaining ordinary cyclists or differential helmet use by impressionable new cyclists, and (2) vehicle choice effects, if users of the new vehicles are a subset of the (existing or would-be) population of ordinary cyclists who are especially (un)likely to wear helmets. Our greatest concern in this regard is that convenience factors relevant to helmet use decisions may systematically relate to similar convenience factors regarding vehicle choices.

Table 1 presents some of the cost and convenience factors relevant to the choice among these three vehicle types. Our subjective judgment is that most riders would regard e-scooters as the most convenient option overall, whereas the cost and convenience differences between ordinary and bikeshare bicycles are more likely to vary based on more specific individual factors (e.g., whether one's destinations happen to be near bikeshare stations). This raises the possibility that cyclists who especially value convenience—and who therefore are correspondingly unlikely to wear a helmet—are more likely to switch from ordinary bikes to e-scooters, compared to other ordinary cyclists for whom convenience is less important than hazards, and who therefore are also more likely to wear a helmet. Similarly, new arrivals to the population who previously would have found an ordinary bicycle to be the most convenient option might now choose e-scooters. As examples, someone who strongly prefers not to arrive at a destination with disheveled hair, and thus rarely wears a helmet when cycling, might also prefer not to arrive sweaty, and thus may be likely to switch to an e-scooter. Those who used bicycles for quickly moving between two buildings on a large campus with few automobiles might have been both unlikely to wear cumbersome helmets and likely to switch to rental e-scooters that are less cumbersome than owning a bicycle. These types of vehicle switching/adoption trends would lead to higher helmet use rates among the ordinary cyclists population, separately from any possible effects on that

Table 1

Comparison of the convenience of ordinary bicycles, bikeshare bicycles, and e-scooter rentals.

Convenience Factor	Ordinary Bike	Bikeshare	E-scooter rental	Convenience Ranking
Access to working vehicle - time and money spent buying, renting, and/or maintaining	acquiring a bike, maintenance expenses	usage-based fees or long-term membership fee	usage-based fees	E-scooter = Bikeshare » Ordinary Bike
Power method - energetic expenditure; costs of freshening up upon arrival	user-powered; customizable to needs	user-powered; one-size-fits all model is heavier than most ordinary bikes	not user-powered	E-scooter » Ordinary Bike > Bikeshare
Parking / retrieving -transit costs between vehicle and destination	bike racks available fairly close to most campus destination	bike stations less common and convenient than ordinary bike racks	deposited nearby any destination during study period; correspondingly could often be found nearby; phone app locator	E-scooter > Ordinary Bike > Bikeshare
Vigilance – costs of protecting property, including expenses on equipment (e.g., bike lock), time spent checking on vehicle, choosing a safer but less convenient parking spot, etc.	always liable for own property; bike theft somewhat common	vigilance only required at stops where rider cannot end liability by docking the rental bike (e.g., visiting a cafe without a nearby docking station)	vigilance rarely required: user can end rental session through phone app and abandon vehicle anywhere convenient	E-scooter > Bikeshare > Ordinary Bike

population's helmet use rate owing to conformity effects and other unidentified factors. We attempt to distinguish between these two possible influences by monitoring riders at several different locations. We will argue that riders at these locations face systematic differences in hazard and convenience factors that make these influences more or less likely.

Here we report the results of 8 months of recording helmet use among bikeshare riders, ordinary cyclists, and e-scooter riders at multiple locations at UCLA. Lastly, because our project revolves around the possibility of stability or change in population-level behavior due to both internal dynamics and parochial external influences, we can expect that such effects may be very local in nature. To investigate this possibility, we conducted an auxiliary investigation at a location at a similar university in the same city.

Methods

Between 2017-10-02 and 2018-05-30, researchers observed bicyclists (and, beginning 2018-02-01, e-scooter riders) entering or traversing the UCLA campus while the university was in session. For each rider, we noted vehicle type (bikeshare, ordinary bike, e-scooter),

helmet use (yes, no), type of helmet (bikeshare, ordinary), and the apparent gender of the rider (male, female). Distinctive in design and color, both the bikeshare bicycles and the free helmets given to bikeshare members are readily identifiable; we distinguish between bikeshare cyclists and ordinary cyclists and helmets on this basis. Although we did not record personally-identifying information about riders, we presume that many individuals generally use the same route over time, and thus that the extended timeframe of our project creates a quasi-longitudinal study.

The timing and location of our observations was such as to record riders as they either entered, traversed, or left the campus, making it unlikely that we counted any individual twice during one observation period. Four locations were selected, two of which are principal gateways to the campus. One location, hereafter termed Main Entrance, is the termination of a large thoroughfare that transects adjoining commercial districts, and, beyond that, links to affordable residential areas at distances of 5-10 km and an elevation difference of 100 m. The second location, Local Entrance, abuts a dense, bounded area of rental apartments adjoining the campus, extending less than 1.5 km from UCLA. We also observed cyclists at two sites within the campus, Central Mid-Campus and South Mid-Campus, where cyclists pass by from the campus residence halls and other areas; some of these cyclists likely exclusively bicycle on the extensive (1.7 km²) campus, which is largely free of automobile traffic. (See Supplement for map and photos of these locations.) Importantly, students (who constitute over half of the campus population, and the majority of its cyclists [6]), circulate throughout the campus and adjoining areas, such that they can be expected to frequently witness the behavior of other cyclists at all of the locations observed. A map and photos of the observation locations are in the Supplement.

Paralleling observations at UCLA, we visited the University of Southern California (USC). Observations were made at USC on 5 October and 2 November 2017, and 3 March 2018. Data were recorded at a location (hereafter USC) similar to the Local Entrance site at UCLA, being a gateway to the campus primarily utilized by individuals traveling from a dense bounded area of rental apartments extending less than 1.5 km from the university, such that observed cyclists would have ridden a short distance along residential streets with limited traffic. Unlike the UCLA campus, the neighborhoods beyond the immediate vicinity of USC are not attractive to students, as the region suffers greater poverty and crime. Accordingly, relative to UCLA, fewer USC cyclists can be expected to have traveled longer distances along thoroughfares. Hence, our USC location is both similar to our UCLA Local Entrance location and, unlike the latter, representative of all entrances to that campus.

The UCLA and USC student populations are approximately the same size (roughly 45,000). However, the two universities do differ somewhat: The median family income is approximately 50% higher at USC, a private institution, than at UCLA, a public one, and, proportionally, UCLA includes roughly twice as many students from the lowest 20% of incomes compared to USC. However, despite these differences between the campuses, there are many overt cultural similarities, including the relaxed outdoor lifestyle and informal dress characteristic of Southern California; the centrality of athletics to campus life; and the strong identification that many students have with their respective institutions. Importantly, although UCLA and USC are only 21 km apart, both the characteristics of the intervening

regions and the nature of transportation in Los Angeles is such that they are relatively isolated from one another.

Results and Discussion

Vehicle types at UCLA

Over the course of one academic year at UCLA, we recorded 8334 total observations of bikeshare cyclists, e-scooter users, and ordinary cyclists (see Figures 1 and 2 for details; see Supplement for auxiliary analyses; data and analytic code are archived at https://osf.io/4nxj7/?view_only=4c7f40ceeb154073a1158a02c88dc67c).

[Fig 1. Hours of observation, by location and date.]

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[Fig 2. Numbers of observations, by location and date.]

To check the accuracy of these observations, we can compare our raw counts at the gateway sites with data from UCLA’s automated cyclist counters. These devices only count riders who are entering the campus and traveling in the bike lane; they do not record individuals riding elsewhere at that location (i.e., in the automobile lane; on the sidewalk; etc.). Because riders generally enter the campus in the morning and exit in the afternoon or evening, partitioning our data at noon affords a rough comparison with the automated counters; our before-noon counts compare favorably with the automated counts (see Figure 3).

[Fig 3. Researcher observations of riders validated against automatic counter data.]

Figure 2. Numbers of observations, by location and date.

We observed 228 bikeshare cyclists across all UCLA locations, accounting for only 2.74% of all UCLA observations. E-scooters ($n = 1390$) accounted for 16.68% of all UCLA observations, despite being entirely absent during roughly the first half of the study period. During the second half of the study, on some days more than half of observations were of e-scooter riders (Figure 4).

[Fig 4. Vehicle types at UCLA.]

Helmet usage rates among vehicle rider types at UCLA and ordinary cyclists at USC

Combining across UCLA locations, helmets were worn by 44.8% of ordinary cyclists ($n = 6716$). In contrast, among bikeshare cyclists ($n = 228$), helmets were worn in only 6.1% of the instances. Helmets were worn even less frequently by e-scooter riders (1.80% of observations; $n = 1390$). The helmets distributed by the bike share program were virtually never worn by ordinary cyclists (11 instances in 6716 observations), and were never worn by e-scooter riders (0 instances in 1390 observations).

At USC, over the course of three observation periods, 4.0% of riders of ordinary bicycles ($n = 965$) wore helmets.

Figure 3. Researcher observations of riders validated against automatic counter data

Interim discussion

Since rates of helmet use are markedly lower among riders the two new vehicle types introduced to UCLA during the study period, the *conformity hypothesis* suggests that the influence of these two natural experiments might be that ordinary cyclists reduce their own helmet use. In contrast, the *selective attrition hypothesis*—i.e., that convenience-oriented cyclists who do not typically wear helmets were especially likely to switch to e-scooters—favors the opposite trend.

As briefly discussed above, compared to the bikeshare natural experiment, the e-scooter natural experiment is better suited to exploring these hypotheses, for two reasons. First, there were far more users of this service. We observed six times as many e-scooter riders as bikeshare riders, which we can treat as an estimate of the proportion of influence that riders from those categories exert over any conformity preferences of ordinary cyclists. (One might speculate that more similar vehicle types might be weighted more heavily in the conformity calculations, and thus bikeshare riders might exert disproportionately stronger influence than e-scooter riders, but we do not explore this issue further.) The much larger population of e-scooter riders seems likely to include more individual riders who would otherwise use an ordinary bike than does the small population of bikeshare riders. Second, we have a full academic term of ordinary cyclist observations preceding the sudden explosion of e-scooter popularity, offering an extended period of observation before and after a dramatic

Figure 4. Vehicle types at UCLA

environmental change. In contrast, bikeshare usage was expected to rise gradually, but never actually expanded beyond the initially very low rates, offering little basis for evaluating how this vehicle choice and users of this service could affect ordinary cyclists.

The USC data indicate very low use of helmets prior to the introduction of e-scooters, such that the conformity hypothesis does not predict that an infusion of helmetless e-scooter riders would change the helmet decisions of ordinary cyclists. The dramatic difference between helmet usage rates between UCLA and USC (Pearson's Chi-square test = 583.66, $p < .001$) illustrates that seemingly similar populations can have very different helmet use norms, whether owing to safety and convenience factors, conformity influences, or both. Arguing in favor of a substantial conformity influence, this difference holds even when the comparison excludes the UCLA Main Entrance site, the site which least resembles the USC site (Pearson's Chi-square test = 293.81, $p < .001$).

Differences in helmet use within vehicle classes at UCLA across time and location

Results of binomial regressions treating observation date as a linear predictor variable indicate no evidence that helmet rates among e-scooter or bikeshare users varied meaningfully between UCLA locations, or across time (see Supplement for model details). At USC, we find no evidence of change across our three time points (Pearson's Chi-square test = 0.98, $p = .614$).

Among ordinary cyclists, a binomial regression predicting helmet use based on location (four observation sites) and date revealed significant interaction effects between locations and date (for model details and visualization, see Supplement).

Restricting the data to observations recorded at the two campus entrances, location is not a significant factor and helmet use significantly decreases over time. Restricting the data to observations recorded at mid-campus locations, location is not a significant factor, and helmet use significantly increases over time. This pattern is visualized in Figure 5; see Supplement for details of the series of models.

[Fig 5. Helmet use patterns by location.]

Figure 5. Helmet use patterns by location

Interim discussion

The observed decrease in helmet use among ordinary cyclists near the UCLA campus entrances is consistent with the hypothesis that the helmet use decisions of ordinary cyclists were influenced by the sudden influx of e-scooter riders who rarely wear helmets. Although the pattern is also consistent with a reversed selective attrition explanation whereby e-scooter riders are disproportionately drawn from ordinary bike riders who tended to wear helmets, this is arguably a less parsimonious account. Prioritizing convenience would favor helmetless cycling prior to the advent of e-scooters and also switching from cycling to e-scooter use thereafter. Furthermore, based on data collected from US high school students in 2015 (a

cohort to which many of the undergraduates we observed a few years later likely belong) bicycling without a helmet is associated with risky behavior in other contexts, including in other vehicle types [13]. Thus it seems unlikely that risk-averse helmeted bike riders would become unhelmeted e-scooter riders.

The pattern observed at the UCLA mid-campus locations is the opposite to that observed at campus entrances. This is consistent with the selective attrition hypothesis. In the pre-scooter era, mid-campus riders of ordinary bikes – who faced few hazards – may have been especially interested in convenience, favoring both low rates of helmet use and high rates of switching to a more convenient vehicle once e-scooters became available.

General Discussion

In an observational investigation of bicycle helmet use at one urban American university, and a smaller comparison study at a similar university in the same city, we find both differential patterns of helmet use across locations and changes over time within locations. As noted in prior observational studies, causal factors can be inferred from patterns in the observations; nevertheless, in the absence of survey data, these inferences must be considered preliminary [14,15]. Although this constitutes an important limitation of investigations such as ours, nonetheless, striking patterns are evident; we interpret these as reflecting the intersection of pragmatic and social factors.

First, resembling patterns found elsewhere [9,16,17], at the outset of our study at UCLA, we find that helmet use is more common among cyclists who, having traveled city streets, are entering the campus than among cyclists traversing the largely automobile-free campus. This pattern is consistent with the idea that helmet use decisions reflect a tradeoff between the costs of convenience and the benefits of safety.

Second, replicating prior reports [18–22], we find lower helmet use among bikeshare cyclists than among ordinary cyclists. This difference is dramatic despite an extensive helmet give-away program. This too undoubtedly derives from issues of convenience versus safety, as bikeshare cyclists are more likely to make short one-way trips, and are unable to store their helmets [11]. Relatedly, of note in an era of limited institutional resources, the UCLA bikeshare program’s distribution of helmets has done essentially nothing to promote public safety, as the helmets are used neither by bikeshare cyclists nor by others. Constant et al. [23] also report limited success of a helmet giveaway intervention.

Third, we find intriguing patterns of change among ordinary cyclists. At the campus gateway for which we have the most complete record, we find a significant decline over time in helmet use by ordinary cyclists. Comparing the Fall and Winter academic terms reveals a substantial drop (see Figure 5; see Supplement for more detail) that coincides with the explosion of e-scooter use (see Figure 4). Previous research on transportation choices documents social-influence effects: residing near cyclists increases the attractiveness of bicycling [24], being embedded in a social network with cyclists increases the likelihood of bicycling [25], and helmet users are more likely to report having friends who wear a helmet than non-users [9,15]. It appears that dynamic cultural norms shape helmet use [10], such that individuals are influenced by—and constantly update in regard to—the practices of those around them. Undoubtedly due to the same factors as obtain among bikeshare cyclists,

despite the availability of low-cost helmets (and despite legal requirements in effect at the time of study), e-scooter riders rarely use helmets. Although the relatively small numbers of bikeshare riders would not be expected to have much impact on other cyclists' behavior, the sudden influx of large numbers of helmetless e-scooter riders at UCLA diluted the frequency with which cyclists observed other riders of personal transportation using helmets.

As illustrated in Figure 4, only a few months after the debut of e-scooters, nearly half of all personal mobility users observed were riding these devices—and virtually no e-scooter riders were wearing helmets. It appears that, as a consequence, some cyclists stopped using helmets and/or new cyclists were less likely to wear helmets from the start.

During the same period, proportionate helmet use increased among cyclists traveling within the campus. Rather than reflecting social influence, we suggest that this pattern is explained by changing patterns of vehicle selection. For intra-campus transportation, e-scooters offer advantages over private bicycles, as they can be left anywhere, allow for one-way trips, and require neither exertion nor maintenance. In the Fall term, campus cyclists who valued convenience highly would presumably have been least likely to wear a helmet; with the arrival of e-scooters, many of these individuals likely used e-scooters instead (see Figure 4). Conversely, given e-scooters' lesser stability relative to bicycles, individuals who valued safety highly—and thus would have been most likely to wear a helmet—would have been least likely to switch from a bicycle to an e-scooter (see [13] for a related discussion of vehicle switching and risk-taking correlates of bicycle helmet use). Hence, the apparent increase in helmet use among intra-campus cyclists is plausibly an artifact of change in the composition of this category.

Fourth, comparing across two similar university campuses, we find dramatic differences in helmet use. This is true even when we take patterns of bicycling into consideration—cyclists at USC are less likely to use a helmet compared to cyclists at UCLA overall, and compared to UCLA cyclists who, like USC cyclists, travel only short distances along quiet streets. Norms of helmet use thus appear to be highly parochial.

Translational Implications

Bicycle use appears to be increasing during the COVID-19 pandemic [26], and may further expand during recovery efforts [27], raising the stakes of public health efforts aimed at bicycle safety.

The observational data we report here are congruent with our ideas about how individual differences in helmet use decisions specifically, and risk mitigation decisions more generally, are consistent with a functional cost-benefit framework, and accommodate the possibility of conformity as a mechanism for estimating costs and benefits. Our ideas and results, while requiring further testing and validation, have multiple implications for studies of, and efforts to increase, helmet use, as follows:

First, results derived from investigations of one or a few locations may fail to generalize to larger populations, or even to seemingly very similar locations in the same region.

Second, patterns of helmet use may change over relatively short timespans.

389 Third, if they are not deployed in conjunction with other interventions, programs
390 providing free or low-cost helmets may have little effect.

391 Fourth, because social influence is likely important in helmet use, informational
392 campaigns can leverage membership in a given community (e.g., “Proud UCLA Bruins wear
393 helmets when on wheels,” etc.); helmet give-aways may be more effective when paired with
394 such campaigns.

395 Lastly, inconvenience will likely constitute a significant barrier to helmet use by riders
396 of shared micromobility vehicles, be they bikeshare bicycles, dockless e-scooters, dockless
397 bicycles, or dockless e-bicycles or minibikes (all of which have since proliferated at our study
398 sites). Folding helmets reduce the inconvenience of carrying a helmet when not in use. At
399 present, folding helmets cost three to five times more than basic helmets, thus adding expense
400 as another barrier to helmet use. With the exponential growth in the use of commercial
401 dockless micromobility vehicles, the negative impact on public health of helmetless riding is
402 rising rapidly [28–30]. Rather than responding to these innovative ventures by eliminating
403 legislation mandating helmet use (as California, the epicenter of the micromobility deluge,
404 has done), jurisdictions could instead require micromobility companies to distribute folding
405 helmets at no or reduced cost, thereby creating an incentive for the production of inexpensive
406 folding helmets.

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412 Author Contributions

413 AS designed the methods, conducted the analyses, created data visualizations, con-
414 tributed to the initial manuscript, and revised the manuscript after peer review. DF conceived
415 of the project, contributed to the methods, and drafted the initial manuscript. MZ managed
416 the data, and contributed to the analyses, data visualization, and the manuscript.

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