

Beyond instrument: smartphone app and sustainable mobility

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The rise of smartphones and mobile applications (apps) is of major importance to multiple recent innovations in sustainable urban mobility, including car sharing schemes and real-time information provision in public transport, as well as the recent surge in urban cycling. Yet, exactly how apps feature in these innovations and trends remains largely unclear. This paper argues that this lack of understanding reflects not only the rapid pace of developments in apps and their technical functionalities but also gaps in academics' conceptualization of the nature of apps and their effects. Too easily and often are apps seen as mere instruments for the realisation of human-centred goals and intentions, or are their capacities and effects assumed to emerge from the webs of relations in which apps and smartphones are enmeshed. An alternative conceptualisation is therefore proposed, one that is informed principally by the object-oriented approach developed by philosopher Graham Harman. After summarising some of Harman's original concepts and developing his account of power, the paper elaborates a series of ideas and recommendations about how the developed conceptual framework can be deployed in empirical research on the interactions between apps and physical mobility in the city.

Keywords: *mobile applications (apps), smartphone, sustainable mobility, object-oriented approach, subjectivation.*

1. Introduction

Mobile phones tend to enter transport studies in one of two forms. The first of these is oblique and concerns their function as an instrument that enables the tracking of the movement of individuals and vehicles (Asakura and Hato 2004; Ahas et al. 2010; Demissie et al. 2013). The second form is more direct and of interest here; it pertains to the ways in which the use of mobile phones, and especially the mobile applications (apps) they support, can affect people's everyday mobility through physical space. Nonetheless, the interactions between apps and physical mobility are only partially understood, in both empirical and conceptual terms.

This lack of understanding is in part due to the rapid pace of developments in digital communication systems: not only do phones and apps continually offer new and technically superior functionalities, they are also increasingly part of wider circuits of mobile data exchange that provide location-based, real-time information about (urban) transport systems and the wider urban environment. Indeed, apps are becoming key means through which transport and other systems in smart cities are governed and regulate themselves. The rise of the smartphone, therefore, is linked to multiple sociotechnical innovations that may durably reconfigure physical mobility systems towards greater sustainability (Geels 2012; Lyons 2015): they may significantly increase the efficiency of existing systems and make alternatives to the usage of fossil fuel-powered private cars – from cycling, traditional urban rail and bus rapid transit to public bike share schemes and 'free-floating' car sharing schemes – much more appealing and convenient.

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Apps will likely play a key part in the expansion of low-carbon urban transport systems organised around principles of high-quality service provision rather than individual ownership.

Lack of understanding regarding the interactions of mobile phones and apps with physical mobility also results from gaps and silences in conceptualisation by academics. In recent years a variegated and insightful interdisciplinary literature on those interactions has emerged, which can for heuristic purposes be classified into two overlapping categories. In Table 1 these are denoted as 'behavioural research' and 'studies of social practices' so as to highlight differences in disciplinary origin, unit of analysis and substantive concern. Both bodies of work are nonetheless characterised by a shared set of largely implicit and taken-for-granted philosophical ideas – correlationism, instrumentalism and relationalism – even if individual studies in Table 1 may be committed to these ideas to slightly varying degrees and in different ways.

Table 1. Past research on the interactions of mobile phone use and physical mobility

	Behavioural research	Studies of social practices
Roots of theoretical concepts	Economics, psychology, engineering, time geography	Sociology, science & technology studies (STS), cultural geography, new mobilities paradigm
Unit of analysis	Individual and his/her behaviour which is seen as the outcome of choice and decisions, i.e. the integration of preferences, needs and constraints and the trading of (financial, time, psychological, social and other) costs against benefits (Dal Fiore et al. 2014)	Social practice, i.e. a routinised nexus of saying and doing that integrates materials (bodies, artefacts, infrastructures), meanings (discourse), procedures (rules, competencies) and affective intensities (Shove et al. 2012; Schwanen 2013)
Key conceptual and empirical concerns	If and how phone use: <ul style="list-style-type: none"> ○ substitutes, generates or modifies physical travel ○ makes transport more efficient ○ reduces space-time constraints ○ occurs during physical travel ○ fragments activities across space and time 	The role of: <ul style="list-style-type: none"> ○ phones in coordination of 'mobile lives' (Urry and Elliot) ○ phones in new modes of sociality ○ phones in social inequality ○ phone use in the experience of mobility through physical space
Selection of relevant publications	Schwanen and Kwan (2008), Tillema et al. (2009), Aguilera et al. (2012) Caulfield and Brazil (2013), Dal Fiore et al. (2014), Dickinson et al. (2014)	Urry (2007), Ureta (2008), Peters et al. (2010), Line et al. (2011), Wilson (2012), Nyblom (2014), Molz and Morris Paris (2015), Porter (2015)

Correlationism is a term coined by philosopher Quentin Meillassoux (2008) to denote the idea that the world and the objects it comprises cannot be known without already being affected by human thought; world and thought are always inseparably correlated. The implication for philosophy is that "[h]uman and world must be the two ingredients in any situation we talk about" (Harman 2010, p. 97) and that little can be said about non-human entities on their own terms. As a result, smartphone apps (and other objects of interest) are reduced in both thought and research to how they appear to human beings rather than seen as objects in their own right. They are stripped of their autonomy and made into passive things waiting to be activated by humans. This, then, paves the way for instrumentalism: the idea that technical artefacts, such as apps, are tools or means to realise pre-established goals on the part of the humans using them.

Now, the ideas of correlationism and instrumentalism have been challenged in various ways since the early 20th century. German philosopher Martin Heidegger, for instance, has famously criticised the idea that technologies are mere instruments (see especially Heidegger 1977) but within a correlationist mode of thinking. More recently Bruno Latour has challenged both instrumentalism and correlationism albeit without deploying Meillassoux's terminology (Latour 1999, 2005). He has offered an alternative understanding of technical artefacts as 'mediators' that modify and transform the intentions of the humans using them. This understanding has had considerable purchase among studies in the social practice tradition (Table 1) and is useful in

many ways, but it is also entirely relational. In other words, an app is defined by its relations and little more “than what it modifies, transforms, perturbs, or creates” (Harman 2009, p. 127). Not only does this relationalism rob artefacts of their autonomy, making it difficult to explain how change and novelty can ever emerge (Harman 2005); it also implies that artefacts are nothing outside of relations and means that intervals in which they are at rest, inactive or inert cannot be rendered intelligible (Ash 2013). At the same time, it would be patently simplistic to locate all of the forces or effects such artefacts as apps are able to generate in those objects themselves. Anyone used to handling physical mobility-related apps knows that most owe their usefulness and effectiveness to the ability to provide real-time, location-based information, which is only possible if they are hooked up to wider constellations for data exchange and communication. Relationality does have an important role to play in conceptualisations of the interactions between app use and physical mobility.

The conceptualisation challenge, then, is to develop an approach that strikes a balance between understanding apps as relevant and generating effects in and of themselves on the one hand, and appreciating the relations with other entities in which they are situated on the other. Directing attention to apps in their own right also implies that thinking about *the* app will be insufficient; the focus must be on particular apps with their specific qualities. This much is also clear from my own empirical research (Box 1); the apps currently on offer and potentially contributing to a sustainability transition in urban transport are too diverse and their effects too heterogeneous to meaningfully speak about apps in general. My claim in this article is that the work of philosopher Graham Harman (2002, 2005, 2010, 2011, 2013a), if complemented with other thinking on how power² operates, offers a useful point of departure to address the identified conceptualisation challenge.³

In March 2014, as part of ongoing empirical research on innovations in urban transport, I made an inventory of iOS smartphone apps that in one way or another encourage utility cycling in UK cities. A wide range of apps with differing levels of functionality, stage of development (versions) and popularity (number of downloads) was identified. These could be classified conveniently on the basis of intended purpose of use into six classes:

- 1) Offer information and/or share this with other users on:
 - a. Competitive performance (e.g. *Strava*, *Cycle Meter*, *Cychosis*)
 - b. Routes and maps (e.g. *National Cycle Network*, *Cycle Streets*)
 - c. Community infrastructure – bike shops & cycle cafes (e.g. *Bike Hub*)
- 2) Enhance cycling skills and competency (e.g. *Cycling Proficiency*, *Bike Safety*)
- 3) Enhance cycling comfort (e.g., *Size My Bike*, *Bicycle Gear Calculation*)
- 4) Aid with bike maintenance/repair (e.g. *Bike Repair*, *Bike Doctor*)
- 5) Contribute to infrastructure repair and cycling safety (e.g. *Fill That Hole*)
- 6) Turn a smartphone into a prosthetic device for cyclists (e.g. *Brake Lights*)

London is the only city with a sizable range of city-specific cycling apps. Most of these offer information, or allow this to be shared, on the city’s bike sharing scheme (e.g. *Cycle Hire App*, *Biximo*, *My Cycle Hire*), routes (e.g. *London Cycle Streets*), parking (*Bike Parking*), bike rentals (*London Cyclist*), community infrastructure and cycling events (*London Cyclist*, *Recce*) and discount at specific businesses (*London Cyclist*).

Box 1. *The diversity of apps for sustainable mobility exemplified for utility cycling*

² This concept denotes, in general terms, the emergent forces and capacities through which effects are generated in and through interactions between entities.

³ Like Meillassoux, Harman is a key protagonist of Speculative Realism, a recent if heterogeneous movement in continental philosophy that seeks to overcome correlationism and think about the myriad objects of which the world exist – from smartphone apps to raindrops to global warming – on their own terms.

Accordingly, this paper aims to sketch the contours of a conceptual framework for thinking about and examining the interrelations between apps and individuals' physical mobility in cities that strikes the aforementioned balance. It draws inspiration from Harman's object-oriented approach yet also moves beyond this by drawing on more explicitly relational approaches developed by sympathetic critics (Shaw and Meehan 2013) and Michel Foucault (1985, 1986). It first covers more abstract philosophical ideas on objects and specifically human responses to the workings of objects (Sections 2.1 and 2.2), which are then condensed into a rudimentary analytical framework (Section 2.3). This is followed by a discussion of implications for research on apps and physical mobility (Section 3) and finally some thoughts on research methods (Section 4). The paper offers a detailed discussion of philosophical concepts that is rather unusual in the transport studies' literature but this is necessary step in the formulation of a more-than-relational and more-than-instrumentalist framework for studying the linkages between apps and sustainable mobility.

2. Starting points

2.1 Harman's object-oriented approach

According to Harman, the world consists only of objects. His definition of objects is, however, very broad: any unified entity that is irreducible to its component pieces or to its effects on the surrounding environment is an object (Harman 2013a, p. 39). Objects do not have to be physical things and can be of any size, durability or level of complexity. A human or smartphone app is as much an object as is a dream, mathematical formula or a trip to the supermarket. Suggesting that objects cannot be reduced to what they modify or create, Harman's definition rejects strong versions of relationalism.

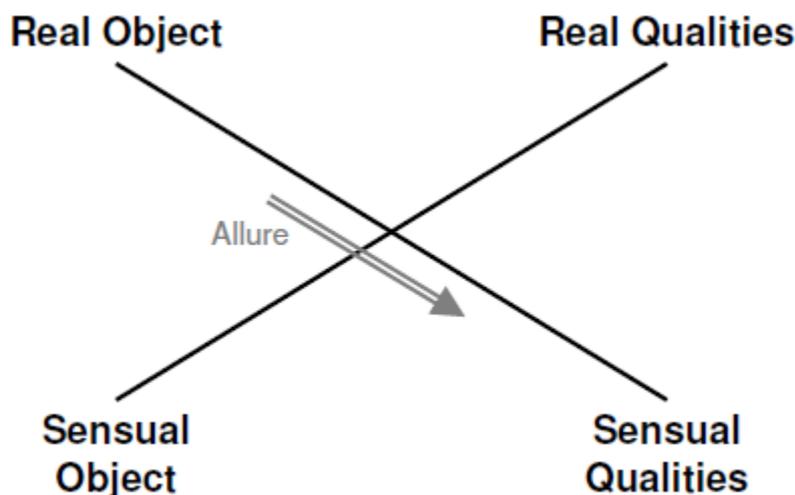


Figure 1. The fourfold structure of an object (based on Harman 2011)

Contra Western commonsense Harman posits that all objects, including a smartphone app and its user, exhibit a fourfold structure (Figure 1). There is the real object with its real qualities and there is the sensual object with its sensual qualities. The former are the true object and qualities; the latter are the ones that other objects 'perceive' and are images or caricatures of the real object and qualities. Harman makes the distinction between real and sensual because one of his key tenets is that real objects withdraw from interaction and exist in their own vacuums isolated from other objects (an idea he develops from Heidegger's philosophy).

In other words, the real object and its qualities are somehow 'hidden' behind their sensual counterparts; they are non-relatable and non-relational. They cannot be accessed or known

directly by other objects. So, not everything that makes a given app what it is, is revealed to the human beings using it, or to the phone and the operating system on which it runs. More generally, the implication of the withdrawal of real objects in their own vacuums is that interaction is asymmetrical and vicarious:

“all relation is a form of translation, so that inanimate objects fail to exhaust each other during collision just as human perception or knowledge of those objects fails to know them. Real objects do not encounter each other directly, but only encounter sensual objects, or images of real objects. All contact between real objects is indirect, mediated by sensual reality, and this holds for raindrops and stones no less than for humans” (Harman 2013b, p. 24).

Nonetheless, the separation of real and sensual objects is not as absolute as it may appear. Even though real objects and their qualities withdraw from interaction, there are specific moments when they dimly ‘shine through’ in sensual objects and qualities (Figure 1). Most important for our purposes are instances of *allure* – moments when a real object becomes vaguely fused with sensual qualities. Harman often exemplifies them with reference to Heidegger’s (1962) famous broken-tool analysis: Individuals usually take pieces of equipment, such as a pair of glasses or a pc screen, for granted and are largely unaware of how they enable such actions as looking or internet browsing. It is only when such equipment breaks that individuals become vaguely aware of the normally veiled or hidden whole object they interact with. This is when the glasses or screen as real objects dimly shine through their sensual qualities.

Harman also distinguishes between object and qualities (Figure 1). This is because the latter give an object particularity. Real qualities make an app what it is and shift our attention from apps in general to Strava, Fill that Hole (Box 1) or indeed any other app. The sensual object is singled out from sensual qualities because the latter change continuously – for instance when an app displays new information or when I hold the smartphone on which it operates closer to my eyes – whilst the app is still perceived as the same object.

Forcefulness and alliance

Withdrawal into their own vacuums is only one side of the coin; objects are simultaneously active and forceful. According to Harman’s often metaphorical descriptions, an object is a “black hole, or internal combustion engine releasing its power and exhaust fumes into the world” (Harman 2005, p. 95). Objects are continually trying to affect, re-shape and dominate each other, but they can never fully master another object because the real dimensions of the latter are withdrawn from interaction. That real dimension constitutes a surplus capability to engender effects in other objects, to be activated at moments of allure. Such moments may be relatively uncommon but are often profound. As discussed in greater detail in Section 3, moments of allure can change how objects – a specific app and me, for instance – relate to each and may even trigger the emergence of new objects. Allure is the mechanism through which novelty is introduced in existing systems.

Harman (2009) follows Latour in arguing that an object’s capacity to engender effects – i.e. its power – is greater if it is *allied* to others. Thus, a route navigation app can affect my mobility to a greater extent if allied to the smartphone’s operating system, its battery, Wi-Fi networks through which real-time information can be downloaded, the IT infrastructure through which that information circulates and is created, the sensors for registering road traffic levels or the presence of bikes for hire at docking stations, the engineers managing this ‘smart’ mobility system, and so forth. Seen in this way, objects constitute *worlds* for each other (Shaw 2012): the character of (sensual) objects, their encounters and the new entities that may spring from these are all affected by the constellation of other objects in which they are enmeshed. How I interact with a specific cycling-related app (cf. Box 1) cannot be understood without due consideration for the myriad objects that are implicated in the formation of both the app (e.g. its design process) and me (the

relationship with my parents, the places where I learned to cycle and use smartphone apps, the moralities according to which I used to and continue to regulate my own behaviour, etcetera).

2.2 *Beyond Harman*

Their high level of abstraction notwithstanding, such concepts as allure and alliance can usefully inform studies on how app use and physical mobility are interrelated. Yet, Harman's approach also needs to be expanded if it is to constitute a veritable theoretical basis for empirical research in at least two ways. It does not sufficiently explain why objects appear in particular ways as sensual entities to other objects, and makes too little of the specifically human capacity for thinking that is induced by encounters with forceful objects.

Sensual versus real

Shaw (2012) criticises Harman for not elaborating which factors and processes determine how an object's appearance to other objects - its sensual layer - differs from its real character. He therefore proposes a hierarchy among objects and the existence of *transcendental objects* that condition what other sensual objects look like and which qualities are likely to remain withdrawn in a specific space and time. Transcendental objects can be said to "act as anchors within a world" (Shaw 2012, p. 621) or as the police (Shaw and Meehan 2013), creating stability and sameness around a specific, dominant logic of appearance. They do so because they occupy the apex of forcefulness with which objects are imbued; they act as the most powerful black holes. Nonetheless, as with other objects, the extent to which transcendental objects can shape and format other objects is never complete, and a given hierarchy of force can always be revised or overturned. Shaw provides few clues what constitutes a transcendental object and what not, on purpose: this cannot be assumed a priori and needs to be ascertained empirically. Below some expectations will be formulated about likely candidates for functioning as transcendental objects in relation to interactions between smartphone apps and users in the context of physical mobility.

The human object

Harman offers multiple insights regarding human beings as objects, including the idea that every human being is also split into a sensual and real object and qualities. Humans can also be thought of as "clusters of relations with a multitude of other entities" (Harman 2010, p. 108) but cannot be reduced to the sum of those relations; there is always a real object with specific real qualities that is isolated from interactions with other objects. If this were not the case, then individuals could never do something new or enter a different alliance. His work also suggests that humans as real objects are over time affected and changed by the relations with other objects in which they were enmeshed; it thus accommodates processes of social learning and acculturation. But exactly how such processes unfold is less than clear. For understanding human responses to the forcefulness of apps and other objects, we need to turn to other thinkers and perspectives.

One possibility is offered by Michel Foucault's (1985, 1986) writings on *subjectivation* - the processes, techniques and practices through which human beings govern and regulate themselves. These writings attend much more closely to the workings of power in the formation of individuals and practices as sensual objects than prevailing perspectives on behaviour from economics and psychology. For Foucault practices emerged from an intricate mixture of frequently subtle forms of domination (government by others) and self-regulation (government by the self) rather than decision making by self-directed and sovereign individuals. Nonetheless, Foucault's conceptualisation of subjectivation is limited insofar as it pays little attention to emotions/affect and physical artefacts (Thrift 2007); makes too little of subtle forms of resistance to and re-appropriation of the forces emanating from social rules and codes of conduct by individuals (De Certeau 1988); and underappreciates both dynamics over time in human responses to external forces (Law 1994) and group dynamics that may occur within communities of practice (which, in our case, can be configured around a specific app). Hence, his concepts and

ideas need to be developed if they are to be employed meaningfully in research on apps and physical mobility in contemporary society.

Foucault (1985) proposes to study subjectivation by considering four dimensions of self-regulation. Reworked in light of the aforementioned shortcomings, these can be summarised as follows:

- *Ethical substance* – the parts of themselves that individuals feel/think require work. In relation to an app promoting sustainable mobility, these may include their mode use but possibly also their attitudes, their fitness levels, etcetera. The exact nature of those parts needs to be verified empirically rather than assumed.
- *Mode of subjection* – individuals' position relative to a force and the mechanisms through which they are made to respond. They can comply, outright resist or subtly re-appropriate the force by a particular app and do so for various reasons. For instance, they may imitate relevant others, wish to lead by example, or simply act almost unthinkingly in response to a pop-up window on their phone's screen. Focusing on the mode of subjection aids researchers' understanding of the objects through which power operates.
- *Ethical work* – the techniques and competencies individuals deploy to accommodate, re-appropriate or resist the exerted force. This allows researchers to better understand which effect is engendered in specific conditions, and also why many apps are abandoned after a while.
- *Telos* – the mode of being to which they aspire. This needs to be considered because specific mobility practices, such as walking to work or using a bike sharing scheme, are often part of wider patterns of conduct. Hence, smartphone apps may engender indirect effects beyond the realm of everyday mobility.

Different combinations of these dimensions lead to differences between individuals, and between moments in time for any given individual, in self-regulation with due consequences for how they interact with apps and physically move around the city. Exactly how those dimensions are interrelated has not been specified, deliberately. Unlike widely used theories of behaviour change or technology adoption from psychology (Schwarz 1977; Triandis 1977; Ajzen 1991; Klöckner and Blöbaum 2010), the Foucauldian framework does not impose an a priori defined causal structure between concepts. It is heuristic and asks for situated analysis: insofar as these can be unravelled at all, the precise ways in which power operates on individuals and the four dimensions interrelate needs to be worked out empirically for different cases (e.g. particular apps) or domains (e.g. physical mobility).

2.3 Towards an analytical framework

From the above discussion a series of interrelated key concepts can be derived that can inform thinking and empirical research on the interrelations between smartphone apps and everyday mobility:

- *Allure*: How often, when and where do moments when the real app shines through its sensual qualities happen? What effects does this generate? What new objects come into being?
- *Alliance and world*: In what ways and to what extent are the effects of a smartphone app stronger when it is embedded in wider networks, such as smart transport systems or communities of practice? How and to what extent do the ways in which an app affects other objects depend on the wider constellations of objects of which it is part?
- *Transcendental objects*: Which objects traverse the alliances of which a smartphone app is part? How do they shape the appearance of objects to each other? What is their relative importance?

- *Subjectivation*: How are individuals made to respond to a smartphone app (mode of subjection)? What, if anything, requires work (ethical substance), by what means (ethical work), in order to achieve what (telos)? How do these dimensions change over time?

The skeleton framework thus emerging is generic. It can inspire research on many different innovations in mobility and beyond; however, it brings specific benefits to the analysis of smartphone apps in relation to physical mobility, sustainable or otherwise. It offers a vocabulary for analysis of the interactions of (technological) innovations with (potential) users and other objects that moves beyond correlationism and instrumentalism by insisting on the significance of the non-relational. It also enables the formulation of original expectations and hypotheses, thus opening up novel directions for empirical research. Moreover, by emphasising the importance of alliances, worlds and transcendental objects, the framework is capable of moving beyond a narrow individualistic focus on app, (potential) user and her behaviour. It thus allows for analyses of how individual-level interactions between apps and physical mobility are situated in and shaped by wider sociotechnical systems and politics – here understood as the processes that shape constellations of power and the sensual layers of objects.

3. Implications

We can now begin to address the question of how an empirical object-oriented analysis of the interaction between smartphone apps and individuals' physical mobility might look like. For reasons of consistency with the introductory section, I use examples from Box 1 but the points raised below can easily be extended to mobility-related apps that do not target cycling.

3.1 *Begin with the app*

A useful first step is to start not with the human individual, her needs, preferences, valuations or even the social practices she is enrolled in, but with the smartphone app and its qualities. Moving beyond correlationism and instrumentalism is greatly facilitated by bracketing the common inclination to start research with how the technical artefact – i.e. the app – appears to the humans who might potentially use it; the challenge is to try to study the app on its own terms. This immediately confirms that studying apps in general is meaningless; as particular apps have unique functionalities and built-in – or scripted (Akrich 1992, see below) – logics, they will engender different effects in objects, including humans, with which they interact. Research should therefore begin by scrutinising what Ash (2013, p. 20) after Bogost (2012) calls the “tiny universe” of constituent parts of specific apps. Apart from describing and conceptualising how those parts interact and how the app in question as object emerges from them, analysts can usefully consider the design process as this is phase in which the app's capacities to engender effects in other objects are being created (even if only a small subset of those capacities are actually being considered or known at that stage). Drawing comparisons between apps – e.g. Strava versus Cycle Streets versus Fill That Hole (Box 1) – may be particularly useful in this regard.

In so doing empirical research may engage with two bodies of work not normally considered in transport studies. One is research informed by Akrich's (1992, p. 208) influential work on scripting – the attempt by designers to “define a framework of action together with the actors and the spaces in which are supposed to act” and embed this into the computer code that is part of the app. Several extensions and modifications are nonetheless required. First, scripting research focuses on how humans interact with a technology; how technical artefacts interacts with other inanimate objects, such as the phone on which an app operates and the real-time information that reaches it via sensors in that phone, needs to be unpacked as well. This is crucial to understanding how its capacities to engender effects are enhanced through alliances. Second, Akrich's approach is relational and thus tells us much more about an app as it appears to other objects than about its real character. Any analysis will have to accept the idea that it is at the

design stage that the app as real object with capacities to perturb other objects is crafted (Bogost 2012) but that those capacities can never be known in full given that real objects withdraw from interaction into their own vacuum. This might trouble some readers as it implies fairly strong limitations on the extent to which conclusions from empirical research can be generalised across space and time. They should nonetheless consider that Akrich also emphasises that the scripts embedded in technical artefacts, including apps, are never absolute or closed: they can – and often are – resisted and re-appropriated by humans interacting with those artefacts. Yet, her relational approach fails to provide satisfactory explanations for such moments of resistance and re-appropriation because it strips the app from its autonomous capacities to engender effects. Thinking of the app as a real object reinstates that autonomy and induces modesty among researchers; it recognises that human or other observers can never fully know what the object is capable of.

Also relevant is the literature in human-computer interaction (HCI) studies on ‘persuasive design’ that charts the interactions and negotiations between the designers and users of apps that seek to encourage sustainable behaviour by utilising insights from psychological theory (e.g. Froehlich et al. 2009; Tulusan et al. 2012). For instance, Froehlich et al. (2009) draw out design lessons from user responses to their UbiGreen app, which offers users small visual rewards that are earned over the course of a week if users take sustainable transport modes (public transport, train, walking, carpooling) more often.⁴ Studies like this allow researchers insight into how capacities to generate effects are built into apps and in how objects’ sensual qualities can be shaped in and through design processes.

Insofar as this has not already been elucidated, analysis could continue by focusing on how a given app is positioned in and utilises wider alliances of technical artefacts and other objects (regulation, pricing structures, maintenance practices, etcetera) for what human users would recognise as its functioning – e.g. delivering real-time location-based information on bike availability at a particular docking station (My Cycle Hire), or allowing individuals to report a pothole in a given road (Fill That Hole). This will aid understanding of the intensity of the force on (potential) human users the app can generate. Here links can be made with recent material approaches to digital communication (Packer and Wiley 2013), although much work in this vein is committed to (rather) strong versions of relationalism; any rapprochement of this work and the object-oriented approach advocated here will have to involve careful dialogue about the nature and significance of the non-relational.

Only when researchers have some sense of the intensity of an app’s forcefulness should they turn attention to the relationship between the (potential) human user and app. The displacement of humans away from centre stage reflects the realisation that humans “are not running the show” (Morton 2013, p. 164). This statement is in no way driven by the increasingly common fears that artificial intelligence will one day come to dominate humans and their actions. It rather affirms that humans are just one of the many entities capable of triggering the emergence of new objects, including app use.

3.2 Consider the emergence of new objects

Recall that for Harman all interaction is asymmetrical: a real object encounters others only as sensual objects – caricatures that in no way reveal those others’ real side. This is as true for

⁴ If the app senses that a trip with a sustainable mode is undertaken, the phone’s wallpaper changes: in one interface an initially bare tree gains leaves, blossoms and apples, and in another a polar bear comes to stand on an increasingly bigger iceberg surrounded by seals and fish. Piloting of the app suggested that users valued the direct feedback that was provided (a commonly replicated finding in persuasive design studies) and “encouraged [the designers] to do more with the game-like properties of UbiGreen and to factor in real time data about friends and transportation options time, cost and CO2 savings” (Froehlich et al. 2009, p. 1051). These conclusions are consistent with the claims elsewhere in this paper that objects in larger alliances are more forceful and that competition is a relevant transcendental object that polices the interactions between app and traveller.

humans encountering an app as it is for an app encountering humans; the latter are for the app reduced to units that may respond to the information it produces by clicking a button, reading, typing and so forth. Yet, such responses as reading or even clicking a button denote a special kind of relation.

Here the distinction that Harman (2005) makes between perception – when a real object such as me expends some level of energy and encounters the sensual object associated with a particular app such as Strava – and causation is relevant. Causation implies something more than perception and moves beyond the level of sensuality. It implies a situation where the Strava app as real object somehow interacts vicariously via its sensual layer with the real object that is me. This, for Harman, enables the emergence of a new combined object, Strava-and-me.⁵ Note that this emergence is a rare occurrence. In the vast majority of instances, the humans encountered by the app will remain indifferent to the forces it engenders, meaning that interaction remains at the level of perception and that no new object will emerge. Occasionally, however, a human will be captivated by an app: their respective forces come to resonate in such a way that the human comes to see the app in an unusual light, as a unity worth engaging with. This formulation suggests a close parallel between captivation and allure and Harman (2005, 2010, 2013a) indeed argues that allure is essential to causation.

Note also that captivation is binary: either the object of Strava-and-me emerges or not. Harman uses multiple terms to denote captivation/allure, including beauty and fascination, and emphasises that it means that humans sense more than the sensual qualities of a given object like an app; they rather gain some sense of the underlying real object. Moreover, whatever the mechanism involved, captivation/allure means that humans experience unusually intense emotions, suggesting that apps capable of invoking strong affects in potential users may be more successful in causing unified app-and-human entities to emerge.

Harman's writings are less helpful in elucidating what allows captivation or affective atmospheres to come into being: why Strava enchants me remains opaque. This is where Shaw's (2012) notion of transcendental objects is helpful. It can help us understand why an app like Strava appears as it does, i.e. what sensual object is at stake for me or other potential users. As argued previously, the nature of transcendental objects needs to be verified empirically; however, in the case of an app like Strava it would appear that competition plays a significant role for many would-be users. This competition is both with oneself at other moments in time and with others whose performances have become part of the wider alliance of the mobile communication system by virtue of which apps like Strava function in the ways that users recognise as normal. Competition may act as transcendental object because it is highly valorised in contemporary capitalism and now pervading numerous domains of everyday life in the global North; people may therefore readily recognise and be drawn to qualities of an app that revolve around competition. Note that this role of competition is to some extent made possible by the operation of other objects, including the increasingly common objects of the quantified self or 'dividual' (Deleuze 1992).⁶ Those other objects not only influence and are utilised in the design process; they also generate effects at moments when the tables, graphs and statistics that the app displays captivate potential users.

Still, competition premised on quantification is not the only relevant transcendental object shaping how Strava and other performance-based apps appear as sensual objects to (potential) users. Others will need to be identified empirically, also for apps whose qualities are not premised on competition. An obvious candidate is the idea of reward, as the earlier example of

⁵ I prefer this rather awkward term over the more usual 'Strava use' because the latter is less symmetrical: it privileges the human over the app and is more conducive to thinking about Strava in instrumental terms rather than as an object with specific qualities in its own right.

⁶ A data representation of a person that can easily be separated from her physical body and easily recombined with other bits of (digital) information in ways that are beyond her control.

the UbiGreen app (Froelich et al. 2009) indicates. Still others will emerge from in-depth research into how particular mobility-related apps captivate potential users, when both app and user are situated in different constellations of objects (worlds) as constituted by: their activity schedules; her competencies regarding both digital devices and various ways of physically moving around the city; the app's functionalities; the ways in which it is enmeshed in wider alliances of digital technologies; the practices of and norms that prevail in her social networks; and so forth.

3.3 Examine the impacts of the emerged objects

Once emerged, an app-and-person entity is on Harman's reading no different from any other object. As a real object it withdraws from interaction in its own vacuum and as sensual object it appears to others, including researchers, as a malleable caricature – i.e. in a particular way that may change over time, depending on the app's and observers' worlds, as well as the observers' real characteristics. The implication is that all academic knowledge of app-and-person entities is partial and to some extent speculative in nature; uncertainty is 'deep' regarding the sensual side of such entities and borders on total ignorance when it comes to their real side.⁷

Nonetheless, there are still meaningful things to say and examine about app-and-human entities. For one, they contain the original objects – Strava and me, for instance – on the inside as semi-autonomous pieces and they have emergent properties that belong to neither original object in isolation. They are also transient, ceasing to exist when the emergent real qualities cease to exist. The semi-autonomy of original objects is evident in what Harman (2010, p. 106) calls retroactive causation, the general form of causal impact "in which a total object has backwards effects on its pieces". In other words, both app and human user may be transformed by the object of their mutual encounter that resulted in the emergence of the app-and-human entity.

In most cases, a greater or smaller number of additional objects will be involved in cases of retroactive causation. For the Strava-and-me example used above, these might well include the cycle trips I am a piece of, or the performances and (written) feedback from other users that reaches me through the app. Harman (2010) therefore speaks of loops or rings of objects involved in causation. Empirical research can usefully document such loops and try to understand systematic variations in their character according to type of app, sort of physical mobility, category of user, and so forth. This will aid understanding of the causal mechanisms through which app use affects physical mobility for different people in different situations.

It is at this point that Foucault's work on subjectivation proves useful. Not only does it sensitise researchers towards asking exactly which parts of human users are being affected in loops of retroactive causation (ethical substance), but also the mechanisms through which this happens (mode of subjection) and the techniques and competencies they deploy (ethical work). Continuing the Strava-and-me example, we can begin to ask what is changing and which new objects involving the user are emerging accordingly (ethical substance): Are greater shares of utilitarian or exercise trips undertaken by bike? Are greater distances being covered per cycling trip? Is the speed of cycling trips going up over time? Do attitudes towards competition change, making her more determined to beat her previous or other users' performances? Are changes in diet or other practices, such as using stairs rather than elevators, also occurring? Also, what exactly is it that induces such changes (mode of subjection)? The ways in which the app compares one's performance at a specific moment in time with previous performances or with those of

⁷ Here I follow the distinction made by decision making scientists and futures scholars, such as Walker et al. (2010), who identify a spectrum of knowability ranging from determinism through various levels of uncertainty to ignorance. The more profound levels of uncertainty are known as deep uncertainty, which can be defined as situations in which observers do not know or cannot agree on how components of a system interact with each other and their context and hence on which effects may be generated (e.g. what futures may unfold). However, unlike many decision making scientists, I hold that deep uncertainty is ontological rather than epistemological: it is not merely a lack of knowledge among human observers that will diminish over time as events unfold, but an endemic and irreducible part of reality.

other users? The messages of online friends in the wider Strava community of practice? Something else? Furthermore, with regard to ethical work, what are the objects through which individuals' conduct is brought in line with the norms and values resonating from the app: which of the app's functionalities are being used and in what ways? How are extra cycling trips slotted into one's activity schedule, through a shift in mode usage for trips that would be undertaken anyway or rather through reduced trip chaining or the generation of genuinely new trips? These and similar questions can be explored productively in empirical research, and they can be adapted easily to other apps that, for instance, seek to provide information about travel options or potential destinations (e.g. Cycle Streets, Cycle Hire App) or contribute to infrastructure management (e.g. Fill that Hole).

Whatever app is under consideration, using the Foucauldian concepts brings significant advantages. By separating out ethical substance from mode of subjection and ethical work, they allow researchers to explore how apps refract and reshape wider dynamics of power, including social influence⁸, and also help them identify and delimit relevant loops of objects through which power operates. Moreover, they sensitise researchers to spill-over effects into domains other than physical mobility in the city. These effects have already been alluded to above, but can be addressed more comprehensively through the telos dimension. The idea that actions in a specific domain, such as physical mobility, are part of wider patterns of conduct opens up a raft of questions about additional loops of objects and retrospective causation: in how far does the app-and-human entity exert significant force over other clusters of relations of which an individual is part? Does it contribute to the formation of environmentally conscious subjects who reduce – or seek to reduce – flying, eating red meat, heating their dwelling, and so forth? Or does the app-and-human entity help to reduce guilt over, or compensate for, captivation by deeply unsustainable objects – fly-and-drive holidays in far away destinations, for instance (Barr et al. 2010) – at other times? Attending to questions such as these offers an inroad into understanding the from a greenhouse gas emissions perspective undesirable second-order effects, for which sometimes the term 'rebound effects' is used, of the introduction of apps that aim to make sustainable urban mobility more attractive and convenient.

Changes over time in the character of the app-and-human entity and dynamics in ethical substance, mode of subjection, ethical work and telos should be given due attention in empirical research. This is not only because changes in telos or the other dimensions will often take time to come into being, or even because individuals develop new skills, sensibilities and habits over repeated engaging with an app that will re-shape the app-and-human entity – both arguments are perfectly valid but focus on the human pole of that combined object. Changes may also happen on the other pole. For instance, the app may be updated automatically and without awareness of the user, or it may break down (e.g. because of particular bits of code on which it is based) whilst in use. The latter case is of particular interest to an object-oriented analysis of the interactions between app use and physical mobility, for at least two reasons. First, moments of technical breakdown expose an app's capacity to engender effects in users and bring new objects into being in ways that remain veiled in instances of normal functioning (Ash 2013). Those moments resemble Heidegger's (1962) broken tool situation and might well induce a moment of allure and trigger some sort of change. Exactly what the element of novelty consists in is an empirical matter, and abandonment of the app, search for a 'better' alternative, or reflection on one's dependence on particular technologies for everyday physical mobility constitute only some of the possibilities. Second, moments of breakdown disrupt the wider dynamics of power through which the providers and developers of specific apps (e.g. the cycling charity CTC in the case of Fill That Hole) seek to influence the actions of others (e.g. cyclists and the local authorities responsible for road management and maintenance). They thus highlight that mobility-related apps – and indeed technological artefacts more widely – are no empty vessels onto which human

⁸ This has received increasing attention in transport studies in recent years (e.g. Páez and Scott 2007; Axsen and Kurani 2012).

interests, ambitions and intentions can be projected and inscribed. They are instead generative of power through such processes as withdrawal, allure and the mediation of transcendental objects (Meehan and Shaw 2013).

4. Final remarks

A central idea of this paper is that apps that may contribute to a transition towards sustainable mobility should not be understood or examined as mere instruments for the realisation of pre-existing goals among humans but as full-fledged objects that exceed the relations of which they are part. As such they are capable of captivating humans and other objects on their own and especially when enmeshed in wider alliances, and of enticing the formation of app-and-human objects which may retroactively induce a range changes in the appearance of the app and especially its users. Yet, it has also been suggested that apps have an unknowable real dimension that can on specific moments shine through its appearance to humans and other objects with whom or which it interacts and so induce unforeseeable changes in individuals' conduct.

Following an outline of the underlying philosophical ideas, the previous section has begun to draw out a range of implications and recommendations for empirical research into the question if and how apps launched to make cycling, walking, public transport and car sharing can actually make significant contributions to sustainability transitions in urban transport:

- Start analysis by focusing on the app rather than the (potential) user or practices;
- Examine the forces a given app can generate to captivate humans and other objects through an exploration of its constituent parts and wider alliances of digital communication technologies and concomitant infrastructures, regulation, management and maintenance;
- Establish what drives captivation of humans by specific apps and the character of the subsequently emerging app-and-human entities, amongst others by considering which transcendental objects are involved in these processes;
- Explore retrospective causation by app-and-human entities, focusing specifically on the question which, if any, combinations of ethical substance, subjection, work and telos and associated objects come into being.

This indicative list suggest salient differences in unit of analysis and key concerns with the behavioural research and studies of social practices traditions briefly summarised in Table 1. The object-oriented approach can therefore be expected to deliver new and policy relevant insights when applied in empirical research.

Such research will be easier to conduct with qualitative methods (ethnography, interviews), possibly amplified by selective and specific forms of quantitative analysis, rather than with the predominantly quantitative methods that continue to dominate transport research. Qualitative methods are particularly suited for examining not only the genesis of particular apps and their capacities to generate effects (i.e. design processes and enmeshment in wider alliances) but also changes over time in the sensual qualities of app-and-human entities and the combinations of ethical substance, subjection, work and telos induced in humans. Moreover, some qualitative methods can be used to induce forms of allure in app-and-human entities, allowing researchers a fuller grasp of those objects and how they might change in surprising ways over time. Harman has repeatedly emphasised that the arts are particularly apposite to generate moments of allure in which the real qualities of an object, however dimly, shine through its sensual version (Harman 2005, 2013a). It thus follows that experimental collaborations between transport researchers and artists - from performance artists to poets to digital design artists - might shed new and unusual light on how users interact with mobility-related apps and how this might shape physical mobility patterns. Such collaboration may seem exotic to most transport

researchers but are increasingly becoming common in such fields as cultural geography (Hawkins 2013).

All of this implies that 'big data' emerging from the real-time tracking of large numbers of smartphones do not necessarily enhance understanding of the interactions between apps and physical mobility, sustainable or otherwise. Indeed, if analysed using conventional means (regression analysis, discrete choice modelling, etcetera), the data generated by real-time tracking may well end up reinforcing correlationist and instrumentalist forms of analysis of those interactions. Yet, tracking data can be of significant benefit to the type of analysis envisaged in the current paper. Because of their breadth and detail, they can help in the identification of moments of allure – for instance when a particular app breaks down. If tracking data on such moments are combined with other methods, such as in-depth interviews or mobile ethnography involving app users, it becomes feasible to understand if and how those moments of allure have resulted in new ways in which users understand and interact with the app and what, if any, the consequences are for physical mobility patterns. Mixing tracking data with other methods in this and other ways may help transport researchers better understand the full range of effects – including the paradoxical, indirect and difficult to foresee impacts – of apps and app-and-human entities on physical mobility.

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