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# How navigation systems transform epistemic virtues: Knowledge, issues and solutions

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**Abstract**

In this paper, we analyse how GPS-based navigation systems are transforming some of our intellectual virtues and then suggest two strategies to improve our practices regarding the use of such epistemic tools. We start by outlining the two main approaches in virtue epistemology, namely virtue reliabilism and virtue responsibilism. We then discuss how navigation systems can undermine five epistemic virtues, namely memory, perception, attention, intellectual autonomy, and intellectual carefulness. We end by considering two possible interlinked ways of trying to remedy this situation: [i] redesigning the epistemic tool to improve the epistemic virtues of memory, perception, and attention; and [ii] the cultivation of cognitive diligence for wayfinding tasks scaffolding intellectual autonomy and carefulness.


*Keywords:* Virtue epistemology; GPS devices; Spatial cognition; Cognitive diligence; Cognitive artifacts; Wayfinding technology; Navigation; Route knowledge; Survey knowledge; Behavioural geography; Design; Cognitive science

## 1. Introduction

Intellectual virtues are knowledge-generating capacities of epistemic agents. There are two kinds distinguished in the literature, namely reliabalist virtues and responsibilist virtues. The former are characterised as faculty-based truth-conducive capacities such as perception and memory, whereas the latter are characterised as character-based truth-conducive capacities such as intellectual autonomy and attentiveness. In this paper, we draw on a rich body of empirical evidence from cognitive science to show how GPS-based navigation systems are transforming our spatial cognition as well as several intellectual virtues. We'll argue that GPS devices can negatively impact on memory, perception, attention, intellectual autonomy, and intellectual carefulness. This is, of course, undesirable in itself, but also because our spatial cognition and spatial awareness have effects on our general sense of well-being and how much we feel at home. Given the very large amount of people using GPS devices across the globe, this is set to be a growing issue. To improve this situation, we propose and consider two strategies. First, redesigning the GPS device by highlighting incidental information about environmental features at certain key decision points. This potentially improves the epistemic virtues of memory, perception, and attention. Second, the promotion of "cognitive diligence" (Menary, 2012, 2018), a virtue concerned with carefully evaluating an informational source, thereby improving intellectual autonomy and carefulness. Jointly,

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these strategies enable agents to be more epistemically virtuous in a practical and feasible manner.

The paper is structured as follows. In Section 2, we outline the general framework of contemporary virtue epistemology, focussing on virtue reliabilism and virtue responsibilism. In Section 3, we then explain how GPS devices are transforming our wayfinding capacities, and we discuss how this undermines a range of epistemic virtues, including memory, perception, attention, and intellectual autonomy and carefulness. In the final section of the paper, we consider two possible remedies to this situation: redesigning the tool and promoting "cognitive diligence".

## 2. Virtue epistemology

Virtue epistemology is a growing branch of contemporary epistemology, focusing not so much on epistemic justification and conditions of truth but on intellectual virtues. Traditional analytic epistemology focusses on truth-values of beliefs; virtue epistemology, in contrast, is much more interested in knowledge-generating capacities of epistemic agents, namely their intellectual virtues (Battaly, 2008). Intellectual virtues are characterised in two ways, resulting in two main camps in virtue epistemology. Virtue reliabilism characterises intellectual virtues as faculty-based truth-conducive capacities such as perception, memory, reasoning, and intuition. Virtue responsibilism characterises intellectual virtues as character-based truth-conducive capacities such as open-mindedness, attentiveness, and intellectual autonomy.

Virtue epistemology has been used to better understand our epistemic relation to cognitive technology. For instance, Michaelian and Arango-Muñoz (2018) use a virtue reliabilist approach to argue for a distributed reliabilism, successfully synthesising distributed cognition and virtue reliabilism. Smart (2018) analyses the Internet from an extended cognition perspective and extended knowledge perspective, concluding that online information can – in some cases – extend our cognitive system and may count as extended knowledge engines. Finally, Heersmink (2018) uses a virtue responsibilist approach to improve our epistemic interactions with Internet search engines. The research in the current paper aims to contribute to this literature on virtue epistemology and technology. We now briefly outline virtue reliabilism and virtue responsibilism before turning to spatial cognition and the impact of GPS technologies in the following section.

### 2.1. Virtue reliabilism

Virtue reliabilists such as Sosa (2007) and Greco (2002) characterise intellectual virtues as stable cognitive faculties, including perception, memory, reasoning, and intuition. Such faculties allow us to reliably generate true beliefs about the world. Our perceptual apparatus allows reliable cognitive contact with the world, in that way generating true beliefs about perceptual objects, structures, events, and states of affairs. These may be visual, auditory, tactile, olfactory, and gustatory (or a combination of these). For most agents, these are reliable and stable faculties, providing an agent with the ability to produce and evaluate true beliefs about the external world.

Human biological memory systems store information about personal experiences (often referred to as episodic memory) and propositions such as Canberra is the capital of Australia (often referred to semantic memory)[1]. Information stored in memory may, of course, be outdated, inaccurate, or false. It is, however, clear that memory can be (and often is) an important source of both self-knowledge and knowledge about the external world. Reasoning skills include inductive and deductive reasoning as well as other basic forms of logic. Making an inductive inference based on past experiences or an inductive generalisation based on some dataset may generate true beliefs. Likewise, deducing a conclusion from true premises results in generating true beliefs. Even without formal training, most people have the ability to use reason and create new knowledge to some limited degree. Lastly, intuition may be characterised as the ability to "instinctively" know that something is true without explicitly or consciously using memory or reasoning. Insofar as intuition can generate knowledge, the cognitive processes that generate this knowledge are most likely proceduralised and executed subpersonally, that is, below the threshold of conscious awareness.

These faculties are in part natural in that we are born with them and in part cultural in that they are shaped and sculpted based on experience, training, and education. Most humans are born with the ability to visually perceive the world: we can all recognise objects and structures in our visual field. This cognitive ability, however, can be enhanced through training. Neuroscience practitioners, for example, are trained to interpret neuroimaging data such as fMRI scans (Alač & Hutchins, 2004). People who are trained to interpret these images see much more and can infer (i.e., induce and deduce) much more knowledge from these images than untrained people. The raw unprocessed percepts may be similar for trained and untrained people, but the way these percepts are processed is significantly different. Likewise, memory, reasoning, and perhaps intuition can be transformed through training and education.

### 2.2. Virtue responsibilism

As noted above, virtue responsibilism characterises intellectual virtues as acquired character traits such as open-mindedness, attentiveness, and intellectual autonomy. These are analogous to Aristotelian moral virtues in that they require the right motivation, behaviours, and

[1] This is, of course, a simplification of human memory. There are more fine-grained taxonomies and types of memory. But for the purpose of this paper, the distinction between episodic and semantic suffices.

affective response[2]. Thus, to be intellectually virtuous, an agent must want the truth, actively seek the truth, and feel satisfied or rewarded when truth is obtained (Baehr, 2015). Like moral virtues, such virtues are a mean between two vices. Open-mindedness, for example, is a mean between the vices of dogmatism and being naive. It requires experience and phronesis to be intellectually virtuous and to avoid being vicious. Virtue responsibilism has a much stronger focus on the ethical and social implications of our epistemic and cognitive capacities than virtue reliabilism (see e.g. Fricker, 2007).

In the *Nicomanchean Ethics*, Aristotle distinguishes between two kinds of virtue. "Virtue, then, is of two kinds: that of the intellect and that of character. Intellectual virtue owes its origin and development mainly to teaching, for which reason its attainment requires experience and time; virtue of character (ēthos) is a result of habituation (ethos), for which reason it has acquired its name through a small variation on ethos" (Aristotle, 2004, p. 23).

Intellectual virtue is acquired primarily through teaching, while the virtues of character arise through habit. To flourish morally, one ought to be morally virtuous. To flourish epistemically, one ought to be intellectually virtuous. Virtue ethics and virtue epistemology have in common that they both evaluate an action, whether it be moral or epistemic, in terms of the properties of the agent performing the action. Virtue ethics argues that an action is moral when it is performed by a morally virtuous agent, for example an agent who is generous or just. Virtue epistemology argues that an action is truth-conducive when it is performed by an intellectually virtuous agent, for example one who is diligent or intellectually autonomous (Turri, Alfano, & Greco, 2017).

Several responsibilist virtues are discussed in the literature, including curiosity, intellectual autonomy, intellectual humility, attentiveness, intellectual carefulness, intellectual thoroughness, open-mindedness, intellectual courage, and intellectual tenacity (Zagzebski, 1996; Roberts & Wood, 2007; Baehr, 2011). These are character traits a truth-desiring person would want to have. Montmarquet (1993) argues that these are not necessarily reliable traits. An agent is not always curious, autonomous, attentive, careful, and so on. An agent may be attentive in one context but less so in another or be more curious when in a good mood as compared to being in a bad mood (Alfano, 2012). We have an epistemic responsibility to ourselves to be as virtuous as possible and to avoid being epistemically vicious. Some philosophers have therefore argued that epistemic responsibility is the ultimate virtue from which all the other virtues derive (Code, 1987; Montmarquet, 1993).

In this subsection, we focus on a number of responsibilist virtues that we think are most relevant for evaluating the effects of GPS devices on our epistemic capacities, namely intellectual autonomy, intellectual carefulness, and attentiveness. This is, of course, not to say that other virtues are irrelevant. In other contexts, and with other cognitive technologies, other intellectual virtues may come to the fore.

Intellectual autonomy is often characterised as an ability to think for oneself. Roberts and Wood (2007) characterise it as follows:

> Autonomy is a cultural achievement passed from generation to generation. This autonomy is exemplified in the student or researcher who is able to work on his own where working on his own involves a wise dependence, a willingness and ability to tap the intelligence and knowledge of others as needed; but it also means an intelligent ability to stand one's own ground against bullying, as well as gentler forms of pressure to conform. (p. 258)

On their view, being intellectually autonomous does not mean that one cannot rely on others, or other informational resources, to obtain true beliefs (see also Carter, 2017). Rather, one has to find the right balance between being completely cognitively independent and completely reliant on other sources.

Intellectual carefulness is about avoiding errors and mistakes such as false beliefs and ignorance. To be intellectually careful, one must be aware of when common mistakes are made. Examples of such mistakes include affirming the consequent, accepting an argument from authority, begging the question, confirmation bias, and other common fallacies and faulty argument techniques. To avoid such mistakes, a basic understanding of logic and critical thinking is necessary. Intellectually carefulness thinkers will not rush to judgement but will carefully evaluate the truth-value of statements or other external representations such as maps.

Attentiveness or attention is the ability to selectively concentrate on the epistemic task at hand, while deliberately ignoring other parts of one's task-environment. An attentive agent will focus on what he or she is doing, for example listening to a lecture, watching a documentary, writing a paper, or solving some problem. It is often said that our attention span is becoming more limited as a result of the Internet and other information technologies (Wilmer, Scherman, & Chein, 2017). It is, however, possible to train oneself to become more attentive. When using GPS devises, our attention is focussed on the device, either on the screen or the audio cues it gives. In this way, GPS uses pay less attention to key features of the environment and instead shift their perceptual focus.

The relation between reliabilist and responsibilist virtues has generated substantial debate (e.g. Greco, 2000). In this paper, we don't prioritise one approach over the other. To have a full understanding of our epistemic capacities, we need both reliabilist and responsibilist virtues. The reliabalist-responsibilist distinction implies a cognitive ontology in which we can neatly carve up the components

[2] There is a lot of work done on virtue ethics and technology. Vallor (2016) and Sullins (2014, 2018), in particular, have developed theoretical models based on virtue ethics for improving our moral interactions with information technology. There is also an interesting link to the work of Patrick Lin (2016) who conceptualised moral criteria for self-driving cars.

of our cognitive system at different levels. Our view is that most of the responsibilist virtues require the reliabilist virtues. For example, to be attentive when performing some cognitive task such as evaluating a newspaper article, one needs to able to perceive to begin with. To be intellectually careful, one needs reasoning processes such as induction and deduction to evaluate information. So, on our view, reliabilist and responsibilist virtues sometimes mesh. Importantly, both kinds of virtues are necessary to interact with GPS-based navigation systems and other cognitive technologies. Perception, memory, reasoning, intellectual autonomy, carefulness, attentiveness (and perhaps other virtues) are essential to successfully interact with GPS-based navigation systems.

## 3. Spatial cognition and GPS devices

When considering navigation and wayfinding as epistemic practices, there are a number of important distinctions that one can make. We first outline these before turning to some brief details on how GPS-based navigation systems work. We then discuss the numerous ways in which navigation systems are undermining epistemic virtues in navigation and wayfinding.

### *3.1. Navigating and wayfinding*

In this section we introduce a number of important distinctions and concepts that are crucial for understanding how GPS devices are transforming human epistemic capacities in regard to spatial cognition: [1] the two differing epistemic tasks of navigation and wayfinding (and their related emotional components and import); [2] route knowledge and survey knowledge; and [3] the cultural aspects that influence this epistemic domain.

A key distinction is between navigation and wayfinding. Golledge (1999) defines navigation as planning a route of how to get from A to B, whereas wayfinding is an understanding of how this route is embedded within a wider frame of reference. Golledge, Jacobson, Kitchin, & Blades (2000); Golledge & Garling (2008) refine this definition further by stating that navigation involves following a pre-set route, whereas wayfinding involves the ability to take a novel route that has not yet been planned. For instance, an example of the former activity would be to travel your regular commute to work, whereas an example of the latter could be travelling to a novel place in your local town (such as an art supply shop you have never been to before). These two examples show that navigation and wayfinding draw on differing knowledge bases – as we shall discuss below in more detail.

Hutchins (1995) defines the two key epistemic questions in navigation and wayfinding as: "where am I?", and "given I am at point A, how do I get to point B?". But there are also other more specific questions related to navigation and wayfinding, such as how much fuel is needed to get from point A to B? What is the quickest route between A and B? What is the topology of the land between points and A and B? What are the important features of the environment that one should pay attention to whilst travelling in a particular location (e.g. road signs, landmarks; or wind direction and other meteorological phenomena; animal types and behaviours; vegetation type; astronomical phenomena; rivers, hills, and other geographical features; tidal patterns and currents; etc.)? And what is the safest route between A and B? Indeed, Golledge and Garling (2008) note that an agent's purpose (e.g., avoiding congestion, speed, or safety) for their journey can impact on their path selection. One can see how the epistemic questions blur in to social, political, and affective concerns by considering these more refined questions.

As such, although our main focus in this paper is on the basic epistemic issues, it is important to note that navigation and wayfinding are not solely epistemic tasks. Our relationship with space is not just a question of where we are, and where we are going. Our relationship to space is also imbued with a range of affective, social, semantic, political, and phenomenological aspects (Allen, 2015; Gillett, Mingon, & Thomas, in preparation; Hebblewhite & Gillett, in preparation; Ingold, 2000; Krueger, 2018). Knowledge of navigational routes and technologies for mapping the earth have long been a heavily political topic insofar that control of territory and reliable movement of peoples is the concern of large organisations (e.g. see Hebblewhite & Gillett, under submission). But there are also a range of findings that the extent to which agent's feel like they know their way around can be linked to their general state of well-being and how much they feel at home (Allen, 2015; Gillett et al., in preparation; Ingold, 2000).

There are also epistemic components to deficits in spatial cognition with a range of mental health issues such as depression, anxiety, and schizophrenia (Krueger, 2018; Wolbers & Hegarty, 2010). These disorders are often accompanied by impairments in terms of how agents judge their own knowledge and skill in traversing their local environment. Conversely, agents with the most robust wayfinding skills and knowledge – and who feel most comfortable and at home – explore and use more of the local space than other people (Lengen & Kistemann, 2012). Points in space within a specific territory in which an agent inhabits – often referred to as "fix points" or "environmental anchors" – are not just bare points but carry multiple meanings or functions (e.g., shelter, sleep, sustenance, socialising, etc.). These not only carry great emotional valence and significance, but also form an important part of how we build up knowledge of our environment and find our way around (Allen, 2015; Gillett et al., in preparation; Golledge & Garling, 2008; Shore, 2012). Although our primary focus here is on epistemic virtues, our aims at identifying and attempting to remedy the way that GPS devices transform navigating and wayfinding has wider social and normative implications. Indeed, the serious impact that GPS devices are having is perhaps best understood in this wider context.

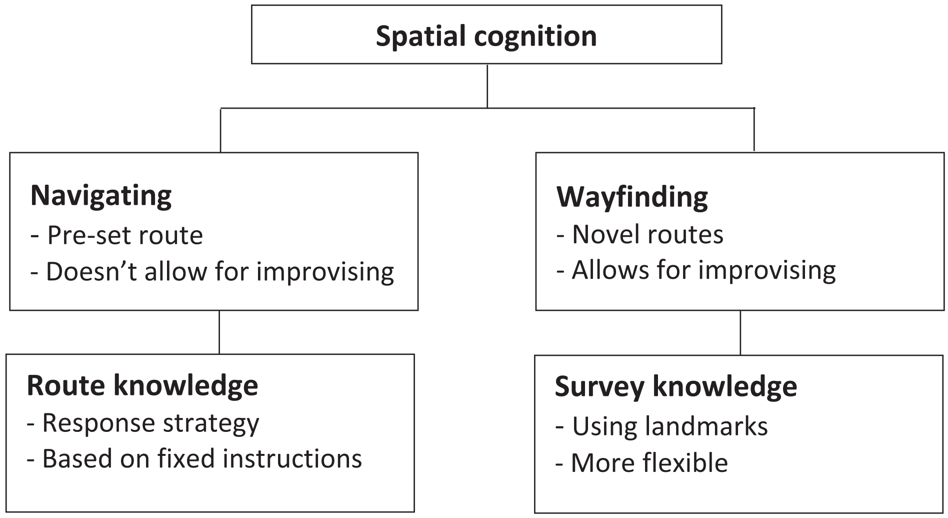


Fig. 1. Summary of key distinctions.

A related second key distinction to make is between two differing forms of knowledge that arise from the strategies associated with tackling navigational and wayfinding problems: route knowledge and survey knowledge (Ishikawa & Montello, 2006). One can tackle a spatial navigation task using one of two main strategies (although it is noteworthy that these can be blended). Firstly, one can navigate through an environment by following a set of instructions like a recipe – e.g. in order to get to the pub the agent remembers or follows a set of instructions such as "Turn left at the third junction, and then travel two blocks before taking a right." Bohbot et al. (2012) refer to this as a response strategy and it produces route knowledge that is limited to the context of that particular journey and does not pertain to a more reflexive engagement with the environment (as in wayfinding).

Another strategy is to utilise landmarks and other particular facets of the environment to get from A to B – for example, one could remember that the pub is in the vicinity of a particularly iconic building. Bohbot and colleagues refer to this as a landmark strategy and note that it facilitates a much more flexible engagement with the environment. Utilising the landmark strategy produces survey knowledge in which the agent is able to build up a more robust cognitive map and enables flexible wayfinding behaviour. Distinguishing these two kinds of knowledge is particularly important because, as we shall see below, solely relying on GPS devices only involves route knowledge. These distinctions are summarised in Fig. 1.

A final important point is in regard to how the epistemic problem-space of navigation and wayfinding is sculpted and shaped by cultural practices. Humans live in a stunning array of differing environments: from the archipelagos of the Pacific and jungles of Western Guinea, to the mountains and tundra of Central and Northern Asia, and the Megacities and urban environments in which an increasing number of our species now live and find their way around. In Section 3.5 we will focus specifically on the Inuit people of Igloolik. The recent adoption of GPS devices has impacted on their epistemic virtues in regards to navigation and wayfinding in the tundra of Northern Canada. Hutchins (1995) has noted that the process of enculturation in which an agent inculcates public representational resources related to wayfinding practices can have a serious impact on the way that an agent approaches tackling tasks in spatial reasoning and navigation (e.g. linguistic terms, geographic coordinate notational systems, physical maps and other orientation-related epistemic tools, and salient features of the environment that are appropriated as cognitive naturefacts[3]). For instance, studies by Stephen Levinson and colleagues (Levinson, 2003; Majid, Bowerman, Kita, Haun, & Levinson, 2004) have shown that primary spatial linguistic terms in differing languages can prime human agents to respond to basic spatial cognition tasks in radically different ways. Some languages preference geocentric linguistic terms to such an extent that agents can reliably indicate the cardinal directions without the aid of a compass (Haviland, 1998). This simple example shows that the kind of knowledge an agent has about their spatial environment, and the framework within which that knowledge is manipulated, can be significantly impacted on by wayfinding technologies (henceforth WFTs)[4] and practices in that agent's cultural niche.

[3] Cognitive naturefacts are naturally occurring phenomena that are utilised for a certain cognitive purpose (Heersmink, 2013). In regards to spatial navigation there are numerous examples, such as: animal behaviour, wind direction, the movement of of the sun, the magnetic field, and astronomical phenomena (Aporta & Higgs, 2005; Chao, 2017; Hutchins, 1995).

[4] It is standard within the behavioural geography literature to only refer to epistemic tools for navigation and/or wayfinding as WFTs (e.g. Mullen, Palac, & Bryant, 2016). In the following section, we shall use the acronym WFT to refer to both. However, in Section 4.1, we will distinguish between technologies that facilitate wayfinding *as well as navigation* as opposed to technologies that only facilitate navigation. This distinction shall be cashed out in terms of those which scaffold epistemic virtues.

Furthermore, it is important to note that in the case of our knowledge about spatial navigation, this cultural niche is historically shaped (Hutchins, 1995; Ingold, 2000). Sterelny (2003) refers to this as "downstream epistemic engineering". Not only do humans accumulate knowledge about their local environment and transfer this in a high-fidelity manner to future generations. They also actively alter this environment to scaffold future cognitive work. In regards to spatial navigation, Hutchins (1995, 2008) points out that much of the epistemic credit must be attributed to previous generations who have partially tackled the epistemic challenges that face the following generations. I.e. the epistemic task is not often "where am I?", but rather "given the tools and knowledge that I have acquired from my cultural niche, how do I use it to solve this problem?" GPS devices are a form of WFTs that have radically reshaped the epistemic problem-space and cultural niche in which human wayfinding and navigation takes place. Arguably, the change is dramatic enough to qualify as a paradigm shift in regards to how different our modern epistemic practices are. In order to demonstrate this, we first discuss some basic details about GPS devices themselves before then focusing on how they have transformed several epistemic virtues (memory, perception, attention, and intellectual autonomy and carefulness).

### *3.2. GPS devices*

GPS devices were invented in the Cold War by the US military and became more frequently used from the 1980s onwards. The GPS system reached full operational capacity in 1995 but was not made properly available for public use until 2000 with the end of "selective availability" (a throttling of the resolution of public signals). GPS devices work by calculating the position of the user through the line of sight of at least four satellites (Kumar & Moore, 2002). The original devices were incredibly complex to use and one had to learn a large range of knowledge about geographic coordinate systems in order to use them (Aporta & Higgs, 2005). But they are now ubiquitous, streamlined in terms of use, and can provide thematic and directional information in addition to one's mere location. I.e. the surface representations – the external representation presented to the user (Norman, 1991) – can encode, respectively, information about the local environment (e.g. topology, amenities, etc.) and also how to get from A to B with a route suggestion.

GPS devices are now increasingly incorporated into other forms of technology – especially smartphone users. Research conducted by the Pew Research Center (Anderson, 2016) shows that the number of estimated smartphone users is set to reach 2.5 billion in 2019, and that nine out of ten people use smartphones for geospatial information. Thus, understanding the impact of these WFTs is crucial. It is undoubtable that widespread availability and use GPS devices, combined with the increasing computational power for geospatial information services and systems, has radically changed how we relate to space in general (Griffin & Fabrikant, 2012). Claudio Aporta and Eric Higgs capture the positive sentiments in the following taglines: "the promise of technology", "liberate us from toil and misery", "the subordination of nature", "the quest for precision", and "the fulfilment of the geographer's dream" (2005, p. 743). Sameer Kumar and Kevin Moore note that the accuracy and precision of the satellite navigational system is unlikely to be surpassed (2002, p. 62).

It is in this context that the impact of GPS devices on epistemic virtues must be placed. The fact that human spatial cognition is heavily enculturated and that we are heavily reliant on a range of WFTs highlights that our relationship to space is incredibly malleable. But of most importance is the fact that GPS devices are qualitatively different in regards to the kinds of information processing that they involve between the agent and the world. It is this factor which is having a significant impact on a range of epistemic virtues.

The behavioural geographer Toru Ishikawa (2016) has identified that how we use most WFTs, such as a map, involves a triadic relationship between [1] internal representations – our spatial memory of a place or route (often referred to as a cognitive map); [2] external representations in the epistemic tool we are using (e.g. a map, or street sign, or some natural feature of the world, such as the stars, exploited for navigational purposes – see Section 3.4 below); and [3] the environment itself. To successfully use a particular WFT for either navigating or wayfinding, the agent must coordinate the internal and external representations and bring them into alignment with the local environment (see Fig. 2 below). For example, an agent using a paper map and compass will often physically rotate the map in their hands until it aligns with their visual field. Or, alternatively, they might rotate their bodies in relation to the allocentric coordinates of NSEW.

The key difference between GPS devices and all other WFTs is that this coordinating activity is omitted or offloaded in the use of the former. An agent using a GPS device does not need to put in much effort to coordinate the surface representation to the world, since the alignment is automatically made by the device itself. There is no need to have any coordination to an internal cognitive map (and as we shall see shortly below in Section 3.3, this is having an impact on the user's memory). We can characterise this difference in information processing as a contrast between

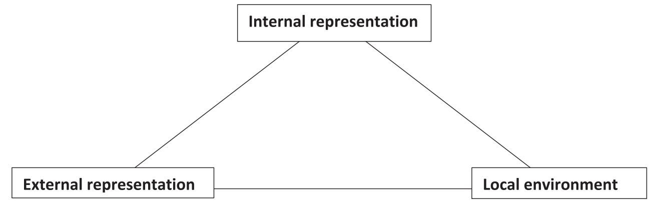


Fig. 2. Triadic information processing in the use of WFT for wayfinding and navigation. The coordination of internal and external representations, with features of the local environment.

*active* and *passive* roles for the epistemic agent (also see Li, Zhu, Zhang, Wu, & Zhang, 2013; Minaei, 2014). By altering how information is processed in regards to the core epistemic tasks of spatial cognition, GPS devices have transformed human cognition. In the following three subsections, we discuss three specific ways in which the habitual use of GPS devices undermines epistemic virtues in relation to wayfinding and navigation: memory, perception, attention, and intellectual autonomy and carefulness.

### 3.3. Memory

A range of differing studies show that GPS devices are having a significant impact on the spatial memories of their users. Field experiments in several countries comparing the performance of GPS users against other forms of WFTs have shown that GPS users perform the worst in memory recall tasks of the journey. Munzer, Zimmera, Schwalma, Bausb, and Aslan (2006) conducted a study in Germany comparing four groups navigating around a zoo. Participants were divided into one of four groups using: [1] a paper map with the route marked by a line; [2] only verbal instructions; [3] both verbal and visual instructions (i.e., a GPS user); and [4] a control group without using any navigational tools. Afterwards, participants were given memory tests about both the directions and relations between locations. Munzer and colleagues found that map-users were the best at this, and they hypothesised that this was because map-users have to engage in more *active* learning. In contrast, GPS users (group 3) do not have to encode the information to such a large degree and as such, have a poor recollection of this spatial information. I.e. it appears that GPS users are *passive* and not forming a sufficiently cogent cognitive map – indicative of the alteration of information processing discussed in the previous section.

In a similar study looking at Japanese participants, Ishikawa, Fujiwarab, Imaic, and Okabe (2008) compared three groups of participants on foot using different WFTs to move around a novel environment: [1] having a guided tour and then attempting to reconstruct the route using only internal memory resources; [2] using a paper map; and [3] using a GPS. Again, participants were tested afterwards on their memory of the route and GPS users did the worst in a range of measures, including poor sketch maps (these are standardly taken in the literature to be indicative of the sophistication, or lack, of an agent's cognitive map)[5]. Interestingly, GPS users also had to travel further during the task and rated it as harder than users of other WFTs.

A small pilot study by Burnett and Lee (2005) on twelve participants in a driving simulator found that those who used GPS devices did far worse in the subsequent memory tests of sketching out the environment that they were navigating through. In other work, Negin Minaei (2014) studied how GPS devices impacted on the wayfinding behaviour of Londoners. She found that people who habitually used GPS devices the most were the worst at seeing London on a larger scale and could not draw a good map of the area. The sketch maps of GPS users were poorest in regards to their completeness, landmarks, and scale. As with the other studies, Minaei proposes that these findings are because the GPS users are passive. I.e. they do not actively have to engage in the coordination activity between internal and external representational states, and thus the task is offloaded.

These empirical findings show that using navigation systems results in less detailed cognitive maps of one's environment. In the key distinctions outlined in Section 3.1 above, we differentiated between route knowledge and survey knowledge. It is important to note that the paucity of GPS user's cognitive maps is indicative of the fact that this form of WFT only supports route knowledge. Furthermore, several neuroscientific studies suggest that this distinction also involves different neural correlates (Bohbot et al., 2012; Maguire et al., 2000). As such, it is arguable – given the importance of memory for human lives in general – that this skewing of an agent's relationship with their spatial environment should be considered in more detail.

### 3.4. Perception and attention

GPS devices alter what agents attend to in their environment. Wayfinding expertise requires a certain way of "seeing" the environment – what Hutchins' (1995, 2008, 2011) refers to as "seeing as". To successfully use knowledge and navigate through the world, agents must attend to features of their environment that are towards this task. One must not only filter out noise but also identify salient patterns. This varies across the wide range of environments that humans live in. For instance, in multiple environments there are no straightforward visual landmarks that can be perceived. Instead, agents must cultivate practices for perceiving a range of other features in the world. For example, beyond the sight of land the traditional Micronesian navigator tracks bird motion to course correct and find land in the Pacific (Hutchins, 1995). In the dense foliage of rainforests of Western Papua, bird song is used for finding one's way around by the local population (Chao, 2017). Bird behaviour, as well as that of other animals, is also crucial to Inuit navigation in the tundra of Northern Canada (Aporta & Higgs, 2005). Inuit hunters must also be able to reliably perceive and track wind direction as their primary means of orientation because there are no stable landmarks with which to determine bearings (we return to this case study in more detail below in Section 3.5).

GPS devices undermine the development of these perceptual capacities and thus reduce the number of affordances for epistemic work. I.e. one gains less information from perceiving one's environment if one learns to

[5] However, it is important to note that there is a general natural variation amongst participants in these kinds of tests (see Ishikawa, 2016; Ishikawa & Montello, 2006).

predominantly navigate using GPS as opposed to other WFTs and wayfinding techniques. Ethnographic research indicates that GPS devices are altering the features of the environment to which agents are attending. An ethnographic study by Leshed, Velden, Rieger, Kot, and Sengers (2008) in the USA found that the use GPS devices alters the way drivers attend to the environment: they pay less attention to key features of the environment and instead shift their perceptual focus. They refer to this as altering patterns of "engagement and disengagement". Rather than paying attention to salient landmarks and other environmental cues, they merely blindly follow the audio and visual instructions. This ethnographic evidence supports the accounts of agents getting seriously lost and ignoring vital and abundant environmental cues whilst driving.

Milner (2016) has documented numerous incidents in which people have only focused on the information received from their GPS devices and have either failed to attend to, or have ignored, information in their environment. In some cases, this has comedic consequences such as a local lady in Europe driving hundreds of kilometres in the wrong direction (from Belgium to Croatia *without noticing*!). But sadly, in other cases this has resulted in deaths with people having driven into the sea and into deserts due to a lack of awareness of their surroundings. Thus, the results described above suggest that habitual use of GPS devices generate a mode of perception that makes epistemic agents less attentive to salient features of their environment.

### *3.5. Intellectual autonomy and carefulness*

To understand how GPS devices are undermining the intellectual autonomy of agents tackling navigation and wayfinding tasks, we now turn to a specific case study: the Inuit of Igloolik. We have chosen this example for several reasons. Firstly, it is an extremely inhospitable environment with very low temperatures and very bad weather conditions, such as whiteouts. Secondly, it is rather non-descript in terms of lacking major landmarks and having a shifting landscape due to icefloes and variable snow deposits. These conditions have previously made the use of WFTs of very limited use – for example, magnetic compasses don't work because of the proximity of the North Pole. Thirdly, people living in the areas around the North Pole are some of the quickest on the planet to accept and use new technologies that they deem to be useful. As George Wenzel puts it: "Probably no culture group is thought to respond to rapid technological change as dramatically as North American (especially Canadian) Inuit" (commentary response in Aporta & Higgs, 2005, p. 749).

Aporta and Higgs note how quick many Inuit have been to relinquish traditional symbols of their culture – harpoons and dog-sleds – in favour of imported and more sophisticated technologies; and that widespread use of GPS devices in Igloolik took less than a decade (2005, p. 737)[6]. This is important to note because it demonstrates that they are not luddites or traditionalists. As such, it entails that the concerns of this community over the loss of cultural knowledge are pertinent and should be taken seriously. These concerns involve a loss of cultural knowledge that is not only tied to specific skills (deskilling) but also disrupts their connections to their land and to their history – a sense of who they are and how they feel at home. As such, it threatens to undermine their flourishing both as individuals and as a community.

These three reasons make Igloolik an interesting case study to examine the impact of GPS devices – with a relatively bare social and physical environment. Without major landmarks or shared external representational systems, the local people have instead developed an incredibly rich and complex set of wayfinding practices that utilise aspects of the environment – primarily wind direction, but also animal behaviour, astronomical phenomena, and snowdrift patterns – for which they have a sophisticated and precise terminology (Aporta & Higgs, 2005). For instance, sixteen bearings can be identified in relation to four major prevailing wind-directions (p. 731). Heersmink (2013; Heersmink & Carter, in press) labels the appropriation of natural features of the physical environment for cognitive purposes "cognitive naturefacts". These epistemic practices are acquired through what Sterelny (2012) terms "hybrid learning": a mixture of direct and indirect teaching, and scaffolded trial-and-error learning. This apprenticeship system requires extensive experience to acquire a robust enough local knowledge so that agents can move around with safety in this hostile landscape. The protracted journeys on dogsleds created a serendipitous space in which this hybrid learning could take place: with experts and novices confined together the former could repeatedly quiz and test the latter in regards to certain salient aspects of their current epistemic task. As Norman (1993) and Hutchins (1995) have both noted, when one redesigns an epistemic tool, one should take care to not break these non-trivial components, which are often overlooked because they are not deliberately designed into the system.

This advanced system of cultural knowledge has enabled the Inuit to thrive in Igloolik for thousands of years. But many of the Elders now see this system of knowledge as under threat. There is a concern that many young people are failing to acquire the requisite knowledge to move around safely because of the increasing use of GPS devices. Aporta and Higgs identify two specific impacts of GPS devices on Inuit wayfinding practices that demonstrate how they undermine the virtues of intellectual autonomy and carefulness: *dislocation* and *black boxing*. We now discuss each of these in turn.

[6] Although there are some important trade-offs with the adoption of these other technologies. Some of these are discussed in subsequent paragraphs.

Firstly, GPS devices entail a dislocation of the agent in their phenomenological experience of the environment because they answer the central epistemic question of wayfinding ("where am I?") without any relationship of the agent to their local environment. We can see this by contrasting this to map-reading or other WFTs in which an agent's relationship or engagement with their environment is mediated by either a physical representation or a set of epistemic practices that guide one's perception of the environment – they still entail an engagement with the environment (the coordinating activity identified by Ishikawa). As discussed in Section 3.2 above, GPS devices can tackle the question without any sort of relationship. Thus, leading agents to play a passive role in tackling the epistemic task.

For the Inuit, the real danger here is that agents who over-rely on GPS devices lack skills for assessing and making judgements about the local conditions of their environment. Viz. the undermining of intellectual carefulness. Aporta and Higgs relate a case where a GPS device was used to move amongst moving ice floes in the fog. Even the most sceptical of the Elders have recognised that GPS devices have led to far better outcomes in this situation because they preserve fuel consumption. Previously, journeys in this changeable environment were precarious. But with a GPS device, one can simply plot a straight line back to one's base camp (devoid of attention to environmental context). However, in this case, the experts were aware that the particular ice formations suggested that this route would actually be longer and more arduous because they were able to see specific aspects of their environment (Aporta & Higgs, 2005, p. 733).

The main issue highlighted in this example is that it appears as if GPS devices have altered the affordances of those agents who have only trained in their use and have not acquired the local cultural knowledge. They lack the capacity to make accurate judgements and have a deeper connection to their local environment – these seem to have been severed by using a GPS device. But this is not a one-off example. Dislocation is highlighted by another case in which a rescue party went out in a blizzard lead by a GPS user. Guided solely by the GPS device, their path selection was too straight, and it was only the Elder's knowledge of the local area that prevented them from straying into dangerous terrain that could have killed them all (p. 736). As with the examples of accidents catalogued by Milner (2016), there seems to be serious undermining of the epistemic virtue of intellectual carefulness. And this is due to the fact that people are overly reliant on GPS devices to tackle spatial epistemic tasks – i.e. they lack proper intellectual autonomy.

Secondly, GPS devices provide instant outcomes to the challenges of wayfinding by incorporating "precomputations" – the reification of cognitive work of previous generations into a physical device (Hutchins, 1995). As such, this entails only "shallow learning" – the agent need only learn how to use these mediating artefacts rather than the deeper form of learning required in traditional wayfinding practices. The limitations on learning involved in GPS devices is partly due to the fact that the cognitive work in achieving the answer to the target problem is done "behind the scenes". Not only is there no need for the user to understand how the answer to the task is reached using a GPS device, it is arguably beyond the scope of most people – viz. to have a sufficiently deep understanding of how GPS devices work one would have to know not only about geographic coordinate systems but also some element of fundamental physics related to the propagation of signals and even a bit of both quantum mechanics and relativity. But instead, this work is done inside a "black box" and the user need only deal with what Norman (1991) calls a "surface representation".

It must be acknowledged that the condensing and codifying of information in this manner is an essential feature of the cumulative nature of human cultural knowledge (Sterelny, 2003; Tomasello, 1999). Indeed, some thinkers have argued that this is the key ingredient to our species' success (Boyd, Richerson, & Henrich, 2011; Henrich, 2015). I.e. that methods and strategies for tackling epistemic tasks at one generation are streamlined into precomputations so that future generations need not go through so much laborious epistemic work and can therefore engage in more sophisticated cognitive operations through having more epistemic resources. So, although GPS devices certainly entail shallow learning this certainly also has practical benefits. For instance, the manner in which a GPS device triangulates position in relation to at least four satellites requires taking into account the relativistic time discrepancies between the GPS device and the satellites. Additionally, the means by which the satellite and GPS device communicate by laser requires intricate quantum properties of particles. But one does not need knowledge of quantum mechanics and general relativity to understand how the device in your hand interacts with a satellite in orbit to ascertain one's position. GPS devices enable many agents to use the collective knowledge of multiple generations to complete tasks that would otherwise be infeasible. Indeed, in contrast to Aporta and Higgs (2005) emphasis on the deskillment that is at play here in shallow learning, Brown and Laurier (2012) have emphasised that learning to use a GPS device successfully requires the "revision" of existing skills. Whilst we certainly agree with this view, it is notable that this revision appears to have many knock-on effects in regards to the undermining of a wide assortment of epistemic virtues. Our claim in the following section will be to mitigate these deficits without calling for the abandonment of this obviously useful WFT in favour of some mythic past epistemic state – which some of Aporta and Higgs' more romantic claims seem to suggest.

So, we acknowledge that epistemic engineering is a key feature of our species' behaviour. However, on the other hand, it also needs to be stressed that the occlusion of so much of the epistemic work behind surface representations in GPS devices renders the agent incredibly dependent on the epistemic tool. There are a number of negative effects to this in regards to intellectual autonomy. One particularly important example here is that the agent has less strategies and skills for dealing with error. Error is a natural occurrence of all human epistemic work (Norman, 1987). Given this state of affairs, Norman argues that the design of epistemic tools should be to not only minimise errors, but also to make them clearly visible and more easily fixable when they inevitably occur (1987, p. 131). The issue with GPS devices is that they undermine the agent's development of other skills and strategies for wayfinding. They promote route knowledge more than survey knowledge and so do not scaffold the agent to make autonomous decisions about how to solve wayfinding problems nor develop a broader knowledge of their environment. Combined with the detrimental effects that GPS devices have on other epistemic virtues, this state of affairs warrants serious attention. In the next section we offer a dual proposal for alleviating this situation.

## 4. Proposed solutions

In the previous sections, we have demonstrated that GPS devices undermine a range of epistemic virtues – memory, perception, attention, and intellectual autonomy and carefulness. In this final section, we consider two sets of proposed solutions to this state of affairs. Firstly, by redesigning the epistemic tool itself so that it scaffolds the development of virtuous perception, attention, and memory. Secondly, by promoting what Richard Menary (2012, 2018) calls "cognitive diligence" in regard to the epistemic practices that assess and maintain the information utilised in getting the epistemic work done. Thereby, developing the virtues of intellectual autonomy and carefulness in relation to this epistemic task. Arguably, both remedies are necessary. Fixing only one part of the problem is unlikely to dissolve the issue. Viz. if we redesign the GPS device but do not alter how people engage with it then they are likely to still be overly reliant upon it. And if we only change people's epistemic practices this will place an unreasonable burden upon them in regards to what it means to be a properly virtuous epistemic agent in relation to spatial navigation and reasoning tasks. As such, we argue that both of the following proposed solutions should be seen as operating in conjunction with one another to enable agents to be more epistemically virtuous in a practically possible manner.

### 4.1. Scaffolding epistemic virtues through redesigning the tool

Concerns for how GPS devices undermine the memory performance of agents has motivated some researchers to consider how we might go about redesigning this epistemic tool. As Li et al. (2013) point out, GPS devices were originally designed as driving guides rather than facilitating the cultivation of spatial knowledge. Such empirical work is noteworthy given the ubiquity of these devices and how often they are relied on in modern society. We argue that this redesign of the epistemic tool can be understood in terms of facilitating and scaffolding epistemic virtues of memory and perception.

Gramann, Hoepner, and Karrer-Gauss (2017) conducted a pilot study on agents navigating around a large virtual city using either standard GPS devices (the control group) or GPS devices with modified instructions. Participants were tasked with travelling to a range of destinations using the GPS device. In subsequent trials, the participants were then tasked in navigating around the virtual city to a range of locations without the device. The modified instructions included incidental information about environmental features at certain decision points – information about the affordances of certain landmarks (e.g. a landmark restaurant and what food one might eat there). This information was supplementary to the standard response strategy (e.g. "turn left in 300 m") which only leads to route knowledge, and subtlety promotes the building of survey knowledge. This in turn allows for a much more flexible engagement with the environment (Bohbot et al., 2012; Golledge, 1999).

Although the experiment was only a pilot study with 58 participants, Gramann and colleagues found that all agents who used GPS devices with modified instructions did significantly better at navigating around the virtual city without the device in the subsequent trials (i.e. with a reduced number of errors). Importantly, users of the modified instructions did not report an increased workload from this additional information compared to standard GPS users[7]. Arguably, this suggests that the modified WFT potentially scaffolds and fosters epistemic virtues in relation to memory, perception, and attentiveness. Agents are steered by their interactions with the GPS device with modified instructions to attend to their world in a different manner. One that facilitates the development of survey knowledge, and thus enables a more robust cognitive map. The superior epistemic abilities of the agents who used the modified WFT was established over several measures. Sketch maps drawn by all participants after they had completed the task were assessed for their correct placement of landmarks, correct path segments, and correct landmark and turns. Respectively, the mean number of correctly reproduced features in the sketch maps were as follows: standard instructions – *landmarks* 3.71, *path segments*, 0.82, and *decision points* 1.88; modified instructions – *landmarks* 5.88, *path segments* 1.69, and *decision points* 4.25 (2017, p. 7). Agents who used the modified WFT did significantly

[7] Another important detail here is that users with the modified instructions were also able to follow route instructions to their original destination in a comparable manner to standard GPS devices. I.e. the modified instructions did not undermine the primary purpose of the device. This is in contrast to Li et al. (2013) Dual-Scale Exploration Aid, which although it facilitates improved spatial memory, does worse than GPS devices at enabling agents to navigate to a chosen destination.

better in both regards. This demonstrates both an improved spatial memory and perception of salient aspects of the epistemic task space.

In Section 3.2 above, we identified that GPS devices differ from other WFTs in regard to the kinds of information processing that takes place in their usage. With other WFTs there is a requirement for the agent to engage in coordinating activity between their internal representations (cognitive map), the external representations of the WFT, and salient features of the external environment. In contrast, the user of a GPS device is passive as opposed to active because this coordinating activity is either omitted entirely or is extremely offloaded or outsourced onto the GPS device itself. We can speculate here that the modified instructions variety of GPS devices might mitigate this effect since they draw the user's attention to features of the environment that would otherwise be occluded. The experimental evidence suggests that this information is encoded and thus the modified instructions potentially scaffold the agent towards a more active role in the processing and coordinating of their internal cognitive maps, the external representations of the GPS, and the local environment.

However, whilst it is a pleasing development that GPS devices could potentially be redesigned to cultivate epistemic virtues in relation to memory, perception, and attention; this is only a pilot study. Such a small sample size and a current lack of replication necessitate caution with inferences drawn from these results. Additionally, Gramann and colleagues also note that, due to reasons of practicality, there is a relatively short duration between the first trial in which the agents use GPS devices and the second trial in which they attempt to navigate un-aided. As such, we must also be cautious about making inferences about the long-term impacts of using modified WFTs. Given that many of the most negative effects of GPS devices involve long-term effects, this is currently a serious shortcoming of the positives raised by this pilot study. Lastly, even if replicated, conducted on a larger scale, and over a longer period of time, these findings must be placed within the wider context in which overreliance on GPS devices can lead to serious – potentially fatal – errors (see Aporta & Higgs, 2005; Milner, 2016; as discussed in Sections 3.4 and 3.5). As such, we cannot solely rely on fixing the device but must also re-evaluate how agents themselves use the devices. One may except a certain degree of responsibility on part of the agent when using navigation systems (Heersmink, 2017a).

### 4.2. Cognitive diligence in epistemic practices

The challenge we are faced with in attempting to cultivate epistemic virtues with regards to the usage of epistemic tools, such as WFTs, is a cost-benefit analysis (Heersmink, 2017b). Viz. how do we successfully balance the completion of epistemic tasks in an expedient fashion whilst simultaneously developing the long-term skills to maximise the agent's performance in future epistemic tasks? As discussed above in Section 3.5, one of the central benefits of the ways in which humans epistemically engineer their environments is that the cognitive workload for certain everyday tasks of successive generations is reduced. In regards to GPS devices, Brown and Laurier (2012) are right to note that learning to use a GPS device appropriately is not a complete deskillment. Although the traditional wayfinding practices are lost or no-longer passed on, new types of skills are generated and passed on. Indeed, this is what one would expect in the evolution of the cultural niche within which epistemic techniques and technologies are increasingly invented, maintained, and refined (Henrich, 2015; Tomasello, 1999). But our concern here is in how these new skills in regards to the use of this epistemic technology might be tailored to both make the best of how GPS devices streamline a complex epistemic task, but also mitigate the undermining of certain epistemic virtues – especially intellectual autonomy and carefulness. To do so, we draw on Menary's (2012, 2018) notion of "cognitive diligence".

The key point here is how should an agent assess the information they receive from an epistemic tool? On the one hand, if one is too sceptical or requires too much assessment on behalf of the agent, then the resource cannot be used in a productive or practically reasonable fashion. On the other hand, if the agent is too credulous and does not assess the source at all, they are likely to go awry if there is any fault in the information. As such, cognitive diligence is the stipulation that in assessing and maintaining an epistemic resource, an agent must strike an appropriate balance in managing this relationship to achieve their epistemic goals without undue error. As Menary puts it:

> We can think of cognitive diligence as a mean between *cognitive obsessiveness* and *cognitive laxity*. The diligent agent avoids obsessively checking the veracity of a judgement even when the evidence clearly points to an outcome and does not bother to inspect or check the veracity of his or her judgement at all. Context matters; sometimes we might want to be very, very careful (bordering on obsessive), and on others, we might perform only the most cursory of checks. (2012, p. 159. Emphasis added)

In managing a relationship between tackling a current navigation or wayfinding task, and utilising a GPS device, cognitive diligence then suggests that the agent must balance between being overly meticulous in checking all aspects of the information produced by the device, and being overly reliant. I.e. one need not sit there with a paper map and compass and cross-reference every route suggestion, nor encode every single landmark (cognitive obsessiveness). But nor does one simply give up all intellectual autonomy and simply passively follow all the instructions emitted by the WFT.

Furthermore, as Menary points out, context matters. This point seems especially important with regards to how we manage our relationship with GPS devices. A distinction can be made between habitual journeys (like the regular journeys that an agent might make around their local area) and novel journeys (to destinations in one's home environment that one may have never previously visited) or in entirely novel environments (as when one visits somewhere on holiday). Arguably, within this context we can now articulate that cognitive diligence – the extent to which one assesses and marshals the informational resource – varies depending on whether this is a one-off trip never to be repeated, or is a journey that is to regularly travelled and involves part of one's local home environment. The novel journey motivates a greater reliance on the GPS device – this WFT enables us to travel to novel locations in a manner that was infeasible for people even a few decades ago. But one should not give up so much autonomy here that one is passive. Such a state of affairs would entail cognitive laxity. Instead, when on a novel journey, the agent should still be assessing and maintaining the informational source. Additionally, such activity will scaffold the epistemic virtues of carefulness and attentiveness.

In regards to habitual journeys, we have a different context. Here, the issue is to what extent the GPS device enables an agent to learn how to get around in their local environment without the agent being so reliant on the device that they fail to build up a sufficiently robust cognitive map. The evidence collected by Minaei (2014) and others, discussed above, implies that those who remain too reliant on the device and do not develop a certain level of intellectual autonomy have the worst cognitive maps. But in order for cognitive diligence to operate in this fashion the agents must have a requisite level of wayfinding skills – i.e. specifically, a robust enough cognitive map and survey knowledge – to properly be able to play this role of inspecting the epistemic tool. Importantly, this entails an active rather than a passive role for the agent: "Virtuous epistemic agents diligently maintain the quality and reliability of the information in the environment. They create, maintain, check and manipulate that information" (Menary, 2012, p. 158).

Operating in conjunction with WFTs that scaffold epistemic virtues, we speculate that an emphasis on cognitive diligence could mitigate the many current downsides to the increasing ubiquity of this technology[8]. Furthermore, the modification of GPS devices proposed by Gramann and colleagues is minor, and given the mostly reliable information accumulated through epistemic engineering with regards to geospatial information, the postulated extra effort here in terms of cognitive diligence is not overly burdensome. Hence, both changes are feasible and practical.

## 5. Conclusion

GPS devices are transforming how we relate to space in general – but particularly, how we tackle epistemic tasks such as wayfinding and navigation. Empirical evidence indicates that an overreliance on this kind of WFT is undermining a range of epistemic virtues: memory, perception, and attention, as well as intellectual autonomy and carefulness. Given that GPS devices are now incorporated into smartphones, and that smartphone usage is increasing – with estimates set for 2.5 billion users by 2019 and with 9 out of 10 people using their smartphones for geospatial information – this is a growing problem. Using a virtue epistemology approach has enabled us to not only identify the various aspects of the problem space, but to also both [i] place these epistemic concerns with the broader framework of how it undermines human lives in general (e.g. our relationship to our homes), and [ii] offer a positive solution.

Our suggested solution is a combination of the redesigning of GPS devices and a realignment of our epistemic practices in relation to the WFT. Firstly, empirical evidence indicates that it is possible to redesign the instructions produced by GPS devices to scaffold epistemic virtues such as memory, perception, and attention. Secondly, drawing on Menary's notion of cognitive diligence, we can also encourage agents to cultivate epistemic practices for utilising GPS devices that assesses and maintains that the information provided by the devices is suitable, thereby promoting intellectual carefulness and autonomy. Working in conjunction with one another, we propose this combined solution can lead to a better use of GPs devices that avoids needless errors and negative impacts, and one that does not place too much of a burden on the agent.

Finally, our suggestions and approach fit in with a broader range of concerns and research about the impacts of ubiquitous technology on human minds. Whilst these technologies can be incredibly useful and even augmentative, empirical research by Wilmer et al. (2017) and others implies that increasing usage of smartphones in general is negatively impacting on memory, reasoning capacities, attention, and emotion regulation. However, as we have argued above, the solution here is not to regressively ban these obviously useful technologies. Instead, we have proposed that through a dual attention to both the redesigning of the device to scaffold epistemic virtues, *and* the cultivation of cognitive diligence, these negative impacts can be mitigated.

[8] A reviewer suggested to elaborate on how we should train and educate people to become more cognitively diligent. This is, of course, not an easy task to achieve. One possible strategy suggested by Heersmink & Knight 2018; Heersmink & Carter, 2018) is to teach intellectual virtues as they pertain to human-technology interaction in schools and universities. Given that life in the 21st century is characterised by spending many hours per day interacting with cognitive technologies, it is a good idea to teach pupils and students to use these technologies in an intellectually virtuous manner. This clearly doesn't guarantee that users will interact with GPS devices more diligently, but including intellectual virtues in school and university curricula (see also Baehr, 2013; Battaly, 2016) possibly gives pupils, students, and graduates the intellectual skills to interact with cognitive technologies in a more responsible way. See Heersmink and Carter (2018) for more details.

## Competing interests

We declare we have no competing interests.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cogsys.2019.03.004.

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