Augmented reality

An interactive overlay on the world

Early on the morning of July 8, 2016, a young woman named Shayla Wiggins slipped on a pair of sandals, left her mother's home in the B&K Trailer Park in Riverton, Wyoming, and walked a block or so south, toward the place where State Highway 789 crosses the Wind River.[1] She came to a chainlink fence, climbed over it, and made her way down to the riverbank on the east side of the highway bridge. There she noticed something bobbing in the water, no more than ten feet from shore. What she saw turned out to be the body of a man, later identified by the Fremont County Sheriff's Office as Jeffrey Day, 28, of nearby Arapahoe. This is how Shayla Wiggins became the first person in human history known to have discovered a body while present in two places at once.

What dragged her out of her home that Friday morning was Pokémon Go, an augmented reality (AR) game that had launched just two days before, and immediately became an unprecedented success. Like all AR applications, Pokémon Go furnishes its users with some order of information about the world and the objects in it, superimposing it on the visual field in the form of a location-specific graphic overlay. But where other applications mostly use this overlay to provide pragmatic information—directions from one place to another, historical facts about a given locale, and so on—Pokémon Go presents players with an alternative reality in which monsters of various types inhabit the Earth. You advance in the game by capturing them, and to capture them you must be physically occupying the place where the in-game map says they are.

Shayla Wiggins may have been standing with her sandaled feet planted on the gravelly bank of the Wind River, but in a very real sense she was also present somewhere else: in that dimension only visible to her through the screen of her iPhone 6, where the riverbank south of the trailer park was a perfectly reasonable place to go looking for the Water-element monster she needed to collect.

The conceptual shear between the physical world and the realm overlaid onto it led to more than stumbling onto corpses, of course. The game's enormous popularity pulled people out into the streets en masse, in a startling disruption of all the usual urban patterns—a Situationist fantasy of boundary transgression made completely and wonderfully real. Within hours of the game's release in any given market, you could find knots of players ranging the city in search of virtual monsters, bumping into other clusters of people doing the very same thing, and their mutual delight was palpable. Palpable, as well, was the total mystification of passersby, unable to imagine why so many people should suddenly be darting across roadways and stumbling into traffic with their smartphones held up before them like digital dowsing wands.

Other problems soon emerged, of the kind that became inevitable the moment somebody proposed superimposing a game of imaginary cartoon monsters onto an underlying terrain that may be strongly charged with meaning, memory and sorrow. In its first days, Pokémon Go lured players to a wide array of wildly inappropriate locations like the National September 11th Memorial and Arlington National Cemetery, where playing any sort of game can only be understood as an act of disrespect.[2] The promise of capturing rare monsters even drew people to places where simply wandering through would place them at terrible risk, like the Truce Village at Panmunjom, in the heavily fortified Demilitarized Zone between North and South Korea.[3] And I doubt that even the most cynical observer ever imagined that a developer would be so irresponsible as to enable game-play superimposed onto the barracks and crematoria of the Auschwitz death camp, but this is just what Pokémon Go did during its first week live.[4] (All of these sites were swiftly deleted from the game by developer Niantic.)

Theorists had discussed the implications of augmented reality for years, and in its first breakout hit just about all of them immediately came to pass: the reality shear, the dissonance of the mundane draped in a virtual shroud of whimsical otherness, the things that happen when different groups of people are presented with varying versions of what had always been a shared baseline environment. If AR is to be a mode through which we broadly experience the everyday, these are the issues it will compel us to contend with.

Augmented reality, and its close cousin virtual reality (VR), are a little different from the other technologies considered in this book. They are interface techniques—modes of mediation, rather than anything more fundamental. The difference between the two is largely the degree to which digital graphics dominate the perceptual field. VR is an immersive experience, and accordingly requires the use of a head-mounted apparatus that isolates its wearer from the rest of the visible world. Once ensconced inside, the user is psychically present in a thoroughly self-contained, fully rendered environment, and for the most part interacts there with things that do not exist on the outside.

By contrast, AR blends its cues and graphic overlays with the ordinary world as we perceive it, and doesn't require any particularly specialized gear. At the moment, as with Shayla Wiggins and her iPhone, the augmentive layer is most often presented on the screen of a phone or tablet. But it can also be superimposed onto a conventional window, a vehicle windshield, the visor of a helmet, or even a lightweight, face-mounted reticle, as with Google's notorious Project Glass.

AR has its conceptual roots in informational displays developed for military pilots in the early 1960s, when the performance of enemy fighter aircraft first began to overwhelm a human pilot's ability to react to the environment in a sufficiently timely manner. In the fraught regime of jet-age dogfighting, even a momentary dip of the eyes to a dashboard-mounted instrument cluster could mean disaster. The solution was to project information about altitude, airspeed and the status of weapons and other critical aircraft systems onto a transparent pane aligned with the field of vision: a "head-up display."

This technique turned to have applicability in fields beyond aerial combat, where the issue wasn't so much reaction time as visual complexity. One early AR system was intended to help engineers make sense of the gutty tangle of hydraulic lines, wiring and control mechanisms in the fuselage of an airliner under construction; each component in the otherwise-hopeless confusion was overlaid with a visual tag identifying it by name, color-coded according to the assembly it belonged to.[5] Other head-up systems were designed to help people manage situations in which both time and the complexity of the environment were sources of pressure—for example, to aid first responders arriving at the scene of an emergency.[6] One such prototype furnished firefighters with visors onto which structural diagrams of a burning building were projected, along with symbols indicating egress routes, the location of other emergency personnel, and the position of electric wiring, gas lines and other potentially dangerous infrastructural elements.

The necessity of integrating what were then relatively crude and heavy cameras, motion sensors and projectors into a comfortably wearable package limited the success of these early efforts, and this is to say nothing of the challenges posed by the difficulty of establishing a reliable network connection to a mobile unit in the pre-WiFi era. But the conceptual heavy lifting done to support these initial forays produced a readymade discourse, waiting for the day it might be possible to augment the whole world through the use of smaller, lighter, more capable hardware.

That day arrived with the advent of the smartphone. As we've seen, the smartphone handset brings together in a single package several different sensing and presentation technologies, which can be recombined to produce distinctly different ways of engaging networked information. Bundle a camera, accelerometer/gyroscope, and display screen in a single networked handset, and what you have in your hands is something that can sustain at least a rudimentary augmentive overlay. Add GPS functionality and a high-resolution three-dimensional model of the world—either maintained onboard the device, or resident in the cloud—and a viewer can be offered location-specific information, registered with and mapped onto the surrounding environment.

In essence, phone-based AR treats the handset like the transparent pane of a cockpit head-up display: you hold it before you, its forward-facing camera captures the field of view, and an overlay of information is applied on top of it. Turn, and the onscreen view turns with you, tracked (after a momentary stutter) by the grid of overlaid graphics. And those graphics can provide anything the network itself offers, whether identification, annotation, direction or commentary. Here is one of the core premises of AR: that everything the network knows might be brought to bear on someone or -thing standing in front of us, directly there, directly accessible, available to anyone with the wherewithal to sign a two-year smartphone contract and download an app. This is a deeply seductive idea. It offers an aura of omnipotence, positioned as a direct extension of our own senses.

Consider, for example, how AR might be used to address a disorder called prosopagnosia, more commonly known as faceblindness.[7] This condition affects an estimated 2.5 percent of the population, and as the name suggests, it deprives its victims of the ability to recognize faces and associate them with individuals; at the limit, someone suffering with a severe case may be unable to remember what his or her loved ones look like. So central is the ability to recognize others to human socialization, though, that even far milder cases can be the cause of significant discomfort, both for the sufferer and for those they encounter.

Sadly, this is something I can attest to from firsthand experience. Even with a relatively attenuated form of faceblindness, my broad inability to recognize people routinely results in the most excruciating awkwardness. Deprived of contextual cues—the time and location at which I habitually encounter someone, a distinctive hairstyle or mode of dress—I generally find myself no more able to recognize former colleagues or students than I can complete strangers. And as uncomfortable as this can be for me, I can only imagine how humiliating it is for the person on the other end of the encounter. I long ago lost track of the number of times in my life when I would have been grateful for some subtle intercessionary agent, a technological equivalent of the nomenclators of old: something that might drop a glowing outline over the face of someone approaching me and remind me of his or her name, the occasion on which we met last, maybe even what we talked about on that occasion.[8] It would spare both of us from mortification, and shield my counterpart from the inadvertent but real insult implied by my failure to recognize them.

In the abstract, the ambition of using AR in this role is lovely—precisely the kind of sensitive technical deployment I believe in, where technology is used to lower the barriers to socialization, and reduce or eliminate the social discomfort that might otherwise prevent us from knowing one another better. But it's hard to imagine any such thing being accomplished by the act of holding a phone up in front of my face, *between* us, forcing you to wait first for me to do so and then for the entire chain of technical events that must follow in order to fulfill the aim at the heart of the scenario.

The device must acquire an image of your face with the camera, establish the parameters of that face from the image, and upload those parameters to the cloud via the fastest available connection, so they can be compared with a database of facial measurements belonging to known individuals. If a match is found, the corresponding profile must be located, and the appropriate information from that profile piped back down the connection so it may be displayed as an overlay on the screen image.

Too many articulated parts are involved in this interaction, too many dependencies—not least of which is the cooperation of Facebook, Google or some other enterprise with a reasonably robust database of facial biometrics, and that is of course wildly problematic for other reasons. Better I should have confessed my confusion to you in the first place.

If phone-based augmentation performs poorly as social lubricant, what about another role frequently proposed for it, especially by advocates in the cultural heritage sector? The utility and value of this mode of use hinge on the argument that by superimposing images or other vestiges of the past of a place directly over its present, AR effectively endows its users with the ability to see through time.

This might not make much sense at all in a young place, especially not any of those new cities now being built from scratch on greenfield sites. But anyone who lives in a place old enough to have felt the passage of centuries knows that history can all too easily be forgotten by the stones of the city. Whatever perturbations from historical events may still be propagating through the various flows of people, matter, energy and information that make a place, they certainly aren't evident to casual inspection. An augmented view returning the layered past to the present, in such a way as to color our understanding of the things all around us, might well prove to be more emotionally resonant than any conventional monument.

Byzantium, old Edo, Roman Londinium, even New Amsterdam: each of these historical sites is rife with traces we might wish to surface in the city that occupies the same land at present. Neighborhoods overwhelmed by more recent waves of colonization, gentrification or

redevelopment, too, offer us opportunities to consider just how we arrived at our moment in time. It would surely be instructive to retrieve some record of the jazz- and espresso-driven Soho of the 1950s and layer it over what stands there at present; the same goes for the South Bronx of 1975. But traversed as it was during the twentieth century by multiple, high-intensity crosscurrents of history, Berlin may present the ultimate terrain on which to contemplate recuperation of the past.

This is a place where pain, guilt and a sense of responsibility contend with the simple desire to get on with things; no city I'm familiar with is more obsessively dedicated to the search for a tenable balance between memory and forgetting. The very core of contemporary Berlin is given over to a series of resonant absences and artificially sustained presences, from the ruins of Gestapo headquarters, now maintained as a museum called Topography of Terror, to the remnants of Checkpoint Charlie. A long walk to the east along leafy Karl-Marx-Allee—between 1949 and 1961, Stalinallee—takes you to the headquarters of the Stasi, the feared secret police of the former East Germany, also open to the public as a museum. But there's nowhere in Berlin where the curious cost of remembering can be more keenly felt than in the field of 2,711 concrete slabs at the corner of Ebertstrasse and Hannah-Arendt-Strasse. This is the Memorial to the Murdered Jews of Europe, devised by architect Peter Eisenman, with early conceptual help from the great sculptor Richard Serra.

Formally, the grim array is the best thing Eisenman has ever set his hand to—here we are most likely perceiving Serra's influence. But as a site of memory, the Monument leaves a great deal to be desired. It's what Michel Foucault called a heterotopia: something set apart from the ordinary operations of the city, physically and semantically, a place of such ponderous gravity that visitors don't quite know what to make of it. On my most recent visit, the canyons between the slabs rang with the laughter of French schoolchildren on a field trip; the children giggled and flirted and shouted to one another as they leapt between the stones, and whatever the designer's intent may have been, any mood of elegy or commemoration was impossible to establish, let alone maintain.

Roughly two miles to the northeast, on the sidewalk in front of a döner stand in Mitte, is a memorial of quite a different sort. Glance down, and you'll see the following words, inscribed into three brass cubes set side by side by side between the cobblestones:

<div align="center">

HIER WOHNTE
ELSA GUTTENTAG
GEB. KRAMER
JG. 1883
DEPORTIERT 29.11.1942
ERMORDET IN
AUSCHWITZ

HIER WOHNTE
KURT GUTTENTAG
JG. 1877
DEPORTIERT 29.11.1942
ERMORDET IN
AUSCHWITZ

HIER WOHNTE
ERWIN BUCHWALD
JG. 1892
DEPORTIERT 1.3.1943
ERMORDET IN
AUSCHWITZ

</div>

Ermordet in Auschwitz: that is, on specified dates in November of 1942 and March of the next year, the named people living at this address were taken across this very sidewalk and forcibly transported hundreds of miles east by the machinery of their own government, to a country they'd never known and a facility expressly designed to murder them. The looming façades around you were the last thing they ever saw as free people.

It's in the dissonance between the everyday bustle of Mitte and these implacable facts that the true horror resides—and that's precisely what makes the brass cubes a true memorial, indescribably more effective than Eisenman's. The brass cubes, it turns out, are *Stolpersteine*, or "stumbling blocks," a project of artist Gunter Demnig;[9] these are but three of what are now over 32,000 that Demnig has arranged to have placed, in some 700 European cities. The Stolpersteine force us to read this stretch of unremarkable sidewalk in two ways simultaneously: both as a place where ordinary people go placidly about their ordinary business, just as they did in 1942, and as one site of a world-historical, continental-scale ravening.

The stories etched in these stones are the kind of facts about a place that would seem to do well when told via augmented reality. The objection could certainly be raised that I found them so resonant precisely because I don't see them every day, and that their impact would very likely fade with constant exposure; we might call this the evil of banality. But these stones compelled me to see and interpret the mundane things I did in these streets through the revenant past, and altered my consciousness in ways subtler and longer-lasting than anything Eisenman's sepulchral array of slabs was able to achieve. Presenting the same information via AR would admittedly drain the poetry from Demnig's potent metaphor, but it's easy for me to imagine the disorienting, decentering, dis-placing impact of having to engage the world through a soft rain of names, overlaid onto the very places from which their owners were stolen.

But once again, it's hard to imagine this happening via the intercession of a handset. Nor are the qualities that make smartphone-based AR so catastrophically clumsy, in virtually every scenario of use, particularly likely to change over time.

The first of these qualities has to do with the way in which we engage the smartphone's functionality. The smartphone is a platform on which each discrete mode of operation is engaged via a dedicated, single-purpose app; any attempt at augmenting the environment must therefore be actively and consciously invoked, to the exclusion of other useful functionality. When it's used to provide an overlay, the phone cannot simultaneously be used to send a message, look up an address, buy a cup of coffee, or do any of the other things we now routinely expect of it.

The second reservation is physical. Providing the user with a display surface on which a graphic annotation of the forward view might appear simply isn't what the handset was designed to do. It must be held before the eyes like a pane of glass in order for the augmented overlay to work as intended. It hardly needs to be pointed out that this gesture is not one particularly well suited to the realities of urban experience. It has the doubly unappealing quality of announcing the user's distraction and vulnerability to onlookers, while simultaneously ensuring that the device is held in the weak grip of the extended arm—a grasp from which it may be plucked with relative ease.

Taken together, these two impositions strongly undercut the primary ostensible virtue of an augmented view: its immediacy. The sole genuine justification for AR is the idea that information is simply *there*, and can be assimilated without thought or effort. And if this sense of effortlessness will never truly be achievable via handset, it is precisely what an emerging class of wearable mediators aims to provide for its users.

The first of this class to reach consumers was the ill-fated Google Glass, which mounted a high-definition, forward-facing camera, a head-up reticle and the microphone required by its natural-language speech recognition interface on a lightweight aluminum frame. While Glass posed any number of aesthetic, practical and social concerns—all of which remain to be convincingly addressed, by Google or anyone else—it does at least give us a way to compare hands-free, head-mounted AR with the handset-based approach. Would either of the augmentation scenarios we explored be improved by moving the informational overlay from the phone to a wearable display?

A system designed to mitigate prosopagnosia by recognizing faces would assuredly be vastly superior when accessed via head-mounted interface. In fact, as things now stand this remains one of the very few credible scenarios in which technical intervention might usefully be brought to bear on relatively close-range interpersonal encounters. The delay and physical awkwardness imposed by having to hold a phone between us goes away, and while there would still be a noticeable saccade or visual stutter as I glanced up to read your details off my display, you might well find this preferable to not being remembered at all.

So maybe here is a valid role for the wearable augmentor—if, that is, we can tolerate the very significant threats to privacy involved, which only begin with Google's ownership of or access to the necessary biometric database. There's also the question of their access to the pattern of my requests, and above all the one fact inescapably inherent to the scenario: that the people I encounter are by definition being identified as being present in a certain time and place, without anyone having lifted a finger to secure their consent to that identification. By any standard, this is a great deal of risk to take on to lubricate social interactions for 2.5 percent of the population.

The Stolpersteine scenario of augmentation, by contrast, fares a little bit better. It's relatively easy to imagine how a "history layer" might usefully, and even resonantly, be superimposed on everything we see. And this suggests something about further uses for augmentive mediators like Glass, for it is by no means just historical information that can be overlaid across the visual field. If our choices are at all times shaped by indistinct currents of traffic and pricing, crime and conviviality, it's easy to understand the appeal of any technology proposing that these dimensions of knowledge be brought to bear on everything we see, whether singly or in combination. The risk of bodily harm, whatever its source, might be rendered as a red wash over the field of vision; point-by-point directions as a bright and unmistakable guideline reaching into the landscape. In fact, *any* pattern of use and activity—so long as its traces were harvested by some data-gathering system, and made available to the network—could be made manifest to us in this way. (In a later section of the book, we'll discuss the very deep challenges involved in producing any one of these bodies of information in a way that doesn't reinforce preexisting patterns of bias and injustice, but for now we need merely note that these are surely present in the datasets that some party will sooner or later attempt to layer over the world via AR.)

Some proposed uses are more ambitious still, pushing past mere annotation of the forward view to the provision of truly novel modes of perception—for example, the ability to "see" radiation at wavelengths beyond the limits of human vision, or even to delete features of the visual environment perceived as undesirable.[10] What, then, keeps wearable augmentation from being the ultimate way for networked selves to receive and act on information?

The consumer-grade augmented reality currently available confronts us with an interlocking series of concerns, ranging from the immediately practical to the existential.

The initial reservations center on the technical difficulties that are involved in articulating an acceptably high-quality experience. Most of the value in AR resides in the proposition that interacting with the world in this way will feel "effortless." But as we've seen, any such effortlessness requires the continuous, smooth interfunctioning of a wild scatter of heterogeneous elements. In order to make good on this promise, a mediating technology needs to fuse a sensitively designed interface with accurate, timely, meaningful and actionable information, and a robust, high-bandwidth connection to the network furnishing that information from any place on Earth.

Unfortunately, the technical infrastructure capable of delivering these elements reliably enough does not yet exist—not anywhere in North America or Western Europe, at any rate, not this year or next. The hard fact is that for a variety of reasons having to do with national electromagnetic-spectrum allocation policy, a lack of perceived business incentives for universal broadband connectivity, and other seemingly intractable circumstances, these issues are nowhere near to being ironed out. This probably doesn't matter very much in the context of a game like Pokémon Go, but would notably degrade the experience of anyone trying to use AR in a more sensitive register.

There are further, deeper concerns as well. In the context of augmentation, the truth value of representations made about the world acquires heightened significance. Merely by superimposing information directly on its object, AR arrogates to itself a peculiar claim to authority, of a more aggressive sort than those implicit in other modes of representation.

Very often, the information that is being furnished so authoritatively will simply be wrong. An overlay can only ever be as good as the data feeding it, after all, and the augurs in this respect are not particularly reassuring. Right now, Google's map of the commercial stretch nearest to my house provides labels for only four of the seven storefront businesses on the block, one of which is inaccurately identified as a shop that closed many years ago. If even Google, with all the resources it has at its disposal, struggles to provide its users with a description of the

streetscape that is both comprehensive and correct, how much more daunting will other actors find the same task? It's easy to argue that anyone involved in the provision of augmentive information ought to be held to a high standard of completeness and accuracy, or, at the very least, that some kind of indication should be offered as to the confidence of a proffered identification. But who is in a position to enforce any such standards?

Beyond this lies a series of well-documented problems with visual misregistration and latency, problems that have only been exacerbated by the shift to consumer-grade hardware.[11] At issue is the mediation device's ability to track rapid motions of the head, and smoothly and accurately realign any graphic overlay mapped to the world; any delay in realignment of more than a few tens of milliseconds is conspicuous, and risks causing vertigo, nausea and problems with balance and coordination. The initial release of Glass, at least, wisely shied away from any attempt to superimpose such overlays, but the issue must be reckoned with at some point if usefully augmentive navigational applications are ever to be developed.

A third set of concerns centers on the question of how long such a mediator might comfortably be worn, and what happens after it is taken off. This is of special concern given the prospect that one or another form of wearable AR might become as prominent in the negotiation of everyday life as the smartphone itself. There is, of course, not much in the way of meaningful prognostication that can be made ahead of any mass adoption, but it's not unreasonable to build our expectations on the few things we do know empirically.

Early users of Google Glass reported disorientation upon removing the headset, after as few as fifteen minutes of use. This is a mild disorientation, to be sure, and easily shaken off—from all accounts, the sort of uneasy feeling that attends staring over-long at an optical illusion, and not the more serious nausea and dizziness suffered by a significant percentage of those using VR.[12]

If this represents the outer limit of discomfort experienced by users, it's hard to believe that it would have much impact on either the desirability of the product or people's ability to function after using it. But further hints as to the consequences of long-term use can be gleaned from the testimony of pioneering researcher Steve Mann, who has worn a succession of ever-lighter and more-capable mediation rigs all but continuously since the mid-1980s. His experience warrants a certain degree of caution: Mann, in his own words, "developed a dependence on the apparatus," and has found it difficult to function normally on the few occasions he has been forcibly prevented from accessing his array of devices.[13]

When deprived of his setup for even a short period of time, Mann experiences "profound nausea, dizziness and disorientation";[14] he can neither see clearly nor concentrate, and has difficulty with basic cognitive and motor tasks. He speculates that over many years, his neural wiring has adapted to the continuous flow of sensory information through his equipment. This is not an entirely ridiculous thing to think. At this point, the network of processes that constitutes Steve Mann's brain—that in some real albeit reductive sense constitutes *Steve Mann*—lives partially outside his skull.

The objection could be made that this is always already the case, for all of us: that some nontrivial part of everything that make us what we are lives outside of us, in the world, and that Mann's situation is only different in that much of his outboard being subsists in a single, self-designed apparatus. But if anything, this makes the prospect of becoming physiologically habituated to something like Google Glass still more worrisome. It's precisely because Mann developed and continues to manage his own mediation equipment that he can balance his dependency on it with the relative freedom of action enjoyed by someone who for the most part is able to determine the parameters under which that equipment operates.

If Steve Mann has become a radically hybridized consciousness, in other words, at least he has a legitimate claim to ownership and control over all of the places where that consciousness is instantiated. By contrast, all of the things a commercial product can do for the user rely on the ongoing provision of a service—and if there's anything we know about services, it's that they can be and are routinely discontinued at will, as the provider fails, changes hands, adopts a new business strategy or simply reprioritizes. (Indeed, as we shall see, this is what happened to Google Glass itself.)

A final set of strictly practical reservations have to do with the collective experience of augmentation, or what implications our own choice to be mediated in this way might hold for the experience of others sharing the environment.

For all it may pretend to transparency, literally and metaphorically, any augmentive mediator by definition imposes itself between the wearer and the world. This, of course, is by no means a quality unique to augmented reality. It's something AR has in common with a great many ways we already buffer and mediate what we experience as we move through space, from listening to music to wearing sunglasses. All of these impose a certain distance between us and the full experiential manifold of the environment, either by baffling the traces of it that reach our senses, or by offering us a space in which we can imagine and project an alternative narrative of our actions.

But there's a special asymmetry that haunts our interactions with networked technology, and tends to undermine our psychic investment in the immediate physical landscape; if "cyberspace is where you are when you're on the phone," it's certainly also the "place" you are when you text or tweet someone while walking down the sidewalk.[15] In the past, I've referred to what happens when someone moves through the world while simultaneously engaged in some kind of remote interaction as a condition of "multiple simultaneous adjacency," but of course it's really no such thing: so far, at least, only one mode of spatial experience can be privileged at a given time. And if it's impossible to participate fully in both of these realms at once, one of them must lose out.

Watch what happens when a pedestrian first becomes conscious of receiving a call or a text message, the immediate disruption they cause in the flow of movement as they pause to respond to it. Whether the call is made hands-free or otherwise doesn't really seem to matter; the cognitive and emotional investment we make in it is what counts, and this investment is generally so much greater than that we make in our surroundings that street life clearly suffers as a result.

The risk inherent in this divided attention appears to be showing up in the relevant statistics in the form of an otherwise hard-to-account-for upturn in accidents involving pedestrian fatalities,[16] where such numbers had been falling for years, and of course we can clearly see it at work in the worrisome tally of injuries that began to mount almost immediately after the launch of Pokémon Go. This is a tendency that is only likely to be exacerbated by further augmentive mediation of the everyday, particularly where content of high inherent emotional involvement is concerned.

The sociologist Lyn Lofland argues persuasively that the ordinary flow of movement on big-city sidewalks should be regarded as a collaborative production—a hard-won achievement in "cooperative motility" that requires the most sensitive attention to the subtle signals other pedestrians issue as to their intended course and speed. But is this achievement being eroded by our involvement with technologies that demand

to be at the focus of attention, to the exclusion of all else?[17] More broadly, what does our immersion in the interface do to our sense of being in public, that state of being copresent with and available to others that teaches us how to live together, and ultimately furnishes the metropolis with its highest and best justification?

At this moment in time, the maximum enthusiasm for the prospect of wearable augmentation appears to have passed. Its vocal cohort of advocates within the technology community have, for the moment, fallen silent, though remnant expressions of zeal still burble up from time to time. Their fervor can be difficult to comprehend, so long as AR is simply understood to refer to a class of technologies aimed at overlaying the visual field with information about the objects and circumstances in it. It only begins to make sense when we grant AR its proper place in the technological imaginary.

What the discourse around AR shares with other contemporary trans- and posthuman narratives is a frustration with the limits of the flesh, and a frank interest in transcending them through technical means. To advocates, the true appeal of projects like Google's Glass is that they are first steps toward the fulfillment of a deeper promise: that of *becoming-cyborg*. Some of these advocates suggest that ordinary people might learn to mediate the challenges of everyday life via complex informational dashboards; the more fervent dream of a day when their capabilities are enhanced far beyond the merely human by a seamless union of organic consciousness with networked sensing, processing, analytic and storage assets.

Beyond the profound technical and practical challenges involved in achieving any such goal, though, anyone uncommitted to one or another posthuman program may find that they have philosophical reservations with this notion, and what it implies for everyday life. These may be harder to quantify than strictly practical objections, but any advocate of augmentation technologies who is also interested in upholding the notion of the everyday environment as a shared and democratic space will have to come to some reckoning with them.

Anyone who cares about what we might call the full bandwidth of human communication—very much including transmission and reception of those cues vital to mutual understanding, but only present beneath the threshold of conscious perception—ought to be concerned about the risk posed to interpersonal exchanges by augmentive mediation. Wearable devices clearly have the potential to exacerbate existing problems of self-absorption and mutual inconsideration.[18] Although in principle there's no reason such devices couldn't be designed to support or even enrich the sense of intersubjectivity, what we've seen about the technologically mediated pedestrian's unavailability to the street doesn't leave us much room for optimism on this count. The implication is that if the physical environment doesn't fully register to a person so equipped, neither will other people.

Nor is the body by any means the only domain that the would-be posthuman subject may wish to transcend via augmentation. Subject as it is to the corrosive effects of entropy and time, forcing those occupying it to contend with the inconvenient demands of others, the built environment is another. Especially given current levels of investment in physical infrastructure in the United States, there is a very real risk that those who are able to do so will prefer retreat behind a wall of mediation to the difficult work of being fully present in public. At its zenith, this tendency implies both a dereliction of public space, and an almost total abandonment of any notion of a shared public realm.

The most distressing consequences of such a dereliction would be felt by those left behind. What happens when the information necessary to comprehend and operate an environment is not immanent to that environment, but has become decoupled from it? When signs, directions, notifications, alerts and all the other instructions necessary to the fullest use of the city appear only in an augmentive overlay—and, as will inevitably be the case, that overlay is made available to some but not others?[19]

What happens to the unaugmented human under such circumstances? The perils surely extend beyond a mere inability to act on information; past a certain point in time, someone without access to the technology almost always places themselves at jeopardy of being seen as a willful transgressor of norms, even an ethical offender. Anyone forgoing augmentation, for whatever reason, may find that they are perceived as somehow less than a full member of the community, with everything that implies for the right to be and act in public.

The deepest critique of augmented reality is sociologist Anne Galloway's, and it is harder to answer. Galloway suggests that the discourse of computational augmentation, whether consciously or otherwise, "position[s] everyday places and social interactions as somewhat lacking or in need of improvement." Again there's this sense of a zero-sum relationship between AR and a public realm already in considerable peril just about everywhere.

This is conscious, if not in the AR community itself then at least on the part of some of the most prominent developers of commercial virtual-reality gear.[20] One of the primary functions these enthusiasts imagine for VR is to camouflage the inequities and insults of an unjust world, by offering the multitude high-fidelity simulations of the things their betters get to experience for real. This is Oculus Rift developer John Carmack: "Some fraction of the desirable experiences of the wealthy can be synthesized and replicated for a much broader range of people." Here we see articulated—in so many words, and by someone at the center of VR development for many years—the idea that all of the vertiginous inequity we live with is so entrenched and so unchallengeable that all we can do is accede to it, and that the best thing we can do with our technology is use it as a palliative and a pacifier. In a different, perhaps better world, this would be an incendiary statement. But in ours, it was received with barely a batted eyelash.

I have little doubt that there will be creative uses aplenty for VR—richly detailed, gorgeously imagined environments difficult or outright impossible to experience in any other way. I cackled with irrepressible glee, momentarily eight years old again, when in a VR playground called The Lab I stepped through the orbit of Jupiter, picked it up to examine its bands of cloud more closely, and then hurled it below the plane of the ecliptic like a schoolyard basketball. On the shoulder of Iceland's Snæfellsjökull glacier, I tossed sticks for a hyperactive animated robot dog to chase and catch, drawing a joy from its delighted bounding that would surely shock anyone who knows how I generally feel about dogs and robots both. In different ways, on different levels, these brief immersions took me a long way from the room in which I was standing—and while it happened to be a nice room, and I was happy to return to it, I also know that this won't always be the case for everyone. I wouldn't want to deny anyone these experiences, or the still more elaborate and beautifully realized ones to come. But I'm afraid that on a deeper level, Carmack has the truth of the situation.

Maybe the emergence of these systems will spur us to some thought as to what it is we're trying so hard to augment or escape from. Philip K. Dick once defined reality as "that which, when you stop believing in it, doesn't go away," and it's this bedrock quality of universal accessibility—to anyone at all, at any time of his or her choosing—that constitutes reality's primary virtue.[21]

If nothing else, reality is the one platform we all share, a ground we can start from in undertaking the arduous and never-comfortable process of determining what else we might agree upon. To replace this shared space with the million splintered and mutually inconsistent realities of

individual augmentation is to give up on the whole pretense that we in any way occupy the same world, and therefore strikes me as being deeply inimical to the broader urban project. A city where the physical environment has ceased to function as a common reference frame is, at the very least, terribly inhospitable soil for democracy, solidarity or simple fellow-feeling.

It may well be that this concern is overblown. There is always the possibility that neither augmented nor virtual reality will amount to very much—that the nausea, disorientation and vertigo they occasion simply cannot be surmounted, or that after a brief period of consideration they are actively rejected by the mainstream audience.

This was the fate of Google Glass. Within days of the first significant nonspecialist publicity around it, Seattle dive bar the 5 Point café became the first commercial establishment known to have enacted a ban on Glass,[22] and this early, weak signal solidified rapidly into a rough consensus that wearing Glass in public constituted a serious *faux pas*. The term most often used to describe users—"Glasshole"—left them with no doubt what others thought of them. By the time Google enlisted couturier Diane von Furstenberg[23] to help design a version that might be more acceptable to the public, and less fraught with overtones of Silicon Valley triumphalism, it was already too late.

Perhaps the AR systems that follow Glass will come to rest in the same cultural-aesthetic purgatory once occupied by Bluetooth headsets, or perhaps, indeed, the paradigm of the face-mounted reticle is permanently dead. But something tells me that none of the objections we've discussed here will prove broadly dissuasive. It is hard to argue against a technology that glimmers with the promise of transcendence. Over anything beyond the immediate near term, some form of wearable augmentive device does seem bound to take a prominent role in mediating the everyday. The question then becomes what kind(s) of shared space will be produced by people endowed with this particular set of capabilities, individually and collectively—and how we might help the unmediated contend with environments unlike any they have known before, enacted for the convenience of the ambiguously transhuman, under circumstances whose depths have yet to be plumbed.