Seeing and Sensing

YANAI TOISTER

Shenkar College of Engineering, Design and Art, ISRAEL

Media Theory
Vol. 8 | No. 1 | 259-276

http://mediatheoryjournal.org/

Abstract

In this article traditional paradigms of photographic seeing undergo scrutiny through the perspective of non-human sensory processes, notably echolocation, fostering a diverse, interspecies interpretation of vision. This inquiry unsettles the anthropocentric norms prevailing in photographic scholarship and technological innovation. Redefining "seeing" as a layered, multisensory activity extending past human limitations propels a revision of photography's foundational assumptions, undermining the conventional dependency on light and human vision for defining the essence of photography. Incorporating non-human perspectives, like the echolocative engagements of bats and dolphins, introduces "active sensing" – an interactive engagement between emitter and receiver, shifting away from the static, observer-centric photography paradigm. This conceptual transition advocates for an engaged, participatory framework in image creation, challenging established passive viewing models. The article particularly emphasizes the implications of these insights for autonomous transportation, like vehicle to vehicle (V2V) communication systems, which arguably mirror biological active sensing methods. This confluence of biological senses and technological advancements not only enhances our understanding of autonomous systems but also invites a dialogue with speculative narratives from science fiction, where the fusion of organic and engineered forms of sensing often prefigures the future trajectories of technological evolution and societal adaptation.

Keywords

Cross-species photographic seeing, Echolocation, Sensory-substitution devices, Active sensing, Autonomous transportation, Waymo, V2V (Vehicle to Vehicle), *Blade Runner*

> In a sense, we do see in the dark when we see that it is dark. In a more common sense, we never see in the dark (Lewis, 1980: 246).

Who are *we* that do not *see* in the dark? Notably, insufficient light for human vision does not necessarily mean darkness for all non-humans. If darkness is a species-dependant condition (Tavakol, 2022), then non-humans might be able to "see" where we cannot. And if light is also a precondition for photography (as its etymology implies), then shouldn't non-human seeing be of interest to writers on photography? With rare exceptions, this is not the case. Until recently, the non-human revealed in and by photography has been nature, machine, automatism or one of their many ontological stand-ins. Photography scholarship is rife with such rhetorical stand-ins which, to this day, form the backbone of its theory and philosophy. One notable exception to the above state of affairs is the notion of "the operative" in imagery, which need not be photographic or contain images at all, a point which most commentators fail to notice or note. Another important exception is Joanna Zylinska's tract *Nonhuman Photography* (2017), a future-facing philosophy informed by past and present technologies. Conversely, the following article begins with humbler notions of the non-human which stem from the aptitudes and behaviors of members of the animal kingdom, such as bats and dolphins. Alternative avenues for philosophizing technologies as photographic or quasi-photographic are developed with and through "traditional" forms of non-human "seeing". I also propose a speculative notion of cross-species photographic seeing (or, paraphrasing Zylinska, a not-always-human not-exclusively-photo no-graphy).

Rather surprisingly, in attempting to explicate an all-too-murky association between human vision and photography in the main, a few analytic philosophers have expressed a mild interest in the sensory aptitudes of bats (albeit only in passing). In so doing, some have also taken their cue from Richard Dawkins, an evolutionary biologist, who raised the possibility that bats might have visual experiences qualitatively like our own (1986). Bats' visual experiences, however, are further removed from those caused by vision as they are augmented by perceptual systems which can manage without light altogether. This is due to their ability to activate sound: to emit sound waves in ultrasonic frequencies and have them bounce off solid objects. Bats' brains are designed to correlate the outgoing impulses with their subsequent echoes, and the information thus acquired enables them to make precise discriminations of distance, size, shape, motion and texture of objects in their immediate surroundings. These are discriminations comparable to those that humans make by eyesight. I'll note in passing that 99.9% of all bat species *do* sense visible light, and the vision abilities of some bats are in fact *stronger* than those of humans. Thus, the saying "blind as a bat", common in numerous languages, is wrong in all those languages. However, over 70% of known bat species also possess echo-acoustic object recognition aptitudes, to greater or lesser degrees (and these bats might be referring to the other 30% of bat species as "blind as a human").

Indeed, "what is it like to be a bat?", asked philosopher Thomas Nagel, explicating the difficult nature of the notorious "mind-body problem", which occupies philosophers of mind to this day (1974). Crucially, what kind of *experience* is afforded by echo-acoustic object recognition (or simply echolocation, its shorter and more popular term), which bats practise? Is it closer to that of standard vision or rather more like audition? Disturbingly, even when opting for sayings like "bats hear sights" (or alternatively "bats see sounds") we are referring only to bats' functional states, which tell us very little about the experience of *being* an echolocating bat. As an analogy, the functional states of robots and automata do not imply that robots or automata experience anything at all. Further, since we do not know whether bats process echolocation consciously or non-consciously, we cannot speculate on the special "feeling" that bats might have about their sensory experience(s), let alone comprehend them. Thus, the most pertinent question here isn't whether (bat) audition might be equated to (human) vision, nor whether it should. This equation can and has been made. Rather, the most pertinent question concerns the ends of such equations today, and how they might serve us in the future. Clearly, functional interchangeability of sensory aptitudes is within the realm of possibility for other sentient beings which humans routinely study for the sake of understanding their own neurology (and bats, for one, feature very prominently in brain research). Therefore, considering the interchangeability (or at least malleability) of sensory aptitudes within human and humanly designed systems is a *sine qua non* (at least for theorizing about those systems' functionality, if not their experientiality). This proposition, although presented as a necessary provocation, ought to make clear that scholarship on photography is now duty-bound to reformulate the reciprocal triangular relationship between sensing (in its myriad forms), visuality and knowledge.[1]

For philosopher Gregory Currie it seemed implausible that bat echolocation would yield visual experiences that are qualitatively like our own. Currie is nonetheless willing to imagine "batlike creatures" for which visual "sensations" are caused by sound waves instead of light (1995: 59). Arguably, sound waves do give information about the objects in a creature's immediate vicinity which is sufficiently detailed and up-to-the-minute for the creature to build complex mental representations of their environment. Such a representation might be (and often is) informative in the same ways that our visual representation of the environment is. Since this is plausible, as many types of bats routinely use echolocation to forage at night (and this is but one example), then bat echolocation may indeed be functionally closer to human neurology of sight than Currie concedes.

Responding to Currie, another philosopher, Berys Gaut, has therefore referred to bat-echolocation as "para-vision", "quasi-vision", "seeing in an extended sense" and, most bewilderingly, "vision under heavy scare quotes" (2008: 394-5). In their original context, these analytic references were responding to (and debunking) Kendall Walton's transparency thesis (1984) – the philosophy of mind thesis which argues that we "see" through photographs, and that such "photographic seeing" may augment or substitute our biological sensory aptitudes (which are derogatorily referred to as "ordinary seeing"). Walton provides two necessary conditions for any experience to count as "seeing through". Firstly, *belief-independent counterfactual dependence*, meaning that one's experience of "seeing through" must depend causally and counterfactually on what is seen. Secondly, *preservation of real similarity relations*, meaning that such seeing occasions the same sort of discriminatory errors as those we are prone to make when seeing the world "ordinarily", that is, with the naked eye.

To those ends, Currie speculated that we may in the future "invent a device which emits high-frequency sound waves, which can be fitted to humans as a prosthesis, and which gives us visual sensations as a result. Then the blind will have their sight restored; they would 'see' by means of sound waves" (1995: 59). Indeed, this is almost reality as sensory-substitution devices (SSDs) which have been in existence for over a decade already offer working solutions for the legally blind, based on converting sights to "soundscapes." Notably these still utilize camera input and not sound emission and reception (so they do not yet fit Currie's bill). This is how one SSD works: "EyeMusic conveys visual information into audition, while preserving shape, colour and location. X-axis information is conveyed through time, such that visual details on the left are heard before those on the right. Y-axis information is conveyed via pitch, as higher parts of the image are conveyed through higher tones than parts lower in the image. Colors are differentiated through musical instruments" (Amedi). Of course, as functionally compelling as such technologies indeed are, because the experience of "trumpet red" will forever be unfathomable to those of us for whom the colour red appears trumpet-less, most of us still do not know what it is like to be blind.

Further, other technologies utilizing other inputs are nowadays in wide use throughout numerous specialized fields as well as in many consumer services. LiDAR scanning, for example, is used in space archaeology as well as in numerous vehicles. LiDAR, other Time-of-Flight methods and similar technologies do not utilize mechanical waves in the same ways that Currie imagined and that bats have been practising for 50 million years. Rather, they use electromagnetic waves which are purposely emitted. The emitted waves propagate through matter but without "disturbing" it (emitted soundwaves "disturb" air or other matter, causing micro-movements in it, thus allowing the sound to be received or heard). However, the principles of operation of technologies based on electromagnetic waves are very similar to those of a foraging bat – timed emissions of waves, careful reception of returning waves and their analysis (which is computational and not cognitive). And while these technologies do not turn individual humans into "batlike creatures", they nonetheless prove that echolocation, and the behaviors that accompany its uses in bats and other creatures (whales, dolphins, blind mole-rats, oilbirds and other species), could be used to explicate emerging photographic, quasi-photographic or speculative photographic technologies. This is of increasing pertinence in technologies involving multi-nodal emission and reception points, multiple participants and emergent forms of constellated and assembled knowledges, be they visual or other. Notable examples include warfare (which has mostly been written about in the context of operativity), Earth observation by satellites (for agriculture and other purposes) and autonomous transportation, some aspects of which I will explicate here.

Whether or not bat echolocation is performed voluntarily or consciously (a question far beyond the scope of this article, as proof of consciousness remains one of the holy grails of zoology), echolocation is crucially an *active* performance – afforded by and always dependent on the active and purposeful (if not conscious) emission or transmission of waves which are subsequently received or sensed. Clearly, such active performances are no longer the exclusive jurisdiction of non-human animals. Rather they are part and parcel of methods, instruments and platforms which humans also use, mostly with electromagnetic waves but also with mechanical waves. This is what zoology, neurology and other disciplines refer to as "active sensing", an ability which we humans rarely practise, unless trained to do so.[2]

Importantly, when one is susceptible to influences or interferences outside one's own body then one is often sensing emission signals (which could be mechanical or electromagnetic). Sensing incorporates not only visible light and the organs of vision but also audition and other sensory abilities which humans do not possess but select members of the animal kingdom do. A notable example is magnetoreception – the ability to perceive the earth's magnetic field, a sensory modality observed in various vertebrate species. There exist numerous examples of increased sensitivities to electromagnetic bands or physical forces which humans also sense (such as sensitivity to the directionality of light, to its polarization or to the gravitational force of Earth). Migrating birds require these to navigate across vast distances, as do honeybees dancing to their followers to indicate the direction and distance of newly found resources. Sensing is thus the utilization of *any* sensory ability (or combination of abilities) for knowledge acquisition and decision-making. It is an overarching technical and perceptual term which circumvents exclusive associations to human vision, vision-dependant imagery and occularcentrism.

Passive sensing is therefore the act of receiving and/or collecting only ambient waves for acquiring knowledge about one's physical environment ('one' here denotes both sentient and non-sentient beings). While early theories of vision (such as those of Euclid and Ptolemy) offered extramission-dependent explanations about the workings of the human eye (as an *emitting* organ), we now know, and have known since the Baroque, that the human eye is an intromission organ – capable of only receiving electromagnetic waves. Therefore, un-augmented human vision is always only a passive sensing system.

Thus, the only place where equating human vision with photography is not entirely unfounded is the photographic camera which, with notable exceptions, is only a passive sensing technology. Had this not been the case, it would have conceivably been historicized, theorized and even philosophized as something other than a proxy or substitute for the human eye (as emblemized in Andreas Feininger's 1951 photograph *The Photojournalist*). Of course, descriptions attesting to the photographer's activeness do abide, and for obvious reasons. The most interesting of these continues to be the photographer's gesture which Vilém Flusser famously meditated on (2011), pronouncing the human photographer's bodily movements to be a form of activity.[3] But be those descriptions or meditations as popular as they often are, they only reveal that while the photographer and their body (or desires) may indeed be active, their sensing apparatus always remains passive. Arguably, the most serious challenge to apparatus passivity is strobe (or flash) photography. Importantly, while strobe light isn't considered "available light" (a point that the photographer Lee Friedlander often joked about, as a strobe unit was always available in his camera case), it nonetheless remains a form of ambient light, so long as variations in its rebound times within the photographed scene are *not* intended to be measured (nor can they be with photographic cameras).[4]

Active sensing is therefore the act of receiving and/or detecting waves which are being *purposely* emitted or transmitted for the sake of sensing one's environment. Human systems of this sort include the familiar SONAR technology (conceived by Leonardo De Vinci in 1490 and not officially invented until the second decade of the 20th century), RADAR technology (conceived in the later decades of the 19th century and operationalized in the early 20th century) and contemporary Time-of-Flight technologies previously mentioned. Crucially, all such technologies involve both transmission and reception *and* emission and reception, as do their animal kingdom counterparts. In other words, they require *both* active and passive abilities, because without the latter the former would be rendered useless for the purposes of one conspecific. Arguably, these two abilities might be shared between two or more conspecifics (think of a transmitting bat and a second "wingman-bat" for receiving) but such evolutionary design would greatly limit the affordances of active sensing – not only in terms of what is received (that which exists only within an inflexibly narrow cone of transmission) but who can sense their vicinity and consequently differentiate between their sensings. Whether it is biological or technological evolution, active sensing always necessitates active *and* passive propensities.

Indeed, collecting and deciphering the patterns of rebounded self-produced emissions (in addition to those already ambient) provides rich information about the environment. It enables a wide range of species to orient themselves under conditions where light levels are low or absent. Further, since the patterns of emission are themselves changeable, so too are their afforded behaviors, making active sensing an even more powerful aptitude or technology. Echolocating animals often produce varying ultrasonic signals and can employ varying acoustic parameters such as amplitude and spectrum. For example, bats routinely adjust their transmissions in terms of call duration, source level and interpulse intervals and these adjustments are done very rapidly (certainly by human standards). They further integrate echoic information over multiple call emissions and actively track objects by aiming their calls at them (Yovel et al., 2011). Rebound echo arrival times, their amplitude and the spectrum of echo reflections thus allow these animals to discriminate the bearing, distance and features of objects of interest. Navigation and foraging are often performed this way (although not always).

Similarly, dolphin echolocation is also the purposeful production of "clicks" or "pings" and the subsequent reception of their returns, which are then processed in order to recognize object attributes. In fact, some dolphins and some bats seemingly recognize object constancy when echolocating (although rebound echoes are already highly variable even when object constancy isn't). Somewhat differently, and in the realm of active sensing by electromagnetic waves, electric fish generate discharges from an electric organ in their tail and sense the location and features of nearby objects from amplitude and phase changes in the electric field, that is, changes occurring over time.

Therefore, although navigation, foraging and all other activities a living creature may be involved in obviously happen in space, "seeing" (or sensing) may not. For bats at least, an object isn't necessarily located spatially at "X distance from my own location" at a bearing of Z. Rather, objects are located spatially at "Y return time" from bearing Z (or similarly, "A amplitude or phase change over B time"). Put differently, although all subjects live in space-time, some subjectivities emerge from time alone, as for them space is perceived exclusively through time-measurements. (Time-measurement manipulation or time-axis manipulation have thus been valuable techniques in studying these alien subjectivities.)

However, as potent as active sensing may be, it remains prone to various types of interference in media: humidity (in the air), chemical compositions (of water or air) and random obstacles (bubbles in water, moving objects, etc.). Moreover, active sensing is susceptible to the most common type of interference which is *itself*. While clearly being an effective sensory modality if a creature is solitary, when multiple active sensing creatures emit wave pulses in proximity, they may "jam" each other and mutually interfere with their ability to detect objects in their environment. For example, when a swarm of echolocating bats simultaneously lifts off to fly out of their cave colony, echolocating as they do so, the emitted and returned waves might be subject to interference. Individual echolocation calls may therefore jam or mask each other and, due to intense jamming, individual bats might have a progressively difficult time detecting the echoes reflecting off their environments (Mazar and Yovel, 2020). The exact same is true for electromagnetic transmissions. When multiple transmission sources operate in relative proximity, and in similar bandwidths, their respective wave transmissions will rarely propagate uninterrupted. Rather they will suffer from either destructive or constructive interference. Such signal jamming might be planned (as in electronic warfare for example) or it could be the unintended outcome of other conspecific presences. Indeed, avoiding such undesired outcomes has recently become a concern for (human) transportation designers as well: "our fifth-generation lidar, cameras, and radar all have different field of view requirements, so we need to carefully curate the placement of the hardware and housing design to ensure the modules aren't blocking one another" (Ahn, 2020a). Note that the "curatorial challenge" here isn't in placing the LiDAR, camera and RADAR apparatuses so that they don't occlude each other's field of view. Rather the challenge is in placing them so that their cones of transmission and fields of sensing (as opposed to fields of view!) remain as free of interference as possible.

How then do bats avoid mid-air collision? How do dolphins forage? Such creatures (and possibly other species) share a surprising strategy: *silence*. A silent bat can potentially trace another bat's position by intentionally listening in on their purposeful vocalizations (Chiu and Moss, 2008). The echoes resulting from these vocalizations may reveal valuable information about object bearings, their respective time-distances and their nature. This strategy clearly provides for swarming and chasing behavior, as well as navigation and communication, in a variety of situations. The discovery of silent behavior also implies the possibility that some creatures may be able to use their conspecifics' echolocation calls to substitute the function of their own.

In fact, echolocating animals have been reported to use *eavesdropping* to discriminate between objects or to orient themselves in the environment. Rough-toothed dolphins swimming in synchronized formation tend to produce fewer echolocation calls than those that swim in an asynchronous formation, which suggests that they use other individuals' echolocation signals for orientation. In addition, an acoustic experiment has verified that bottlenose dolphins can use echo returns from other bottlenose dolphins (receiver and transmitter) (Xitco and Herbert, 1996). A group of Hawaiian spinner dolphins have been reported to passively listen to one or a few group members' echolocation signals to orient themselves in the ocean (Lammers, 2003). Similarly, echolocating bats listen to echolocation calls made by conspecifics and use them to track food sources or find an unoccupied roost. We might provisionally conclude that passively listening animals can localize objects from echoes generated by a neighboring conspecific under a third condition (which must be met in addition to the previously mentioned conditions of proximity and bandwidth similarity): that the listener-transmitter spatial formation is knowable. When all three conditions are met, some animals can even eavesdrop on animals from other species. By extension, human systems can similarly eavesdrop on other human systems. For example, passive radar systems like the German-made Sabbia 2.0 receive signals originating from Starlink satellite constellations for target detection, acquisition and classification.[5]

The term “eavesdropping” is often applied to descriptions of a listener extracting information from others in a communication network. Indeed, most zoological studies on this topic have similarly focused on non-echolocating animals like birds or frogs doing just that. However, silent behavior revealed amongst big brown bats suggests that eavesdropping, or “cooperative echolocation”, might exist there, although differently. Eavesdropping in these contexts is strategic, reciprocal (everybody potentially eavesdrops on everybody else), accepted and expected. Importantly, the number of active individuals in a group required to support such behavior, as well as the exact types of information acquisitions facilitated by such support, remain empirically unanswered. We similarly do not know whether acoustic data carry location- and object-specific information exclusively or might deliver richer information as well. To that end, researchers using CymaScope technology have argued that the clicking sounds dolphins use for echolocation form reproducible holographic pictures (Kassewitz et al., 2016). This invites speculation that dolphins practise a “sono-pictorial” form of language, whose exact uses, depth and richness remain elusive and mysterious.

As with dolphins and bats, so too with human technologies that utilize active sensing (whether by mechanical or electromagnetic forms): seeing becomes augmentable. Such augmentation is a long way away from the “seeing-through-photographs” debated within analytic philosophies of photography. As conceptually useful as this thesis may have been to some, it remained committed to two conditions which are now outdated. Firstly, to light, which is always required for seeing through photographs (even for those rare photographic examples captured by other means), and secondly, to humans doing the seeing. However, if we accept that photography today need not involve photo (or *phos*, “light” in Greek) at all, and that non-human agents and actants might nowadays also be doing some seeing-through, then Friedrich Kittler’s pronunciation that “sense and the senses become mere glitter” (2012: 32) no longer pertains only to media outputs (as in his context) but also to media inputs. Consequently, we might prefer to accept philosophical accounts of “seeing-through-photography” as opposed to “seeing-through-photographs”. The functions of the latter are in any case different for humans and non-humans. We might even consider “cross-species photographic seeing" as a more accurate description (or to paraphrase Zylinska once more, "cross-species sensographic perception") (Zylinska, 2023).

The latter description of seeing is commensurate with at least some contemporary technologies, most notably Waymo's "Driver". Waymo is a prominent transportation company (a subsidiary of Alphabet and a sister company to Google) providing autonomous ride-hailing services in Phoenix and San Francisco. The Driver is Waymo's autonomous driving technology (which can operate on various vehicle platforms) and is trademarked as "The World's Most Experienced Driver". Sidestepping Nagel's expected reluctance to accept the Waymo marketing team's choice of words, Waymo's Driver's "experience" includes an accumulated "20+ million miles of real world driving and 10+ billion miles in simulation." This arguably equals "hundreds of years of human driving experience which benefits every vehicle in our fleet" (Ahn, 2020b). Note that the latter statement doesn't imply that every vehicle in Waymo's fleet has its own driver (as is the case with humanly driven vehicles). Rather, every driven vehicle might have its own functional states (changing in accordance with requested trajectories and road conditions, etc.) but all driven vehicles have one and the same Driver.

Much like similar services, Waymo trains its Driver by first mapping the desired territories of operation in high detail (from topography to lane markers to stop signs to curbs and crosswalks). Further, its training approximates the anticipated behaviors of hundreds of known object-types which typically share the road (from vehicles to pedestrians to pets and construction equipment) (Ettinger et al., 2021). During operation, these mappings and approximations are matched with real-time sensor inputs whenever needing to determine a vehicle's exact location, its preferred route or best courses of action (Chen et al., 2024).[6] The Driver thus instantly determines the exact trajectory, speed, lane and steering maneuvers needed to complete the vehicle's task. Importantly, the complex data gathered from Waymo's advanced suite of car sensors (including LiDARs, cameras and RADARs) is processed with artificial intelligence machine learning applications (Ngiam et al., 2022).[7] However, even without those, Waymo's Driver is an unquestionably operative imaging system. With machine learning it is arguably even more autonomous and more operative than most weapon systems, and potentially more deadly than some.

Moreover, like all operative imaging systems, there are two required conditions for operativity: data-basing, which means territory mapping and object behavior approximations, and communication. Importantly, imaging isn't a condition for operative imaging systems at all. Rather, it is only the message type (or media) carried by communication (which also requires an explanation for the absence of "operative audio" articulations). Communication in the autonomous transportation industry can be divided into several rough categories: vehicle to infrastructure (V2I), in this case Waymo vehicles communicating with their Driver; vehicle to people (V2P), which will undoubtably become more important as more autonomous vehicles share the road with more pedestrians; most uncannily, vehicle to vehicle (V2V), wherein all forms of road transport (including cars, trucks, buses, vans and motorcycles) are able to communicate *directly with each other* to share and collaborate on traffic conditions, road issues and other relevant information; and vehicle to everything (V2X), which is a generic term for referring to all forms of communication across the industry. While manufacturers like Waymo voluntarily provide some information about their V2I protocols, and V2P is a still-developing category, information about V2V communication remains limited with little to no open data about the extent of its uses today. Even so, V2V systems are always active, only then collective and finally operative.

Perhaps appropriately, "vision systems" is often the umbrella term used in the transportation industry to refer to the on-board combination of LiDARs, cameras, RADARs and other sensors a vehicle is designed with. As potent as this combination is, one of the primary limitations to vehicle vision systems remains obstacle detection. For example, vehicle vision systems (much like our own) struggle to detect "unknown unknowns" (to paraphrase Donald Rumsfeld). Such unknowns include a developing traffic jam or a broken-down vehicle behind a bend. This is where implementation of V2V functionality might prove most useful (as V2V communication is not constrained by line-of-sight, unlike some of the sensors comprising the vehicle's vision system). V2V can use dedicated short-range communications (DSRC), which is somewhat like Wi-Fi, as it operates at 5.9GHz and has a range of approximately 300 metres. And since V2V can form a mesh network with up to 10 "hops", the usability of the system can extend much further.

What is more, whether it is just the I in V2I (or rather the 2 and the I), the Waymo Driver exemplifies one way in which autonomous transportation infrastructure comprises both hardware and software (perhaps similarly to Flusser's "programme" (2020)). And whether such collective "Drivering" amounts to a form of intelligence remains contestable at this moment in time. Nevertheless, the combination of various sensing modalities, of which the photographic is but one, is already amounting to a form of augmented seeing. Furthermore, the intent of V2V developers is to eventually merge inputs from the vehicle's vision system with the communication inputs from other vehicles to eliminate redundant or conflicting notifications. We might call this "other-sensor fusion" or an "intromission-extramission cocktail". No matter the name, V2V communication in autonomous transportation ought to be understood as facilitating a unique form of collective seeing. Such collective seeing (without heavy scare quotes) is arguably quasi-photographic and hypothetically sharable within species and across species.

Be that as it may, such sharing is hardly unprecedented. The "original non-humans" did it long before vehicle designers. Accordingly, the evolving ways in which we study non-human forms of sensing, and how we taxonomize them, reveal not only present ethical stances about "non-humans" but also future epistemologies. Perhaps it is not bats which are "a fundamentally *alien* form of life" as Thomas Nagel referred to them (1974: 438), but rather human creations which might in the future perceive us as aliens. This is made abundantly clear in the *Blade Runner* film scene occurring in Hannibal Chew's eye-design lab. Hannibal Chew (portrayed by James Hong) is being interrogated by Roy Batty, a renegade Nexus-6 human replicant (portrayed by Rutger Hauer). Chew mumbles to Batty: "All I do is eyes" (or in other words, "I make others see, but I do not know"). Batty reacts by saying, "If only you could see what I've seen with your eyes". Indeed, most scholarship about Ridley Scott's film centres on the question of humanism – is agent Rick Deckard (portrayed by Harrison Ford) a replicant or a human? Are replicants human? And by far the most profound question in my eyes: Are humans human? (Macarthur 2017). Surprisingly, little attention has been given to another question from which definitions of humanity are traditionally extracted: "Do we see?" We might further ask, "How do we see?" and most crucially, "*What happens when we see through others' eyes*?"

Early iterations of the latter question have occupied philosophers since Descartes. These often featured the concept of an "evil demon" or "Deus Deceptor" (elsewhere known as "malicious demon", "evil genius", "evil doctor" or "the wizard") capable of presenting complete illusions of the external world. The most interesting of these accounts, in David Lewis's classic philosophy of mind article "Prosthetic Vision and Veridical Hallucination", raises the perplexing possibility that an illusion cast by a wizard's spell might on occasion be completely identical to sensory inputs from the external world. Contemporary systems merging vision with other sensory inputs and capable of active sensing on demand or desire are far less removed from philosophy than we may be tempted to think. With active sensing-programmed-eavesdropping now hardwired into transportation systems, on the earth's surface and in outer space, our seeing increasingly resembles the scenarios existing in zoology, or others vividly speculated on in science fiction: "It might be found that a few of us have visual systems that work on different principles from other people's. The differences might be as extreme as the difference between AM versus FM transmission of signals; analogue versus digital processing; or point-by-point measurement of light versus edge detection. If so, would we be prepared to say that the minority don't really see? Would those who belong to the minority be prepared to say it? Surely not" (Lewis, 1980: 242).

References

Ahn, Y. (2020a) *Designing the 5th Generation Waymo Driver*. Available at https://waymo.com/blog/2020/03/designing-5th-generation-waymo-driver.html (Accessed 30 November 2023).

Ahn, Y. (2020b) 'Designing the Waymo Driver', *Waymo*, 26 March. Available at https://youtu.be/o8rCOKSDMcg?si=omtXdH66_z-PPqZE (Accessed 30 November 2023).

Amedi, A. (No date) *Eye Music*. Available at https://www.runi.ac.il/en/research-institutes/psychology/bct/projects/ (Accessed 30 November 2023).

Amichai, E. and Y. Yovel (2021) 'Echolocating bats rely on an innate speed-of-sound reference', *Proceedings of the National Academy of Sciences of the United States of America* 118(19):1-9.

Chiu, C. and C. F. Moss (2008) 'When Echolocating Bats Do Not Echolocate', *Communicative & Integrative Biology* 1(2): 161-162.

Chiu, C., C. F. Moss and W. Xian (2008) 'Flying in Silence: Echolocating Bats Cease Vocalizing to Avoid Sonar Jamming', *Proceedings of the National Academy of Sciences of the United States of America,* 105 (35): 13116-13121.

Currie, G. (1995) *Image and Mind: Film, Philosophy and Cognitive Science*. Cambridge: Cambridge University Press.

Dawkins, R. (1986) *The Blind Watchmaker: Why the Evidence of Evolution Reveals a World without Design*. New York: W. W. Norton & Company.

Flusser, V. (2000) *Towards a Philosophy of Photography*. London: Reaktion.

Flusser, V. (2011) 'The Gesture of Photographing', *Journal of Visual Culture* 10(3): 279-293.

Gaut, B. (2008) 'Opaque Pictures', *Revue Internationale de Philosophie* 246(4): 381-396.

Kassewitz, J., M. T. Hyson, J. S. Reid and R. L. Barrera (2016) 'A Phenomenon Discovered While Imaging Dolphin Echolocation Sounds', *Journal of Marine Science: Research & Development* 6(202).

Kittler, F. A. (2013) 'Gramophone, Film, Typewriter', in J. Johnston (ed.) *Literature, Media, Information Systems.* London: Routledge, pp.31-49.

Lewis, D. (1980) 'Veridical Hallucination and Prosthetic Vision', *Australasian Journal of Philosophy,* 58(3): 239-249.

Macarthur, D. (2017) 'A Vision of Blindness: Blade Runner and Moral Redemption', *Film-Philosophy,* 21(3): 371-391.

Mazar, O. and Y. Yovel (2020) 'A sensorimotor model shows why a spectral jamming avoidance response does not help bats deal with jamming', *eLife* 9: 1-23.

Lammers, M. O. (2003) 'Directionalty in the Whistles of Hawaiian Spinner Dolphins (Stenella longirostris): A Signal Feature to Cue Direction of Movement?', *Marine Mammal Science* 19(2): 249-264.

Nagel, T. (1974) 'What Is It Like to Be a Bat?' *The Philosophical Review* 83(4): 435-450.

Salerno-Garthwaite, A. (2024) 'Germany demonstrates passive radar system using Starlink satellite radiation', Army Technology, 18 January. Available at https://www.army-technology.com/news/germany-demonstrates-passive-radar-system-using-starlink-satellite-radiation/?cf-view (Accessed 1 March 2024).

Scott, R. (1982) *Blade Runner*. Film.

Seidel, V., J. Heckenbach, F. Kriehmigen, I. Pisciottano, M. Ummenhofer and C. Diego (2022) 'High resolution DVB-S based passive radar for ISAR imaging and drone detection', in *EUSAR 2022; 14th European Conference on Synthetic Aperture Radar*, Leipzig: 1-4.

Tavakol, R. (2022) 'Thinking Dark Anew', *The Journal of Natural and Social Philosophy* 18(2): 467-485.

Walton, K. L. (1984) 'Transparent Pictures: On the Nature of Photographic Realism', *Critical Inquiry* 11(2): 246-277.

Xitco, M. J. and H. L. Roitblat (1996) 'Object Recognition Through Eavesdropping: Passive Echolocation in Bottlenose Dolphins', *Animal Learning & Behavior* 24(4): 355-365.

Yovel, Y., B. Falk, C. F. Moss and N. Ulanovsky (2011) 'Active Control of Acoustic Field-of-View in a Biosonar System', *PLoS biology* 9(9).

Zylinska, J. (2017) *Nonhuman Photography*. Cambridge: The MIT Press.

Zylinska, J. (2023) *The Perception Machine: Our Photographic Future from the Eye to AI*. Cambridge: The MIT Press.

Notes

[1] An intriguing reformulation is offered by Zylinska. Therein the outcomes of photography's encounters with other media technologies (dubbed "sensography") reconfigure perception "on an individual, societal and infrastructural level" (Zylinska, 2023: 18). My account shares a great deal with Zylinska's (notably its desires, spirit and arguably conclusions), but differs in three important aspects: definitions of infrastructure, non-causal linearity and an emphasis on temporality.

[2] Daniel Kish, a totally blind man, is a living example that human echolocation is indeed possible.

[3] Note that most such descriptions attempted to prove that activeness guarantees subjectivity (as opposed to objectivity, which photo-modernism so needed to distance itself from).

[4] Such measurements were at times possible in the assembled and constellated systems constructed by Harold "Doc" Edgerton, but these don't traditionally qualify as photographic and they require a separate article, which is currently being written.

[5] Sabbia 2.0 systems are thus unsusceptible to jamming and have reduced detectability by potential adversaries.

[6] GPS is also used by the Waymo Driver, but not exclusively since signal strength may not always be sufficient.

[7] Interestingly, some of Waymo's promotional materials feature a LiDAR, camera and RADAR triad while others opt for a LiDAR, vision and RADAR combination.

Yanai Toister (Ph.D.) is an artist, writer and educator. Toister is an associate professor at Shenkar College of Engineering, Design and Art in Tel Aviv (where he was director of the Unit for History and Philosophy between 2017–22 and Dean of International Programs between 2022-24). Toister's artworks have been shown in numerous solo and group exhibitions (including Sandroni.Rey, Los Angeles; Dvir Gallery, Tel Aviv; Kunstahalle Luzern, Switzerland; Bolsky Gallery, Otis College of Art and Design, Los Angeles; Maison Europèenne de la Photographie, Paris; the 11th International Architecture Exhibition at the Venice Biennale; Kunstmuseen Krefeld, Haus Lange, Krefeld, Germany; and Israel Museum). Toister's writing has been published in various catalogues and journals (including *Digital Creativity*; *Flusser Studies*; *Journal of Visual Art Practice*; *Journal of Science and Technology of the Arts*; *Philosophy of Photography*; and *Photographies*). Toister's book *Photography from the Turin Shroud to the Turing Machine* has been published by Intellect/University of Chicago Press.

Website: https://yanaitoister.com/

Email: yt@yanaitoister.com