Technical Responses To Critique: The Case Of Skin Tone

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Abstract

How do technical actors respond to critique by developing novel technologies? In this paper, we follow the actors that have positioned themselves as critics of technology; we examine the inspirations and sources of their critical capacities and; we trace the development of concrete technological artifacts designed to respond to those critiques. To illustrate our approach, we outline the case of digital cameras tuned to capture diverse human skin tones, a technical response to long-standing critiques of whiteness bias in photography. Our investigative approach synthesizes three theoretical threads: the sociology of critical capacities, the anthropology of ethics, and studies of valuation. To trace the arc of technical responses to critique: (i) inspect the conditions under which actors are, or are not, capacitated to be critical; (ii) the conditions in which critiques are communicated, disputed, modified, furthered or ignored; and (iii) trace how matters of concern are materialized in technical outcomes.

CCS Concepts

• **Human-centered computing** → **HCI theory, concepts and models**; **Computer supported cooperative work**.

Keywords

skin tone; race & ethnicity; Big Tech; critique; camera; methodology

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1 Introduction

Today 'Big Tech' is the subject of a great deal of social critique. The weight of scrutiny and demands for reform can be heard from the academy, in protests on the streets, and increasingly, in the press and social media. What effect does all this critique have? In this paper we seek to develop approaches to inspect the operations of critiques that result in technical transformations and novel computational capacities: where do these critiques come from, how do they gain traction within technical enterprises, and under what conditions do these critiques result in transformations to technical capacities themselves?

To illuminate these questions we inspect the case of Real Tone, a complex package of technologies that we unpack below, but which can be summed up as better tuning cameras to capture the diversity of human skin tones. Real Tone is a response to a long standing recognition of white bias in the design of both film and digital/computational photographic cameras: a failure to accurately capture darker skin tones [95]. Since 2021, Real Tone has been built into a commercial product—Google's Pixel 6 series (onwards) smartphone's camera [20, 89]. We trace Real Tone's arc of development, specifically focusing on the relationship of longstanding and mounting criticism and technical responses in the form of a novel camera. In our analysis, we recount many arguments for and against cameras tuned to skin tone, but we are neither critiquing Real Tone nor championing it; instead, we seek to trace the emergence of a novel technical capacity as a response to critique.

Conducting this analysis demanded we develop a novel methodological approach in which we are analysts of both critique and technical response. Our primary contribution in this paper is to offer this symmetrical theory-method package that will serve to inspect the development of critiques, their adoption by technical actors, and to trace the development of novel technical capacities responsive to those critiques. To do so we synthesize theoretical traditions that have not been considered in CSCW or CHI, namely, the sociology of critical capacity [9], studies of valuation [35], and the anthropology of ethics [78], three theoretical approaches that have tuned themselves to inspecting the cultures and consequences of critical analysis.

In surveying the existing discourse around Big Tech in CSCW and CHI and bringing it in conversation with critical capacities literature, we argue that critique is not external to the phenomena, nor is it the exclusive role of the distant analyst nor the explicit activist (as we will show, these actors are part of the situation, but not the only). Our study problematizes [37] such understandings by locating responses, reactions and its consequences simultaneously within ongoing and over seemingly disconnected historical sociotechnical endeavors. We recount decades old, and since mounting, objections to legacies of white bias in camera design and demonstrate how a long pathway of articulating critique, stretching back to the 'pre-digital', was needed to animate reforms today at the bleeding edge of digital-computational innovation.

We build our analysis using public interviews and those we conducted ourselves, public documentation released by Google, and published scholarly literature as we trace these formations of critique taking shape within Big Tech. We do this by tracing the critical capacity of internal actors such as marketing professionals,

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product managers, image engineers, artists, user researchers, community experts and technologists. Without such inspections of the 'inside' of an organization one misses how change can occur at all, especially at scale (as with a commercial camera) and misses the necessary dynamic that we emphasize as an 'internal adoption of critique.' We show how critique needed to be translated again and again 'into' the local concerns of technical actors, and then 'outwards' as a marketed product, and only thus came to have material consequences in the world. Following Boltanski & Thévenot [9], we propose that critique needs to be a part of the empirical analysis, rather than only inspiring it, or remaining an uninspected part of the researcher's toolbox : Where, why, and from whom does critique come from? How did past criticisms capacitate actors 'today'? The paper follows a three part structure, first examining the sources of critical capacity, then how those critiques were translated across spheres of scholarship, activism, the popular press, engineering and marketing, and finally how those critiques came to shape a newly capacitated technology.

The sources of critical capacity: Our first section finds the sources of critical capacity stretching back decades, a long-standing recognition of white bias in cameras. But that trajectory is also surprising, not simply rooted in concerns with capturing diverse skin tone in a racially tumultuous America, but also in an industry that faced demands to capture the color-tone of other things, such as wood and chocolate. Humanistic and social scientific scholarship too play a direct role in popularizing critiques of white bias, serving to translate into public discourse the experiences in industry and consumer's dissatisfaction with photography. These critiques eventually make their way to Google by way of this scholarship and its popularization in the press, such as with the New York Times and Aperture magazine, in the everyday curriculum of university photography classes, and amongst other direct and less direct avenues.

Translating critique: In this section, we trace how these decades-old critiques of cameras were translated 'into' Google via re-articulation as a doable engineering problem [41]: a challenge of designing a digital-computational camera responsive to diverse skin tones, while also satisfying the many ongoing concerns of marketing, legal, manufacturing, a financial 'bottom line', and the product launch cycle itself. Crucially, this is all accomplished in a process that also sought to engage and give voice to the impacted community, here users of Pixel camera who have darker skin tones.

Materialization: Our final section traces the completion of the arc of development, focusing on the widely heterogeneous work that was needed to market, manufacture and circulate this novel technical capacity–Real Tone. We focus on the collaboration of the team at Pixel camera with 'community image experts', an activity Google came to recount as 'a process of listening'. We also trace how deep concerns with Real Tone's reception in the context of existing social critique of Big Tech led to processes of seeking certification from external evaluators about the degree of inclusiveness that could be claimed. Finally, we discuss the work of alignment that is required to design and develop a 'human centered' product and launch it as "the most inclusive camera in the world" [91].

This paper attempts to trace the development of technologies aimed at social transformation. We show that critique itself must necessarily be treated as an inseparable object of analysis and not as something external to the studied phenomenon. Our efforts are aimed at providing a deeper understanding of the mechanisms by which change does or does not occur in the world.

2 The Conditions of Critique and their Consequences

Critical approaches have long been a part of CSCW and HCI and today are a thriving subset of the field, but there has been very little scholarly work that has sought to unfold the conditions under which critique occurs (or not), and trace their consequences (or lack thereof). In this theory and literature review section we weave together, on the one hand, three threads of formal social scientific scholarship that have sought to inspect conditions of critique, and on the other hand, those HCI and CSCW scholars who have attempted a clear-eyed pragmatic inspection of their own conditions as they engaged in public critique and action.

Critical perspectives have historically been an integral part of HCI, and as a responsive and sensitive field it has grown to confront more complex socio-technical evaluations that address ethical, cultural, and political dimensions of technology in society. We are taking a necessarily broad view of critique as it is a multifaceted, 'loaded' term. Thinking along with Puig de la Bellacasa [26] we see critique here (of others and ourselves) as an act of embodied care, as a task of asking the difficult questions that push and pull at the boundaries of our discourse. We also align ourselves with Su et al. who treat critique as ordinary and situated [103] as it diverges from the "paranoid inquiry" approach identified by Sedgwick [98], characterized by a defensive and preemptive critical stance that often leads to predictable outcomes–limiting alternative, generative possibilities.

Research in HCI often seeks to interrogate the ways technologies embody, reflect, and shape human values. There is a long tradition in CHI that fosters and critically engages values in design through critical design methods such as Value Sensitive Design [11, 25, 39, 40] and Speculative Design [8, 19, 34, 36, 87]. Concomitantly, extensive discussion has also taken place about the limitations and potentialities of values within a design justice framework [21], urging us to consider "whose values?" as they mount a critique of 'universal values' [3, 23, 43]. On the other hand, valuation studies focuses on the socio-material practices through which value is created, negotiated, and stabilized in various domains, such as markets and cultural institutions, sometimes drawing significantly from the sociology of critical capacities [30, 58].

Existing studies in CHI and CSCW have extensively looked at aspects of inclusion and diversity [60], AI ethics [18], activism and academia [71] and the affective, felt dimensions of critique [103]. Metcalf et al. observe that as critical data studies gain traction in the tech industry, there is growing skepticism about the meaning of "tech ethics" [80]. They are in conversation with Ogbonnaya-Ogburu et al. in critiquing the surprising beneficiaries of diversity and inclusion programs, such as the leaders of such programs. While committed to ending all discrimination, they recognize the risk of diluting race concerns under the broad term 'diversity' and "treating

race as a discrete variable in the design process" [85]. Hoffman also critiques the inclusion paradigm, as "itself a kind of technology" of subjectivation through accepting the terms of inclusion [60]. Hoffman follows Walcott [105] in arguing that "inclusion discourses gesture toward social transformation as a way to diffuse resistance to structural conditions of domination and subordination". Chi et al. argue that while diversity and inclusion are becoming more actionable for engineers through technical means like diverse datasets, this approach often neglects broader civil rights contexts and the deeper societal implications of these values. Relating this reconfiguration to the histories of corporate diversity and inclusion work in the 1980's, they assess it as making a tradeoff in short term progress in diversity goals for longer term social reform by privileging 'a drift into engineering logic' [18]. We recognize these critiques of diversity, inclusion and ethical paradigms as they are implemented in different aspects of tech organizations. These frameworks of addressing differences in society are far from perfect and in most cases as the literature suggests, are inadequate. We situate ourselves in the middle of these debates and we focus our attention inside the tech organization where we can empirically trace these processes of encoding values (such as inclusivity) into a technical artifact.

To conduct our analysis we draw from three theoretical traditions that have as yet received little attention within HCI and CSCW: the anthropology of ethics, the sociology of critical capacities, and valuation studies. Each of these are vast research programmes unto themselves, but here we hone them to a single key point we draw from each. These three programmes do not each fully cohere with the other – they disagree on the fine points – but still share a common commitment to treating critique as the empirical object of study, as part of the phenomena rather than external to it:

(1) An anthropology of ethics (and not an 'ethical anthropology') has sought to recognize that today ethics has become a vast sphere of institutional action, with its own venues, actors and resources. Tech ethics in particular has its own conferences, funding lines and publication venues, all of these activities occurring 'here amongst the anthropos' rather than in some rarefied ethical atmosphere divorced from practical human concerns. Metcalf et al., for example, have traced how the field of 'critical data studies' – its language, styles of argumentation, and key intellectual figures – have gained enormous traction in the tech industry, becoming one of the *de facto* ethical registers in tech scholarship and popular press discourse, all at once [80]. An anthropology of ethics thus recognizes that such spheres operate with all the trappings of modern human life: within the halls set to discuss ethics there are also are reputations and careers at stake, there are those with more resources and less, there are institutionalized pathways of influence and buttressed corridors that seek to corral them. In sum, the dynamics of human life are not left behind by those spheres that have dubbed themselves to be concerned with ethics–ethics instead occurs in real world practical and material circumstances. In this paper what we wish to draw from an anthropology of ethics is to treat ethical action symmetrically [54] with all the other spheres of action (technical, marketing, activism) that we inspect as a matter of technical response to critique.
(2) Valuation studies has sought to examine the assignment of 'value' as a practical process that can be examined empirically [32]. The term 'value' in valuation studies tends to operate as an intentional double-entendre, meaning both 'values' in their moral sense but also in its economic sense, i.e. the generation and exchange of worth. What is 'valued' is a matter of both. In this, valuation scholars have examined, for example, economic practices of discounting [29]. What we wish to draw from valuation studies is a practical inspection of the techniques by which value is assigned [32, 74], techniques which we approach as simultaneously about moral concerns (such as racism) and about economic value (such as selling a camera). Real Tone is at times one, at times the other, and at many other times the two are difficult to distinguish.
(3) The sociology of critical capacities (and not 'a critical sociology') has sought to examine the conditions under which actors are capacitated to be critical: Where does critical thought and argumentation come from? What kind of practical work does it take to develop novel forms of critique? Under what conditions can critique be heard and acted upon, or not? The main foil for the sociology of critical capacity has been any form of scholarship that treats critique as though it does not require an explanation or as though it does not demand a historical or practical accounting. Any treatment of critique that approaches it as primarily ideational or moral, rather than practical and accomplished, fails to recognize critique as necessarily situated and done.

What we wish to draw from a sociology of critical capacities are empirical methods for tracing who articulated critiques, and who, based on those criticisms, in turn engaged in projects of reform. In sum, we attend to the conditions of possibility for critique [38]. In doing so, what we found is that concerns with white bias in photography emerged from surprising sites, with some of the most vocal voices only sometimes concerned with racism, and very often instead animated by other kinds of critiques. As Lorna Roth in her study of Shirley Cards (reference standards for skin color, more on that below), lamented about the history of reforms to racism in photography:

> Peoples of colour, whose embodied imagery would have benefited from a more sensitive chemical emulsion in the case of still photography and a more dynamic range in the case of digital technology, were not the constituency group leading the visual engineers and scientists to further explore the dynamic range of their company's film products. [93]

Roth found that the criticisms that animated reforms to Shirley Cards, and then also recent phases of digital reforms, were often driven neither by critical scholars nor the impacted racial groups. Instead it was other actors within commercial enterprises, such as those concerned with advertising products, who drove initial reforms. Still, those initial reforms were then mobilized by other actors more directly concerned with social justice. Written in the language of the sociology of critical capacities, these critiques were drawn from an 'industrial order of worth' [10], and not the 'civic order of worth' that usually animates anti-racist endeavors. In

sum, the sources of critique–where they 'come from'–are more heterogeneous than any account that only roots them exclusively in critical scholarship or popular activism.

CSCW and CHI have largely not yet engaged these intellectual traditions. Nevertheless, these fields have not been wholly absent of comparable concerns, with a deep desire to approach social reform with reflexive (rather than idealist) care, and sometimes an astute understanding of the real-politique of achieving reform in a world of competing interests. As an illustrative example drawn from work in CSCW and HCI, one exemplary work has been Irani & Silberman's long-term work on the Turkoptikon [61, 62]. Very briefly, Turkoptikon sought to turn the eye of surveillance platforms back on the labor practices of those platforms (in their case, Amazon Mechanical Turk), with the aim of promoting workers' rights and empowering labor. What is notable for our interest in critical capacities are Irani & Silberman's frank situating of themselves within wider milieu's of practical action, of complex ecologies of corporations and labor:

> Turkopticon is not an expression of our own values, or even the values of the users we interviewed, but a compromise between those values and the weight of the existing infrastructural norms that torqued our design decisions as we intervened in this powerful, working real world system. [62]

While Irani & Silberman's work was not directly inspired by the three theoretical threads we elaborated above, their work nevertheless captures some of the same sensibilities: critique is neither formulated, accomplished nor impactful under conditions wholly of one's own making. Instead, critique originates from many sources and it must be enacted under conditions of practical action in which there are many additional competing voices insisting to be heard. Finally, the outcomes of critique are always a compromise or 'translation' [16], and never simply a linear trajectory from ideation to actualization [103]. Put more abstractly, we are contesting two features commonly found in much of (but not all) critical scholarship in CSCW and HCI: first, any tidy model of 'before and after critique' and secondly, any clean distinction between 'inside and outside' or 'critics' and 'objects of critique'.

In the empirical sections that follow, we situate ourselves in the thick of these debates, initially 'outside' of Big Tech where critiques were formulated and acted upon (again and again), and then later we focus 'inside' the tech organization where we empirically trace these processes of encoding values like inclusivity into a technical artifact, and then finally return once again 'outside' of Big Tech as the critique and reform is realized as an off-the-shelf camera tuned to skin tone.

We argue that each of these processes, imperfect as they are in comparison to our ideals of emancipation and liberation, require minute attention if we are to trace how change does or does not occur in the first place. In order to do so, we must also treat our actors not as cultural dopes but as critically capacitated precisely within the 'mess' that is outside and then inside and then outside again. We must reconsider our ideas of inside/outside if we have to pay sufficient, useful attention to how critique–that hitherto has largely been defined by its exteriority or a view from above/outside–also has an impactful life inside the very ensemble entity critiqued. Thus we find ourselves empirically following the changing nature and conditions of critique within an established object of critique–technology organizations. As we will show, the development of a camera better tuned to diverse skin tones does not occur in a single leap but as a matter of recurrent reforms over years and decades; across film and digital transitions; and both within, without and across activism, the academy, and corporate entities.

3 Case & Methods

Real Tone debuted in the fall of 2021 [46] as a built-in feature of the Pixel 6 series of smartphone cameras. Its developers promised to accurately, pleasingly, and automatically depict darker skin tones in photographs. They did so by tuning the algorithms responsible for white balance, auto-exposure, tone mapping and an original algorithm to deal with stray light [66, 67]. The marketing materials explicitly positioned Real Tone as tackling the problem of historical racial bias in imaging technologies. In a multimillion dollar Super Bowl ad featuring the singer Lizzo [28], Google championed their new socially transformative technology as pioneering positive human impact through skin tone equity (later as "the world's most inclusive camera" with the next version of Pixel smartphones, the Pixel 7 [91]). The marketing campaign for Real Tone went on to win multiple awards [22, 99] .

Accessing corporate organizations for research is notoriously difficult, and Google was no exception. Our initial efforts involved leveraging alumni networks and LinkedIn searches to map Google's organizational landscape, focusing on individuals connected to Real Tone or the Pixel camera team. These efforts, while informative, did not yield direct access. A breakthrough occurred when the first author contacted a lead product manager (PM) on the Pixel camera team on LinkedIn. Media-trained and in a leadership role, the PM facilitated both his own interviews and access to FK, a central figure in the development of Real Tone. After nearly nine months of preparatory work, we conducted semi-structured interviews with the PM and FK. The PM participated in four 45-minute sessions over several weeks, while FK provided detailed accounts of mobilizing the project with a focus on its early stages. Although requests to interview additional team members were denied due to organizational constraints, these conversations offered key perspectives on the arc of Real Tone's development.

Our views of the 'inside' of Google were necessarily limited, but along the way Google externalized a great deal via press releases, online presentations, publicly recorded videos and interviews with key organizational actors. Our interviews were limited to two 'media-trained' members of Google who had permissions to speak with the public (i.e. us), but we also use many additional materials published online [see appendix A]. We built our analysis using interviews, documentation, and existing literature as we traced formations of critique taking shape within Big Tech, and then traced them 'backwards' in time to their origins many decades ago–recounted in the next section. We did this by tracing the critical assertions of internal actors such as marketing professionals, product managers, image engineers, community experts and technologists. Real Tone's development involved a process of 'tuning' or 'training' algorithms for capturing and rendering darker skin (especially for portraits) across different scenarios (e.g. in heterogeneous lighting settings, or

with darker skinned subjects in the same frame as lighter skinned people). In part, this technical capacity depends on face detection in a frame, followed by the prediction of the skin tone of the subject through a skin tone classifier. This was achieved through a combination of machine learning [90], new training sets, and the human-centered design process we recount below. The full range of what computational photography owes to machine learning is beyond the scope of this paper [27]–there is much more than we can tell you–but we do want to highlight the intersection of very new technologies and long recognized problems.

Without such inspections of the 'inside' of tech one misses how change can occur at all, especially at scale (as with a commercial camera) and misses the necessary dynamic that we emphasize of an *internal* assembly of critique. We show how critique needs to be translated again and again 'inside' to the local concern of actors and thus come to have material consequences in the world ('outside').

None of these conditions for our data gathering were ideal – whether media-trained interviewees or publically posted but edited interviews, still, in sum total there was a sufficiently large number of sources that allowed us to triangulate and make the carefully bounded assertions we present below. This completed paper was reviewed by participants to ensure accuracy (though we did not grant any veto rights). Although we see this research as collaborative in the larger sense, it was conducted independently with no funding ties to any technology corporations. This study was approved by the Institutional Review Board of the University of Washington. All participants were informed about the purpose of the study, their rights, and confidentiality measures before providing their consent.

Following Boltanski & Thévenot [10], we propose that critique needs to be a part of the empirical analysis, rather than only inspiring it, or being allowed to remain uninspected: Where and who does it come from? How did past criticisms capacitate actors today? Real Tone, or even digital photography as a whole, comes quite late in this history we recount below. Without attending to this recurrent history of recognizing and tackling white bias in skin tone, it would not be possible for us to locate the source of critical capacities that eventually spur the creation of Real Tone. In other words, the section that comes below, tracing a 60 year trajectory, is not simply a historical backdrop (or literature review), our argument is that it took all that occurred over those 60 years to generate the critical capacities which then were mobilized again to give impetus to the development of Real Tone.

The next three sections explore a three-part arc of problematization, disputation, and eventual technical materialization of a capacity to adjust to skin tone in a commercially available camera. In the first section we outline the long genealogy of critiques and responses to white bias. In this narrative Real Tone appears only at the tail end, with bias as a topic steeping for decades, recognized and reformed again and again–critiques that ultimately make their way to Google in 2019. The second section delves into the alignment 'within' Google for how critiques were translated into a technical (largely engineering) discourse, the internal disputes that arose, and the eventual alignment that led to the project's realization. The third section traces how these matters of concern [70] were materialized in technical outcomes, detailing the specific technological innovations and network assemblies that responded to the critiques.

4 The social conditions for a critical technical practice

4.1 The conditions for a critique of white bias

As one of our Google interlocutors noted, by the time they were initiating the Real Tone project in 2019, white bias in photography was "well known in the community":

> Interviewer: When were you first aware of the problem?
> PM: I really can't say for sure. Like I said, it's well known in the community. Anyone who works in imaging or is serious about imaging and doesn't recognize this problem, it just means they're not paying attention. (Interview, PM)

This section briefly outlines activities across decades that sought to bring to light the problem of white bias in photography. In sum, we seek to understand how it could be that by 2019 a manager within a corporation could treat white bias as something 'well known'. As we will show, the critiques that came to animate the development of Real Tone originated and matured very far from that technical challenge, or even the social concerns that justified this reform project. What we recount below still constitute the 'precipitating factors'–the conditions of possibility–that come to propel actors to form the Real Tone project.

Below we outline four sets of actors–practitioners, industrialists, scholars, and popularizers. Each contributed in their own way to the development and circulation of a critical discourse. Our key takeaways are twofold: first, that formulating critique is situated work demanding time and effort, and second, that the conditions of critique can emerge from many sources–e.g. occasionally from social movements but at other times from relatively non-political commercial exigencies.

4.1.1 The Practitioners. Perhaps the first groups to recognize the challenge were users of cameras who took people of color as their subjects; photographers who were members of these communities themselves or passserbys documenting lives. These actors soon found themselves regularly challenged:

> ...an ensemble of practices emerged to address these deficiencies with reference to human skin tone reproduction quality. These deficiencies include the difficulty of imaging high contrasts in skin tones within the same screen shot—for example, a very dark-skinned person sitting next to a very pale-skinned person...and the lack of establishment and design of appropriate lighting and make-up for peoples of darker skin colours. [93, p. 115]

Over time, practitioners developed strategies to work around the designed limitations of these cameras, such as specialized lighting techniques, makeup, customized film processing, and specialized filters [42, 56].

4.1.2 The Industrialists. In 1957 the Kodak corporation introduced 'Shirley Cards' as a means to globally calibrate skin color in photography. Named after the white woman portrayed in the first set of images, Shirley Cards circulated in the mid 20th century as an ideal standard for skin tone in Kodak's photo labs. Shirley Cards

can thus serve as a metonym for photographic racism, a constant reminder of what counted as the right 'flesh tone' at a certain time and place.

But these calibration cards did not go uncontested. Historian Lorna Roth traces initial criticisms to 1959, merely two years after the creation of Shirley Cards: "Between 1959 and the present, there have been innumerable versions of Shirley as she has crossed the decades, continents, and skin color lines." The late 20th century witnessed Japanese Shirleys and multiracial Shirleys amongst many others [94]. But who made these critiques and for what reason may be unexpected. Roth notes that some of the first critiques of the white Shirley cards emerged from commercial interests unconcerned with skin tone altogether, and instead complaining about how their wares looks in photographic advertisements, products such as wood or chocolate:

> "Apparently, in reproducing chocolate candies, Kodak was receiving complaints that they weren't getting the right brown tones on the chocolates. Also, furniture manufacturers were complaining that stains and wood grains in their advertisement photos were not true to life, and that they weren't appropriate, so the chemists did some work on that. Earl[1] also said to a certain extent, that research to improve those professional markets and addressing their questions helped them to do a little bit better with ethnic skin colours. (Kathy Connor, Executive, Kodak, Rochester, NY, personal communication, August 16, 1995)." [95, p. 119]

We tell this tale in part because it highlights how critical capacity can be cultivated in many venues, some surprising, and certainly not always aligned across political goals. Nevertheless, a critique of white Shirley Cards so as to better capture wood or chocolate did come to aid the political causes interested in questions of skin tone by cultivating a discourse that recognizes the limits of photography—thus denaturalizing the technicity of photography.

4.1.3 The Scholars. There is a very wide and long-standing tradition of humanistic scholarship that has recognized racial biases in the social practices of photography and imaging–for example in how photographs are framed, how bodies are positioned, or how images are captioned in print [82, 97, 100, 106]. But the scholarly inspection of the concrete technical apparatuses of visual reproduction are far fewer. Media scholar Brian Winston's studies were some of the first, as he turned his attention to the very chemistry of film processing, finding a bias in the choice of chemical composition itself. As Winston wrote:

> Were these stocks to offer "a direct...registration of color in the natural world," we could simply attribute the difficulty of representing blacks on film to a natural racial disadvantage somewhat like sickle-cell anaemia. But color film does not directly register the world: "a whole technology of dyeing intervenes." [107]

[1]Earl W. Kage was Kodak's head of camera research and the head of Color Photo Studios [75].

Winston argued that the rhetoric around color film, both in technical and scholarly literature and in advertising and popular accounts, implicitly denied this partiality and biased cultural specificity. Instead, photographic discourse emphasizes naturalness, realism, verisimilitude and the technical virtuosity of film, "mathematics, as it were, rather than painting". He noted that for Kodak, exact reproduction of color, which was purportedly the goal of photographic and cinematographic projects, was secondary to culturally determined "optimum" reproduction. This optimization was geared towards Caucasian skin tones rendered not as they are, but as they were understood to be *preferred* by their customers through market research – a whiter shade of white.

We wish to position Winston's, and other scholarship that directly criticized the technical means of photography, in a way that is unusual for papers in CSCW and CHI: this scholarship served to codify a critical discourse, and then later that discourse became the basis–the critical capacity–that propelled reforms in camera design. Winston's work, and Roth's work cited above, sought to break a conception of the photographic technicality as natural, and thus indisputable and outside the sphere of designerly choice, as though cameras, skin and light 'are just this way.' Instead this body of scholarly work sought to place photographic design (lens, film, chemicals) into the realm of social construction or sociotechnical choice (i.e. a complex intersection of physical exigencies, design commitments from amongst many possibilities, and arbitrary social preferences).

As we will see, the 'naturalness' or inevitability of photography comes to be debated again within Google. Our argument is not that these social scientists and humanistic scholars were able to dispense with technological determinism once and for all–it instead recurs over decades, still today–but they did cultivate a critical rejection of any analysis that sought to place technical action outside social life, assuming it was simply a reflection of Nature, determined by wholly 'technical factors'.

4.1.4 The Popularizers. Scholarly works such as Winston's, Roth's, and many others, unearthed forgotten histories of film, and argued against both naturalism and technological determinisms. Their work influenced a wider discourse, for instance, by working their way into the curriculum of some photography classes. One of our interlocutors at Google recount having taken undergraduate photography classes and encountering these constructivist arguments while the other notes their absence. But ultimately social scientific and humanistic scholarship is esoteric, itself limiting the range of possible readerships. A further step was needed to reach wider audiences, to render critiques of photographic white bias available beyond these arenas.

Most recently, these critiques were brought to the attention of our interlocutors at Google through the efforts of scholar, curator, and writer Dr. Sarah Lewis, whose public speaking and scholarship have highlighted these critical issues. Dr. Lewis curated and edited the 2016 special issue of Aperture magazine titled "Vision and Justice," which she later expanded into a course within Harvard University's core curriculum and into a civic initiative [76]. Her work and especially her essay republished in New York Times explores the role of visual culture in shaping and challenging narratives

around race, citizenship, and representative justice in American society.

> Her comment reminded me of the unconscious bias that was built into photography. By categorizing light skin as the norm and other skin tones as needing special corrective care, photography has altered how we interact with each other without us realizing it. [75]

Ultimately, we position these popularizations as the tail-end of decades of efforts to form critiques and demand reforms: popular publications were built on the shoulders of practitioners and their accommodationist changes in their photography (lighting, makeup); industrialists and their reforms of Shirley cards and related calibration technologies (even if only sometimes directly engaging the question of human skin tone); and humanistic scholarship that unearthed and articulated the past.

In our interviews with members of Google, especially FK, Dr. Lewis' public scholarship is credited as the platform which inspires the possibility of something that was to ultimately be Real Tone. Additional inspiration is credited to Joy Buowalmini's scholarly activism around issues of dark skin and facial recognition [64, 88] (quite central to the worlds of CSCW and CHI[2]), especially her most well known publication in collaboration with Dr. Timnit Gebru while at Google Research: Gender Shades [15]. The study revealed significant racial and gender biases in commercial facial recognition systems, with higher error rates for darker-skinned and female faces. Shortly after this, Google tried to obtain face data of darker skinned individuals through questionable and unethical means to "build fairness into Pixel 4's face unlock feature" [1].

4.1.5 Conclusion. What we have recounted in this section is a 60 year arc of critical capacitation [10] with respect to white bias in photography. Our key points have been to treat critical capacity as a kind of achievement, something hard-won rather than obvious, intuitively understood, or rooted in moral intuition. Recognizing the white bias in photography involved the scholarly labor of many humanists, the practical knowledge of skillful photographers who struggled to capture darker skin tones, and the consequences of almost arbitrary reforms not initially motivated by combating racism at all but which nevertheless crafted the conditions that now seek to address it.

Importantly then, even while this section has been historical it should not be read as a 'literature review'–we have not simply reviewed past discussion related to our topic. Instead we have outlined the conditions of possibility such that white bias in photography could be, in 2018, spoken of as 'well known' and asserted with sufficient confidence so as serve to initiate a technical project of reform. We treat the constitution of a common sense critique as accomplished, it is neither natural nor obvious, neither purely political nor activist. The scholarly work, practical skill, and corporate reforms we described above steeped for decades, working their way into (some, not all) liberal arts photography curricula and then eventually popular press articles. So much so, that it would come to propel a project reforming in the functioning of digital cameras.

4.2 Translating Critique

> All these things were entering my orbit. And out of that emerged the initial thought of a possibility: what if we at Google, leveraging all of the tools that we have, redirected our energy or directed our energy at this problem. (Interview, FK)

As we saw in the previous section, the critique of white bias in photography came framed as a concern of representative justice in visual culture to Google, through the work of Dr. Sarah Lewis via a Googler, FK. In this section we trace the processes by which that critique translated into a doable problem with the Pixel camera team. With a decade of experience working in marketing at Google, FK had training and a keen interest in photography. He attended a conference where Dr Lewis spoke about her project 'Vision and Justice' which sought to address issues of hidden racial bias in cameras. These ideas coupled with a working understanding of computational photography capacitated him to envision the possibility of a camera that would respond to Dr Lewis' critique. FK's dedication to the project came with significant professional risks, leveraging a decade of credibility at Google and managerial support through internal initiatives like the '80/20' program. This set him off on a path to make an 'organizational swing' [48] within Google and transition from marketing to bring these concerns to the Pixel camera team[3]. Eventually, he started to enroll [16] fellow colleagues, kickstarting what would become Real Tone and ultimately becoming Google's first Image Equity Lead. Notably, FK tapped into and utilized Google's internal employee networks, including the Black Googlers Network, to identify and connect with employees whose roles intersected with camera or related technologies [48]. Serious conversations about the project's potential took place with higher-level executives across marketing and product teams "up to the CMO". Once FK's 'mission' gained enough traction within Google, his first challenge was establishing credibility with the engineers, which required him to "translate what is a very humanitarian mission statement into a series of technical challenges" (Interview, FK). Skin tone, as a subset of overall color reproduction, was already something that the Pixel camera team had been working on for years [17]. What FK brought in was a politically charged and historically informed technical critique which demanded a change in the characterization of the tasks at hand. In order to translate this into a doable technical problem [41], existing organizational and product goals needed to be aligned. There were numerous early conversations with the engineers to understand technical aspects of computational photography, existing team priorities, and how the proposed project of Real Tone did or did not align with their existing mission statements [48].

[2]Research with regards to skin tone in HCI is relatively new and rare although there have been some relevant research in fields like dermatology [73, 86]. Recently researchers have begun to look at bias in image datasets for facial analysis [96] and transparency in skin tone annotations [6, 53]. We noticed that these relevant scholarly works were not mobilized as heavily [83] as *Gender Shades*.

[3]While FK's contributions were undeniably pivotal to the development of Real Tone, it is crucial to recognize that this aligns closely with Google's official narrative. Framed as a success story of equity, inclusion and Google's internal organizational culture, the narrative celebrates the 'heroic' efforts of FK, whose unique position within Google allowed the project to gain traction. In fact, FK came to be the 'face' of Real Tone, eventually becoming the 'Image Equity' lead at Google, a position that did not exist before.

The core of the translation and problem setting process reflected broader historical debates on the objectivity of cameras [55, 95] when it comes to capturing skin tone. The dispute revolves around the claim that the Pixel camera exhibits racial bias, a problem inherited from traditional digital cameras. This claim further operationalizes the critique that a lack of racial diversity within the team of image engineers at Google possibly leads to a persistence of whiteness bias in its camera [67]. The counterclaim, also historical, argues that the issue arises from the 'limitations of physics', rather than unconscious racial bias–a counterclaim that needed first to be overcome.

4.2.1 Translating in. This section tracks how critique was 'translated into' the technology organization in ways that rendered those criticisms recognizable, credible, and tractable to organizational members, or as we will say, a 'doable problem'. In the previous section we recounted the vast critical labor that had been needed to recognize white bias in photography as a kind of social problem, instead of cast as an intractable one of 'physics' (e.g. of light and skin). We showed how the new understanding of white bias was effortfully achieved by photographic practitioners; via scholarly unearthings of technical histories (e.g. Shirley Cards); and via popularizations in the press and via magazines (e.g. New York Times and Aperture). But this new public understanding did not automatically translate, or 'diffuse' [92], into action within the technology organization. Instead, as we will show, an additional effort was needed to 'translate in' those critiques to motivate a project of technical reform.

Sociologist Joan Fujimura writes of 'making doable problems' in which practical skills, organizational imperatives, and technical means must be aligned before something can even be recognized as a problem, much less tackled [41]. We too see something akin in our case. In order for these engineers to engage white bias in photography 'within Google', the problem first needed to be rerendered in terms recognizable to organizational members, and especially, in alignment with the technical, financial, and practical criteria in effect across the divisions concerned with producing the next generation of Pixel camera.

From our interviews and archival digging, at the beginning of Google's engagement with the problem of bias in photography around 2019, the Pixel camera team had already been improving color reproduction for their camera more generally, but not specifically engaging the question of skin tone and bias. Problems of color accuracy in portraits (of which skin tone is a subset) were thus already being worked over (in part informed in the reviews of the previous generation of their cameras in Pixel 4 [17]). Color is one of the most important metrics of image quality for any camera [33], and by 2019 planned improvements were already documented in existing 'road maps' of camera product development. Color was already a recognized challenge.

But, at inception, that team did not consider their camera to be plagued by bias rooted in social prejudices that had congealed in the technical apparatus of cameras. Initial efforts to introduce the topic of white bias were greeted with reserve, especially when they were introduced by members from outside the engineering team:

> It came from someone who was in a marketing organization, not a technical organization. So that person didn't have the credibility to tell us the specific ways in which our camera was problematic. That person could only say "In general cameras appear to be problematic in the following ways. How's yours?" (Interview, PM)

Our interview respondents recounted to us that at this point it was not yet possible to convince the image engineers that their camera was *particularly* bad at photographing dark skin, or to the extent that it was a recognized problem, that it represented a problem of social bias and not of physics. In sum, at first the image engineers interpreted the issue as a matter of fact [69] i.e. "Dark skin is just harder" for cameras in general, a matter of photons, lighting and the properties of skin, and not that of design, tuning and training.

It is worth noting that this is a recurrence of exactly the types of arguments encountered by critics in wider public spheres. As we recounted above, for many years (and still today), many dismissed the problem of bias as one of physics, light and skin. To change these ideas in the public sphere, much ink first had to be spilled to convince that, for example, selecting only a white woman called Shirley as the standard bearer for calibrating skin tone in photography had contributed to bias. In sum, the argument 'out there' (in popular culture) that photography was 'just physics' could also be observed 'in here' (amongst the engineers of Google), and this first needed to be displaced and reframed before these engineers could recognize and tackle the problem of bias.

One of our key respondents from Google, who we dub "PM", recounted to us how the question was reframed in order to move beyond the impasse by leaving aside the question of cause ('because of physics or because of racism') by instead crafting an engineering problem: is there way to improve the situation, regardless of cause?

> There was a lot of headroom, easy pickings, low hanging fruit that they could fix to make the experience [of photographing darker skin] dramatically better that they [technical actors in imaging] had just ignored for years, decades, because it fit their expectation, their prejudicial expectation... So we looked at the problem and said, Hmm…we don't know if there's a problem there, but it would be really impressive if we managed to fix something there! And it turned out to be meaningful. (Interview, PM)

For the problem to be rendered legible and legitimate to the engineering team, bias in imaging required, first, being localized to concerns of this Pixel camera (and not cameras in general) and that the problem be characterized 'using data' generated from testing this camera (and not far off accounts of Shirley Cards). The engineers wanted to 'see the data' that was specific to their camera in order for this problem to be proved 'here' and therefore practically solvable *'in this camera'*.

Beyond the engineering team, however, PM was acting on his own and was able to mobilize some of those very same critical resources that we have recounted above, such as popular press and scholarly articles. Across the team, these published critical accounts began to spur novel discussions, at least placing into

question whether it is really 'a matter of physics'. This was a crucial move in crafting a doable problem. Here, alignment involved a dual move of assessing the technology itself (evaluating) as well as producing value or adding value to the existing product (valorizing) [104].

Asking the image engineers to test their assumptions about how their camera fared when it came to capturing dark skin led to overcoming this primary impasse we detailed above. Quantifying the camera's performance of capturing skin tone via an increased precision in problem definition helped navigate this dispute within the team. This move of alignment convinced the engineers of a possibility of scope for innovation and formed a common ground between diverging viewpoints in the team (regardless of whether 'it is physics' or 'it is society'). They set out to first identify where (if at all) they could locate the problem 'as data', and then attempt to solve it.

In brief, we have shown how the critique of white bias was brought inside the team and how it was rendered as a local doable problem. These negotiations we recounted led to new measurements of the performance of the camera with regards to darker skin, which in turn led to framing doable problems, not as a matter of racial legacy 'out there' but instead as an engineering problem that could be tackled by concrete design innovations 'here'.

In the following section we explore the third part of the arc of development focusing on the work that was needed to manufacture, market and circulate this novel technical capacity, that is, as a technical response to critique: now materialized in a camera traveling 'outside' the organization as a commercial product.

4.3 Materialization

We use the term 'materialization' to refer to the extension of a novel technical capacity, along with a wide associated sociotechnical network, designed to respond to critique. In the previous section we recounted an 'internal' series of negotiations as long-standing matters of fact in photography were translated into a corporate setting of critique, design and valuation. 'Within,' the technologies of Real Tone came to be developed:

> Once we're able to detect the face and perform the skin tone prediction … and then make computational photography adjustments to render it properly from there. (Interview, PM)

But the full circuit of critique and response is not complete without extending this novel technical capacity into the world, outside of the lab [68]–on the one hand as a novel camera, ready for sale 'off-the-shelf', and on the other hand, as a web of relations that seek to propel the novel technology–effective *and* legitimate–across the globe. We track this double movement below.

4.3.1 *Translating out.*

> But when you're coming with negative brand equity as an entire industry and you want to make a big claim, PR is going to say, "Hey, how do we land that? How do we make sure we are believed and trusted?" (Interview, PM)

Anxieties about race and technology are not new to Google. In the recent past, the corporation has faced public outcry over racial bias in their technology [65, 108]. Not the least of these (and the one explicitly related to skin tone and therefore to Real Tone) was a dermatology app [14] that used AI to detect skin diseases from images. It received criticism for an underrepresentation of darker skin types in the database used to train the model potentially leading to subpar discriminatory experiences for some users [7].

Google had been working on this project that would eventually come to be known as Real Tone from as far back as 2019. In one of the earlier names for the project, it was nicknamed 'Frederick Douglass'[4] after the most photographed American of the 19th century [59]. While Google claimed to have substantial improvement in their 2020 camera, they waited because they wanted to "do it right." The project passed through multiple extensive tests by both internal and external bodies.

Organizational diversity numbers are skewed against darker-skinned individuals, an issue acknowledged by Google [63, 67], and echoed by the people we spoke to. According to PM, this problem of representation due to a lack of diversity makes it very unlikely that the team working on this project "will have even one person who is personally affected by the problem". To remedy this, Google entered into a partnership with a diverse team of 'image experts' [79] or creative professionals a lot of whom were in FK's network outside of Google.

The design process for Real Tone attempted to mobilize existing critique of the lack of representative data in image datasets used to train machine learning models which leads to biases [72]. They did so explicitly by enrolling the image experts to improve the training dataset [31]. Not only did this diversify the image datasets used to train face detection models but also in turn made it possible to make nuanced adjustments in tuning algorithms for auto white balance and auto exposure. In their marketing material and product design blogs [57], Google made sure to emphasize: "Building better tools for a community works best when they're built *with* the community." [66, Original emphasis]. This team of renowned cinematographers, colorists, directors and photographers who are known for their 'beautiful and accurate imagery of communities of color', were brought into collaboration with the Pixel camera team [66]. This collaboration was different from the regular user testing process in terms of the time spent and the degrees and modality of interaction between the internal image engineers and external image experts. Instead of product managers acting as a translation layer, in this case, the representatives from the engineering team interacted with the image experts "without any editorializing". The engineers actively worked towards translating the professional lingo of the image makers to more precise technical language. This is particularly hard to do as these practices are wildly heterogeneous and peculiar to the individual professional–while for it to be actionable from a technical standpoint, aesthetic choices need to be precisely expressed in a standardized form.

Eventually thousands of new portraits featuring people with darker skin tones across various difficult lighting conditions were collected with assistance from the image experts. This provided the necessary image data to test and refine algorithms and classifiers for these communities by making their image datasets "25 times

[4]Dr. Lewis mentions Douglass' Civil War speech "Pictures and Progress," as one of the inspirations behind her "Vision and Justice" project [76].

more diverse" [46]. The team took the improved product back to the image experts who 'in a device-agnostic survey comparing top smartphone cameras' rated 'Pixel 6's rendering of skin tone, brightness, depth and detail as best for people of color' [66]. Google tested these performances using model cards [81], a benchmarked evaluation framework produced at Google Research aimed at mitigating bias in human-centered machine learning models used especially in the fields of computer vision and natural language processing. It is here a lens borrowed from an anthropology of ethics [78] is useful to treat the set of institutional practices centered around ethics (such as those pertaining to 'Responsible AI' or 'Image Equity') symmetrically with the other spheres of action such as engineering and marketing.

Gradually, Google began to describe Real Tone as "a family of technologies" [47] or a framework [46]. Eventually applications of Real Tone were extended into other products as Google hailed their commitment as "not a moment but a mission" [66] to make their technologies more equitable racially. For a later iteration of Real Tone in the Pixel 7, Google continued this process with image experts. They approached Diversify Photo Co. a non profit organization which focuses on greater representation and diversity in photography [91] to test their cameras. It was through their certification Google was able to claim the Pixel 7 as "the most inclusive camera in the world". Following the success of this launch of "the fastest selling Pixel phone to date" [4], Google incorporated Real Tone into other product lineups such as Meet [45] and Real Tone filters in Google Photos[5] [12]. In 2022, Google integrated a skin tone filter into Search [49, 52] purportedly making it easier for users to search and shop online. These products follow on the heels of a new skin tone scale by Google's Responsible AI team for evaluating machine learning systems. Created in collaboration [52] with a professor of sociology at Harvard, Dr Ellis Monk, the now open sourced Monk Skin Tone scale [83] claims to be a critical improvement on the industry standard Fitzpatrick scale that Google researchers critiqued in the past including in the paper on Model Cards [15, 24, 81].

5 Discussion: A Symmetrical Analysis of Critical Capacitation

This paper's primary contribution is methodological–a theory of method, in which we have sought to synthesize three intellectual traditions that enable a symmetrical approach to the inspection of technical responses to critique: valuation studies, anthropology of ethics, and a sociology of critical capacities. A symmetrical analysis of critique seeks to approach both the object of criticism (here, skin tone representation) and the generation of the criticism (the accusation of white bias) as equally demanding of inspection, analysis, historicization, and explanation. The generation of critique and its downstream consequences (or lack thereof) too must be inspected with an equal rigor to the problem, rather than treated as external to formation and reform (such as 'an obvious problem', a moral good, or an unquestionable statement of fact). Formulating and articulating a problem is work; convincing others of the need to address the problem is challenging; and securing corporate commitment to develop a novel technical capacity is an investment. The key in a symmetrical analysis is not to treat criticism as natural, obvious nor easy–and most especially, to recognize that whether a criticism is 'true, correct or moral' is at stake in the trajectory of that critique itself, rather than foreordained.

To demonstrate our methodological approach we sought to situate ourselves in the thick of debates, seeking to understand the genealogies for how actors came to recognize legacies of iniquity, how these hard-won recognitions eventually came to form the impetus for a technical project of reform, and then how the outcomes of that reform project were materialized into a new ready-to-hand commercial artifact that (cl)aims to address those iniquities. Our three part investigative trajectory thus traced i) the sources of critical capacity, ii) followed by investigations of efforts to 'translate in' those critiques to a corporate body that responded to criticisms via technical investments, and finally iii) 'translating outward' those novel capacities in an artifact with real-world consequence. We argue that tracing each of these trajectories of technical responses are required to show how those critiques are made real, and how the world is remade (in small or large ways) via technological manufacturing, marketing, and circulation.

By focusing on the disputes within an organization and exploring the justifications offered by the actors (e.g. 'FK', image engineers, 'PM'), we showed how a critique rooted in the works of critical scholars, industrialists, artists and activists found its way 'inside' Google's Pixel camera team. We treated our interlocutors, such as 'FK', neither as 'heroic figures' acting in the greater good, nor did we discount him as being motivated by a purely professional ambition. Largely we stayed out of our interlocutors heads and motivations altogether. Instead, we attended to how concrete critiques entered 'inside' Google via FK who had been sensitized to this history of whiteness bias in photography by other actors at large, such as the scholar and curator Dr Sarah Lewis. FK and other's capacity to be critical 'within' Google was rooted in redeploying the critique of whiteness bias developed 'outside' in order to dispute the claim to objectivity of cameras 'inside', at each moment crafted within the organization to meet local evidentiary standards, marketing demands, and manufacturing considerations.

Boltanski & Thévenot–two scholars credited with originating the sociology of critical capacities–introduce the concept of 'polity' or 'orders of worth' to refer to different moral frameworks that people and organizations use to justify actions, decisions, and evaluations in social life [10]. Such orders of worth serve as plural yet structured ways of reasoning about what is valuable, legitimate, or justifiable in different contexts. Deploying the frame of orders of worth to analyze the disputes and justifications that arose around the Pixel camera, we find the negotiations with image engineers centered, initially, around what Boltanski and Thévenot called an 'industrial order of worth' in which the mode of evaluation is technical efficiency. On the other hand, the critique of racial inequality via whiteness bias in cameras comes closer to the 'civic order of worth' which has as its mode of evaluation collective welfare and fundamental rights to equal citizenship. Ultimately, only after being subject to a relevant mode of proof under the 'industrial order of worth' i.e. measurement (exactly how much 'worse' is dark skin

[5]This filter in effect 'corrects' color for any digital photograph (not just ones taken with the Pixel camera) and was eventually added to the Auto Enhancement operation in Google photos. It claims to optimize "color and lighting in any picture, across all skin tones"[46].

for the Pixel Camera measured 'using data'), was the work of alignment between the three levels of 'laboratory, experiment and social world' [41] made possible. Thus we see the civic order of worth being translated inward into an industrial order of worth through 'compromise towards a common good' which is defined within their framework as:

> ...the possibility of a principle that can take judgments based on objects stemming from different worlds and make them compatible. It aims at a common good that transcends the two different forms of worth in presence by including both of them. ([10], p. 278)

In this paper, we have traced the mechanics of this compromise which rendered the 'problem' as doable as a technical-commercial response. It is within the processes where the determination of worth is at stake that we have attended to the practices, performances, and institutional arrangements of valuation.

In conducting our analysis we have neither praised nor criticized old worlds and their technical capacities, nor the coming into being of new worlds, organizational arrangements or technical capacities formed in response to critique. We have not championed these new cameras. Why do we reserve judgement? Why not align with the Good? Why not oppose white bias in photographic technology? As we noted earlier in this paper, our methodological commitment to a symmetrical analysis has sought to cultivate ambivalence, to place into question the obvious goodness, morality, or benefit of the actors. More precisely, the normativity of a particular programme of reform is at stake in the development and trajectory of criticism itself. Whether a technology, such as a camera tuned to identifying, representing, and capturing skin tone is a social good, is at stake in the histories of photography and race themselves.

This is precisely why we consider our critique to be rooted in care [26]. We aim to engage thoughtfully with debates on critique, particularly in cases where certain approaches to "doing critique" unintentionally constrain generative possibilities by overlooking their own prefigurations. Approaching the problem in ways that historicize and situate critique– we have sought to cultivate a different, symmetrical way of investigating critique which is sensitive to ambiguity, geographic and cultural specificity (such as models of equity in the US circa 2020), historical change over time (including reversals), and competing interests that do not necessarily resolve into a singular Good.

Finally, as per an anthropology of ethics that situates assertions of morality rather than treating them as transcendent, we have sought to treat the sphere of action around 'tech ethics' not as external to tech corporations but in part composed of them. This paper thus responds to a wider 'metacriticism' of critique itself [50, 69] which has sought *inter alia* to reframe critique's relationship to interiority and exteriority. We place value in situating ourselves as not external to the 'society' or this network of actors (e.g. one of the authors has extensively used a Pixel camera), so as to be methodologically attentive to the mess that attends critical technical practice [2].

6 Limitations and Future Work

By 'following the actors' in this investigation we bound ourselves to the North American context–largely we inspected criticism and reform occurring in the US, about corporate bodies rooted there too. The development of Real Tone was primarily an American endeavor, circa 2017-2021, rooted in the particular formulation of racial legacy and desire for equity manifest in some parts of the US at that time. But we have never claimed that this is the only project that has sought to detect and represent skin tone, nor have we claimed that all those projects seek to capture skin tone for the same purposes. Indeed, the picture is different elsewhere. For example, a global inspection of technical efforts to capture and render skin tone would reveal many other motives than those promoted in this camera's marketing, such as Chinese smartphone manufacturer Transsion's parallel efforts in Africa to attune their cameras to skin tone [5, 77]. What will a camera capacitated to detect skin tone mean in contexts beyond North America? How will cameras capable of capturing skin tone as data come to mobilize those data to new ends? The matter is further complicated by the paradoxical relationships between the development of "better cameras for everyone", development of computer vision and that of racialized surveillance [13, 51, 102]. What is equity in one place, may be surveillance elsewhere, and market segmentation in still another. While these discussions of complex geopolitical implications are beyond the scope of the current paper, they are on our agenda for future work. But our point about the value of symmetry is more compact: an inspection of the conditions of possibility for critique and reform must itself recognize that the legitimacy of critiques are at stake–debated and negotiated, shaped and themselves reformed by the actors engaged in the formation of critique, which includes the next round of critique and possibly reform.

7 Conclusion

Often critical consequence is attributed to exterior actors, to a view from above/outside e.g., the activist, the advocate, the critical scholar. In this paper we have not taken away critical capacitation from those actors–all of the initial recognitions of bias are rooted in practitioners, activists, scholars and their publications. But we have argued that in order to have wide worldly consequence, critique must also have impact 'inside' the entity that it takes as its object. This is especially the case for technical responses to critique which often demand significant investments of expertise and capital to generate and then circulate novel capacities, such as a commercial camera available off-the-shelf that is responsive to skin tone.

In order to conduct our investigation, we drew from three methodological threads drawn from three social theoretical traditions–a sociology of critical capacities, a study of valuation, and an anthropology of ethics–and thus throughout we sought to treat our actors (both social critics and technical experts) neither as cultural dopes following prescribed trajectories, nor rarefied ethical actors operating beyond practical exigencies. Our contribution, then, is primarily in developing a theoretical and methodological approach for inspecting the conditions for critical capacitation, that is, how to trace technical responses to critique.

In our symmetrical approach, actors (and not only analysts, such as critical theorists) all came to be understood as being engaged in reflexive critical activities, formulating and then reformulating the nature of the problem and how it may be addressed. We saw this with photographic practitioners and critical scholars but also

within marketing and engineering teams. Coming to recognize white bias in photography was the effortful work of photographic practitioners, humanistic scholars, and, occasionally, corporate actors initially wholly unconcerned with racism. But over years and then decades, as this critical recognition matured, and via the inclusion of scholarly work in curricula and popularizations in the press, white bias in photography came to be a 'well known problem.' The actors cannot be treated as though they are befuddled, dupes, or ideologically blinded, even while the external critical analyst is able to see what is truly happening, identifying structures, historical regularities or power dynamics unavailable to the actors. In sum, we insist on giving credit where it is due–to those who so effortfully worked to articulate, evidence and then tackle a critical problem.

We first showed how criticisms of white bias in photography gained sufficient traction so as to mobilize a project of technical reform. But there was nothing automatic nor easy in the translation from critique to the development of novel technical capacity seeking to address it. 'Within' the technical enterprise, the problem of photographic bias had to be translated into a doable problem for engineering, for marketing, for manufacturing. Google's publicly visible challenges around diversity–such as in hiring employees [63, 84], or in the wider capacities of their technologies [44, 57]–too formed the grounds (the conditions of possibility within), that made it possible (even, needed) to invest in this project of technical reform.

Finally, we approached this empirical case *in medias res* [101], telling our tale neither 'from the beginning' nor claiming its end. Shirley Cards were not the 'beginning' of white bias in photography, and Real Tone is not the 'solution' to the diversity of human skin tones. There was more that came before, and there has been more since Real Tone too. Throughout this trajectory the Good has been at stake, and it remains so today. Is a camera tuned to identify, capture and circulate 'skin tone' necessarily a Good? While almost every actor we have given voice to (activists but also technologists) in this paper has certainly thought so, once we leave the North American context–as the lead author has begun to do–we have already started to find otherwise. But by approaching the topic symmetrically–granting critical views to all parties and not only one–we have situated the good as being articulated, contested and reconfigured. Even as the terrain of technology and justice shifts over time and Big Tech's policies and discourse around the determinations of Good continue to change–we have attempted to offer a way that can account for such changes in the entire developmental arc of novel technologies aimed at social transformation.

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A Table of heterogeneous sources

In addition to our extensive semi-structured interviews with two 'media-trained' Googlers who were central to the arc of development of Real Tone, we draw on a wide range of sources to write up our case. On the next page, Table 1 provides a detailed list of sources we mobilize ordered by date.

Table 1: Sources Ordered Chronologically

Date	Title	Publisher	Type of Article
2009	Looking at Shirley, the Ultimate Norm: Colour Balance, Image Technologies, and Cognitive Equity	Canadian Journal of Communication	Journal Article
2013	The Fade-Out of Shirley, a Once-Ultimate Norm: Colour Balance, Image Technologies, and Cognitive Equity	Springer Netherlands	Book Chapter
2014	Google Finally Discloses Its Diversity Record, and It's Not Good	PBS	News Article
2015	Google Photos Tags Two African-Americans As Gorillas Through Facial Recognition Software	Forbes	News Article
2016	Vision & Justice, Aperture 223	Aperture	Magazine
2017	Keeping 'Insecure' Lit: HBO Cinematographer Ava Berkofsky on Properly Lighting Black Faces	Mic	Article
2019	Google Diversity Annual Report 2019	Google	Report
2019	Monk Skin Tone Scale	Google	Scale Documentation
2019	The Racial Bias Built into Photography	New York Times	News Article
2020	Updated: Google Pixel 4 Camera Review: Excellent Color and Skin Tones	CNET	Review
2020	Google Apologizes after Its Vision AI Produced Racist Results	Algorithm Watch	News Article
2020	How We've Taught Algorithms to See Identity: Constructing Race and Gender in Image Databases for Facial Analysis	ACM	Conference Paper
2021	Using AI to Help Find Answers to Common Skin Conditions	Google	Blog
2021	Image Equity: Making Image Tools More Fair for Everyone	Google	Blog
2021	How Google Is Using the Pixel 6 Launch to Talk about Race and Photography	Fast Company	News Article
2021	Google's New AI Skincare Tool Lacks Diversity, Experts Claim	Euronews	News Article
2022	10 Camera Upgrades on the Pixel 7 and Pixel 7 Pro	Google	Blog
2022	Welcome to Google Pixel's Real Tone AMA	Reddit	AMA
2022	Google Partners with Dr. Ellis Monk to Improve Skin Tone Representation across Its Products and Technology	DPReview	News Article
2022	Google Puts Diversity (and Lizzo) at the Heart of Its Super Bowl Ad	Ad Age	Special Report
2023	Made by Google Podcast S2E4: Real Talk About Real Tone	Google	Podcast
2024	How We Tested Guided Frame and Real Tone on Pixel	Google	Blog