Legitimating Emotion Tracking Technologies in Driver Monitoring Systems

Aaron Doerfler[1], Luke Stark[1,2]
[1]Western University, London ON
[2] Canadian Institute for Advanced Research (CIFAR) Azrieli Global Scholar Program, Toronto ON
adoerfler.msc2023@ivey.ca, cstark23@uwo.ca

Abstract

Contemporary automobiles are now incorporating digital technologies, including emotion recognition technologies intended to monitor and sometimes intervene on the driver's mood, attentiveness, or emotional state. We investigate how the firms producing these technologies justify and legitimate their design, production, and use, and how these discourses of legitimation paint a picture of the desired social role of emotion recognition in the automotive sector. Through a critical discourse analysis of patents, advertising, and promotional materials from industry-leading companies Cerence and Affectiva/Smart Eye, we argue both companies use potentially spurious arguments about the accuracy of emotion recognition to rationalize their products. Both companies also use a variety of other legitimation techniques around driver safety, individual personalization, and increased productivity to re-frame the social aspects of digitally mediated autonomous vehicles on their terms.

Introduction

Congratulations on having a paper selected for inclusion On January 29th, 1886, Carl Benz patented an invention he called a "vehicle powered by a gas engine": a two-seated, three-wheeled machine which looked like a contemporary children's tricycle. Benz' patent served as the "birth certificate" for the automobile, a mode of transportation whose form enveloped driver and passengers in a private realm of "automobility" (Mercedes-Benz, n.d.; Urry 2004). Personal automobiles were initially unaffordable for most people and the automobile's transformation into a material representation of 20th-century capitalism, individual consumption, and social status was not preordained (Gkikas 2013, vii). Technological and industrial expansion, specific vested interests, and particular policy choices enabled the automotive industry to dominate transportation in North America and elsewhere (Ross 1995; Kline and Pinch 1996). Despite deleterious environmental impacts, harm to pedestrians, and the balkanization of urban space, personal automobiles and the broader sociotechnical "system of automobility" have become the predominant form of mechanized mobility, influencing infrastructure, products, and services, and organizing social life around the world (Urry 2004).

Copyright © 2024, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved.

Computing technologies, including internet connectivity (Burnett and Porter 2001; Goggin 2012; Lee et al. 2016; Kazmi et al. 2019), global positioning systems (GPS) (Souza et al. 2012; Baria and Samant, n.d.), AI-enabled personal assistants enabled by natural language processing (NLP) algorithms (Abuelsamid 2019), and a wide array of other digital sensors for monitoring drivers and passengers (Schmidt, Paradiso, and Noble 2011), are increasingly ubiquitous in today's personal automobiles (Marx 2023). Though the prospect of fully autonomous private vehicles operating in everyday settings appears unlikely in the medium term (Koopman and Osyk 2019; Carey and Lienert 2022; Saltzman 2022), automakers and digital technology firms have sought to digitally mediate various aspects of the human driving experience. Among these proposed mechanisms are emotion tracking and recognition technologies, incorporated into the driver monitoring systems (DMSs) which watch over and sometimes intervene depeding on a driver's mood, attentiveness, or emotional state (Zepf et al. 2020; Braun et al. 2020; McStay and Urquhart 2022). The automotive market is one of the most promising areas for the application of such affective computing systems (Picard 2000; Boehner et al. 2005; McStay 2018; Stark 2019; Roemmich and Andalibi 2021a). Yet the process of integrating these technologies into personal automobiles is as contingent on social, regulatory, and cultural choices as was the personal automobile's initial widespread adoption—including the choices made by the automobile's makers around how to market these technologies and promote their potential benefits.

This paper examines how the discourses used by digital technology firms developing DMSs for personal automobiles to frame the emotion tracking and monitoring elements of their products. We pose the following research questions:

[**RQ1**] *What discourses of legitimation do automotive emotion tracking companies use, and in what contexts?* Discourses of legitimation are the means through which social actors justify their activities and behaviors: they appeal to various kinds of authority, tradition, evidence, or normative principles to support an individual or group's actions or inactions (Leeuwen 2008). In this case, we are interested in

how the firms developing emotion monitoring technologies for personal automobiles present them as valuable, desirable, useful, and/or necessary to different audiences including regulators and the public.

[**RQ2**]: *What social goals and actions do these legitimation discourses explicitly or implicitly support?* Legitimation discourses, either implicitly or explicitly, are both descriptive and prescriptive: they not only provide justification for past actions but also for future ones. These discourses together constitute what Gabriel Abend terms a "moral background": the set of second-order moral precepts that structure normative behavior in a society or social group (Abend 2014; Greene, Hoffmann, and Stark 2019). By exploring how these digital technology firms imagine the future of the personal automobile, we gain insights into these firms' understanding of emotion tracking's broader prospective use cases as well.

Review of Literature

Emotion Recognition and Emotion AI

Digital technologies designed to track, predict, and modulate human emotion are increasingly ubiquitous (Stark 2018a; McStay 2018; Stark 2019; McStay and Pavliscak 2019; Ellis and Tucker 2021; Roemmich and Andalibi 2021a; Cowie et al. 2001). An array of scandals beginning with 2014 Facebook "emotional contagion" study, continuing with "psychographic profiling" by Trump campaign contractor Cambridge Analytica, and extending to the increasing popularity of social and emotional artificial intelligence (AI) systems have brought these technologies into public consciousness (Kramer, Guillory, and Hancock 2014; Granville 2018). There is increasing academic attention to these systems' conceptual underpinnings (Stark and Hoey 2021; Nagy 2022), historical antecedents (Martin 2007), business models (McStay 2016; Stark 2020; McStay and Rosner 2021), and impacts on users (Andalibi and Buss 2020; Roemmich and Andalibi 2021a; DiBerardino and Stark 2023). The privileging of cognition as the locus of intelligence meant that researchers in both artificial intelligence (AI) (Simon and Newell 1971) and human-computer interaction (HCI) (Card, Moran, and Newell 1983) had little interest in emotion for much of the latter half of the twentieth century. The rise of the personal microcomputer in the late 1970s destabilized this model of human-machine interaction: it was no longer tenable for computer scientists to ignore the actual human users of computers and their social interactions. Over the past twenty years, computer scientists rediscovered the universal, quantifiable models of emotion they had abandoned in the 1950s and 1960s (Minsky 2006). These conceptual models, coupled with technical advances in digital data collection and related Silicon Valley business practice, have prompted new enthusiasm for tracking, quantifying, and simulating human emotional expression via AI systems (Picard 2000; Scheutz 2012; Calvo et al. 2015).

Different academic disciplines have widely varying definitions of human emotions (Barrett 2006a; Leys 2017; Barrett et al. 2019), and the ways computer scientists represent, elicit, and develop proxy measures for emotional states are central to emotion's operationalization in various domains including automobiles (Zepf et al. 2020). Technologists designing digital systems to collect and analyze emotive data often rely on a narrow set of "motivational" or "anti-intentionalist" models which understand human emotions as biologically based, expressed in universally comprehensible ways, and uncomplicatedly legible to the observer (Ekman, Sorenson, and Friesen 1969; Dixon 2012; Siegel et al. 2018; Barrett 2006b). While such "Basic Emotion Theory" (BET) is increasingly contested in affective science (Barrett 2006a; Barrett et al. 2019; Russell 2003), this conception of emotion underpins most commercial digital applications such as automated facial analysis, sentiment analysis of digital voice recordings, and the analytics of social media platforms like Facebook (Davies 2017; Stark 2018a). However, these developments have prompted pointed critiques that the datafied models of human emotion are woefully incomplete (Boehner et al. 2005; Suchman 2006; Boehner et al. 2007; Stark 2018a; Wu 2022) and are focused chiefly on commercial exploitation and institutional surveillance in fields such as education (Williamson 2017; 2019; McStay and Urquhart 2019; McStay 2019; Article 2021; DiBerardino and Stark 2023). Skeptics also point to the dangers of incorporating these sensitive data about core aspects of human identity into the growing and already granular profiles of our datafied selves (Cheney-Lippold 2017; Grill and Andalibi 2022; Roemmich and Andalibi 2021; Corvite et al. 2023; Roemmich, Schaub, and Andalibi 2023; Andalibi and Buss 2020; Roemmich et al. 2023).

There has been considerable recent academic and public concern regarding the potential for automated decision systems, including those involving emotion tracking and recognition, to lead to discrimination and other unfair social outcomes (O'Neil 2017; Noble 2018; Rhue 2018). In the case of emotion recognition, these concerns are heightened by the contested nature of emotional concepts themselves (Grill and Andalibi 2022b), and by these representations' historical roots in racialized and gendered power imbalances (Stark 2018b; Schuller 2018). These concerns are if anything heightened in the automotive context. For instance, the common failures of face recognition and analysis technologies on darker-skinned people, particularly darker-skinned women (Buolamwini and Gebru 2018; Raji et al. 2020), have the potential to exacerbate the hazards faced by racialized drivers. Driving is already a dangerous activity (as proven by the statistics emotion tracking firms deploy to sell their products), and emotion recognition systems have been shown to work less well on darker skinned individuals (Rhue 2018). Adding, for instance, racial bias to the dynamics of an algorithm designed to make instantaneous and potentially life-altering decisions based on the perception of a driver's emotional state is potentially disastrous. Worse,

driving never takes place in a vacuum. Black and Hispanic Americans are more likely to be killed in a traffic-related fatality than White or Asian Americans (Raifman and Choma 2022), and that Black Americans are more likely to be stopped by police on the road (Pierson et al. 2020; Project, n.d.). The data collected by emotion tracking systems in cars has the potential to exacerbate these disparities by giving law enforcement officials new pretexts for biased stops, new avenues for surveillance, and adding further layer of complication in situations where racialized motorists' lives are in danger. In automobiles and more broadly, these technologies also raise concerns around invasions of individual privacy, automated bias, and the perpetuation of systemic injustices (Roemmich, Schaub, and Andalibi 2023; Stark 2016; Stark and Hoey 2021).

Computing and Automotive Technologies

During the expansion of the automobile industry in the late 1980s, automotive manufacturing companies began to experiment with integrating digital communication and information systems into their cars (Goggin 2012, 313; Zepf et al. 2020). Over the past decade, digitally connected vehicles have become commonplace (Kern and Schmidt 2009; Tan, Zhu, and Zhao 2012; Cha et al. 2015; Guo, Yang, and Zhang 2022). Vehicles are equipped with electronic control units that guide functions related to the engine and transmission, rolling up windows, unlocking doors, monitoring fuel efficiency, and many other tasks. Even in the mid-1990s, these technical advances were enough to prompt discussions regarding the possible legal and societal implications of so-called "road safety informatics." For instance, a European Union report pointed to "assisted route planning, in-vehicle information on traffic conditions, and automatic control by the infrastructure operator in the event of difficult driving conditions" as ways to potentially decrease traffic congestion and other environmental impacts through more efficient use of existing automotive infrastructure (Camus and Fortin 1995, 3). Over the next decade such vehicle-based systems were implemented in both Europe and North America not only with heightened safety controls, but with connectivity features unrelated to safety or efficiency concerns. Such "connected vehicles" are now common, and many of their features are exemplary of "infotainment," enabling connected vehicles to provide both informational and entertainment media (Kazmi et al. 2019). Goggin observes that automobile manufacturers envisioned cars as, "the internet on wheels" as early as the turn of the century (Goggin 2012, 316), reflecting the now-common positioning of the automobile dashboard as a "fourth screen" (a term describing the rapid proliferation of networked screens outside of the home and beyond an individual's personal device (Miller 2014)).

More recently, the prospect of fully autonomous vehicles has captivated both Silicon Valley and the traditional automotive sector. Cars which can leverage machine learning and computer vision technologies to navigate the landscape without direct or even indirect human control have been under development for more than a decade (Murali, Kaboli, and Dahiya 2022; Koopman and Osyk 2019; Bonnefon, Shariff, and Rahwan 2016; Souza et al. 2012). However, the technical and design requirements for such vehicles have proved daunting in practice (Kaye et al. 2016; Hong et al. 2022). Standardized levels of autonomy for personal vehicles were initially articulated by SAE International (formerly the Society of Automotive Engineers); the adoption of these levels by the United States Department of Transportation has meant this metric has become a *de facto* global standard for autonomous vehicles (DOT 2021). In this taxonomy, levels 0 to 2 describe automated features which support the driver; levels 3 to 5 articulate mostly or fully autonomous vehicles. Contemporary autonomous personal vehicles like those produced by Tesla are rated at level 2, while Waymo's robot taxies are rated at level 4 (while the latter do not require driver control, they follow pre-mapped routes within the cities where they are licensed to operate) (Ackerman 2021).

Previous work at AIES has explored the broader ethical and social implications of autonomous vehicles, including assessing the values inherent in their decision mechanisms (Markham et al. 2020), examining the social risks, harms, and benefits of their development (Conitzer et al. 2019), and strategies for their regulation (Furman et al. 2018). Coppola and Morisio observe that today's cars are equipped with a dynamic set of contextual functionalities that offer various automated features, purportedly to make the trip safer and more enjoyable (Coppola and Morisio 2016). In the context of level 3 autonomous vehicles, in which driver functions must be transferred to a human under certain high stakes conditions, developers often present emotion tracking technologies as a solution to the problem of how to manage this crucial problem of human-machine interaction (Kaliouby et al. 2019). McStay and Urquhart observe further that even in the hypothetical of a fully autonomous personal vehicle, emotion tracking technologies will still be appealing for their personalization functions (McStay and Urquhart 2022, 9). As emotion recognition technologies are central to the digital mediation of contemporary automobiles, the discourses around which these systems are being incorporated into both connected and autonomous vehicles have broad societal relevance.

Emotion Recognition in Automotive Technologies

In a 2020 review, Zepf et al. found more than 60 peer-reviewed research papers on the topic of emotion recognition in automobiles (Zepf et al. 2020). Even without full automation, automakers are increasingly leaning towards the use of emotion recognition technologies to support the driver with all tasks that encompass the driving experience (Eyben et al. 2010; Zepf et al. 2020). These functions are often lumped together under the rubric of an Advanced Driver Assistant System (ADAS), including some form of Driver Monitoring

System (DMS) which uses digital sensing technology to scan the interior of the vehicle. The basic function of an ADAS is to mitigate human error through an automated adaptive assistant, including through features such as blind spot detection, parking assistants or adaptive cruise control (Sarala, Yadav, and Ansari 2018). Emotion-tracking technologies deploy sensors such as cameras, microphones, and biometric data collectors/sensors to recognize physiological proxy indicators for emotive expression such as facial expression, tone of voice, or increased heartbeat (Wachter 2019; Kaur et al., n.d.). Trained neural networks then analyze data regarding emotive expression it receives and make a prediction as to what emotion the driver is experiencing (Eyben et al. 2010; Wachter 2019).

While there is considerable interest in developing emotion recognition systems for the automotive market, there are a relatively small number of firms in the process of actively developing these technologies. We examined materials from two of the market leaders in this area, the companies Cerence and Affectiva/Smart Eye, as case studies for our analysis. In 2019, Cerence Inc. was spun out of Nuance Communications, an American firm specializing in conversational AI agents which contributed to the development of Apple's Siri voice assistant (Maffei 2020). The company's research focuses on four specific areas: virtual assistants, autonomous driving, vehicle intelligence, and shared mobility solutions. The company's main products, Cerence CoPilot, and Cerence Drive, analyze voice, gaze, gesture, and touch while integrating edge network technologies in vehicles with cloud analytics (Cerence, n.d.). With twenty-four offices around the globe, Cerence is now one of the global leaders in automotive voice assistants with over 450 million cars equipped with its technologies. Despite recent challenges to vehicle manufacturing such as a shortage of semiconductors, the company has expanded its client list over the past two years to include BMW, Ford, and Toyota (Seitz 2021). Affectiva was founded in 2009, grounded in pioneering work on affective computing at the Massachusetts Institute of Technology's Media Lab (Stark 2019; Nagy 2022). As one of the commercial founders of emotion AI, the company has contributed to these technologies' adoption in multiple industries. Affectiva boasts its interior sensing technologies enable the car to go beyond understanding the emotions of the driver and extend to how others in the vehicle are interacting with that environment (Affectiva, n.d.). In 2019, Affectiva was purchased by the Smart Eye Group, a Swedish company known for its eye-tracking technology. Smart Eye was founded in 1999 and has since emerged as one of the leaders in human sensing AI. In the automotive context, Smart Eye has integrated the emotion recognition technologies developed by Affectiva into their Driver Monitoring Systems and Interior Sensing solutions (SmartEye, n.d.-c).

Much of the data collected by these firms involve visual sensing and surveillance (Zepf et al. 2020). Affectiva, for example, states in a 2019 patent that a camera can include a "webcam, a video camera, a still camera, a thermal imager, a CCD device, a phone camera, a three-dimensional camera, a depth camera, a light field camera, [or] multiple webcams used to show different views of a person" (Kaliouby et al. 2019, 18). The patent goes on to state that the camera captures "gestures, smiles, brow furrows, squints, lowered eyebrows, raised eyebrows, attention, and the like" (Kaliouby et al. 2019, 22) and thus can infer mental states such as being "alert, engaged, impaired, asleep, unconscious, reclined, drowsy, fatigued, or inattentive; exhibiting antisocial behaviour" (Kaliouby et al. 2019, 24). Similarly, Smart Eye uses camera data to track "eye gaze, head movement, and body position of driver and passengers" (*Smart Eye Automotive Interior Sensing - Overview* 2022). The entirety of the driver's face and visible body is used to determine how they are feeling in any given situation.

Visual data can be coupled with audio data to support the automated emotion recognition process. For example, Affectiva's 2019 patent notes that its in-car audio recording system will record not just speech, but non-speech utterances such as "grunts, yelps, squeals, snoring, sighs, laughter, filled pauses, unfilled pauses, [and] yawns" (Kaliouby et al. 2019, 19). The algorithm then analyses "timbre, prosody, vocal register, vocal resonance, pitch, loudness, speech rate, or language content," to determine the emotional or cognitive state of the driver (Kaliouby et al. 2019, 22). In addition to visual and audio data, these systems also aim to collect other biometric data. In-car tracking and analytic systems use physiological data as proxies for a driver's emotional state. For example, Cerence implements "galvanic skin response receptors (e.g., mounted on a steering wheel or other input), and/or other sensors that can predict a physiological characteristic of the user" to gain access to biometric data of the driver (Cerence 2021b), including metrics such as heart rate variability, skin temperature, blood pressure, muscle movements, or respiration (D'mello and Kory 2015).

Methodology

Data and Source Collection

To understand which discourses of legitimation are being mobilized by automotive emotion tracking companies and how they represent the benefits and impacts of the technologies they produce [**RQ1**], we analyzed a variety of publicly available promotional materials, advertising, and company patents from Cerence, Affectiva, and Smart Eye. We first searched for all publicly available patents related to those companies. Examining this corpus of data yielded four patents from Cerence and seven from Affectiva within the scope of interest for this study, i.e. related to each company's automotive technologies. SmartEye had no publicly available patents. This scan yielded a final set of 11 patents. We also searched for all technical papers published by au-

thors associated with these three companies, yielding 10 relevant technical papers. Further, we collected public investor information. Cerence' 2019 IPO meant that a variety of disclosure forms and other financial documents were available and added these to our corpus. We also analyzed a variety of marketing, advertising, and promotional materials drawn from each company's public-facing web presence and promotional oeuvre.

In this study, we draw on promotional materials to surface not their relative presentation of some purported ground truth, but rather, as a set of artifacts through which to understand how the industry assumes, expects, and desires individual consumers to interact with these technologies in their everyday lives. Advertising and promotional materials, as the sociologist Michael Schudson observes, are inevitably a "reflection of a common symbolic culture," though one that does not faithfully document actual practice (Schudson 1984, 210). Historian Roland Marchand notes that, American advertisements of the early twentieth century "portrayed the ideals and aspirations of the system...they dramatized the American dream" (Marchand 1985). Such materials do not reproduce the actual complexities, improvisations, and inequalities of social life. Instead, they present idealized images of consumption as the advertiser wishes it would occur, reflecting both the "social fantasy" of the consuming classes and the "assumptions [and] aspirations […] of the social mainstream" (Schudson 1984, 210).

We include company patents within this broader category of advertising and promotional materials deliberately. Quantitative analysis of patent data can be a valuable way of tracking the development of technologies over time (Yang and jingjing 2021; Liu, Huang, and Xing 2021). Increasingly, scholars have also begun to analyze patents using qualitative methods such as critical discourse analysis (Burk and Reyman 2014; Karppi 2018; Delfanti and Frey 2021). Burk and Reyman (Burk and Reyman 2014) observe patents are the basis of their own "peculiar, perhaps unique discursive community" (Burk and Reyman 2014, 179), in which the patent as a genre serves multiple social and legal purposes: to claim rights to technical development, to disclose details about novel devices, and to set the boundaries of a technology's use broadly and in ways favorable to the entity filing the patent. As Delfanti and Frey note, however, "patents cannot be taken at face value" (Delfanti and Frey 2021, 657). Patents are not merely legal documents, but also a highly formalized genre of speculative fiction. While they do, as Delfanti and Frey argue, "allow for a thick textual analysis of the material layer of technology," they often present these technologies within a particular frame, one that "materialize[s] the company's desire for a [particular] technological future" (Delfanti and Frey 2021, 658). In conjunction with other publicly available promotional materials, patents provide a rich source of insight into how a company would like its products to be used and perceived. Content analysis of this collection of material also allowed us to provide provisional answers to our [**RQ2**] regarding what social goals and actions are mobilized and supported by these companies through the discourses of legitimation they advance. As texts, these documents tell stories freighted with normative claims about how technologies will interact with the world and how the world should respond (Delfanti and Frey 2021). While there is no guarantee drivers, passengers, or regulators will subscribe to or agree with these discourses, their presence provides a baseline against which other groups in society will invariably be forced to contend.

Content Analysis

We performed a comparative content analysis on the patents, technical reports, advertisements, and other promotional materials collected from Affectiva, Cerence, and Smart Eye according to the principles of critical discourse analysis (CDA) (Leeuwen 2008). Critical discourse analysis is a method for understanding the ways in which texts and other forms of representative media are grounded in social practices and power relations. Because we were interested in the ways these companies argue and advocate for emotion recognition technologies in the automotive context, we used CDA's framework for unpacking the *discursive construction of legitimation* (Leeuwen 2008, chap. 6) to shape our content analysis. Such legitimation discourses are, "the answers to the spoken or unspoken questions 'Why should we do this?' or 'Why should we do this in this way?'" (Leeuwen 2008, 105). Van Leeuwen distinguishes four major categories of legitimization discourse. These are *authorization*, appeals to the authority of custom or tradition; *moral evaluation*, or legitimation by reference to values; *rationalization*, or appeals to the goals, ends, and uses of a particular activity; and *mythopoesis*, legitimation through explicit or implicit narratives of virtue and vice (Leeuwen 2008, 105). We coded company materials in order to discover textual evidence for such discourses: as such, our analysis was "directed," as our coding scheme was developed both before our analysis (with the focus on legitimation adopted prior to coding) and during the analysis, including particular themes identified during the coding process (Hsieh and Shannon 2016). We used the qualitative coding software ATLAS.ti to perform manual qualitative coding of the materials analyzed. After an initial calibration exercise, coding of all documents was primarily performed by the first author, with the second author providing reliability checks at regular intervals. After primary coding of all documents was completed, both the first and second author iteratively analyzed the codes to surface general themes present across the text corpus.

Research Ethics and Positionality

Identifying our own positionality as researchers is a critical element of qualitative research (Holmes 2020). Neither author has affiliations with any of the companies analyzed in the paper; both authors viewed this project as an opportunity

to critically evaluate emerging emotion technologies in an emerging application sector. We were both attuned to the broader societal impact such technologies could have if implemented widely. As researchers with considerable though varying amounts of positional privilege, we both sought to be consistently aware of how our identities shaped our preconceptions and research foci, particularly towards consumer practices and new technologies that are associated with hyper-developed societies.

Results

The two most common legitimating discourses across materials from all three companies were those of driver safety and of individual personalization. However, Cerence and Affectiva/Smart Eye also deployed second-order legitimating discourse that enlisted the charismatic appeal of contemporary digital technologies (Ames 2019), to justify their agency and interventions in both safety and personalization. Across their patents and promotional materials, both Cerence and Affectiva/Smart Eye frequently deployed what van Leeuwen terms a discourse of legitimation via *theoretical rationalization* (Leeuwen 2008, 113). In such discourses, narratives of legitimacy are, "grounded on some kind of truth, on 'the way things are'" (Leeuwen 2008, 116). These theoretical rationalization discourses were present in the companies' messaging and marketing materials in two forms: a) *experiential rationalization* and b) *scientific rationalization*.

The analysis of emotion data by AI systems depends on large amounts of historical and real-time data collected and analyzed, and both companies boasted frequently in their materials about the large amounts of data they collect. This discourse is an example of *experiential rationalization* (Leeuwen 2008, 116), appealing to the state of things as self-evidently justified. In this view, more data obviously and self-evidently signals increased confidence in the company's ability to predict and respond to human emotions in the vehicle: data quantity is presented as equivalent to data accuracy. For example, the 2021 Smart Eye Group annual report claimed that "Smart Eye has amassed the most unique and largest Human Insight AI data repository of its kind" (SmartEye 2021, 15). Both the scale and scope of their data sets ("12 million facial videos from more than 90 countries and over 40,000 hours of driving data from more than 6,000 unique individuals") are cited by the company to claim legitimacy. Visual, audio, and biometric data are combined, as Smart Eye puts it, to "give insight into complex human emotional and cognitive states in context" (SmartEye 2021, 10). The invocation of data collected from around the globe further supports the company's claim of universal legitimacy for their data products.

The firms in question also present conceptual models of emotion grounded in Basic Emotion Theory as paradigmatic and uncontested. Across the documents, data are depicted as being collated to create emotional metrics intended to track the state of the driver (Braun, Weber, and Alt 2022). This discourse is exemplary of *scientific rationalization*, which supports the experiential rationalization described above. Van Leeuwen notes that, "creators of legitimating discourses can remain at arm's length from the legitimating uses of their work, and often it is only in hindsight that the connections between scientific discourses and institutionalized social practices can be clearly perceived" (Leeuwen 2008, 117). Other scholarship has shown that emotions are complex and fundamentally unquantifiable in all aspects (Stark and Hoey 2021; McStay 2020), and that BET is a contested theory. Yet because the Basic Emotion Model is implicit in company materials, its normative implications, such as that emotional responses trump individual intentions, are not obvious (Leys 2011; 2017; Stark and Hoey 2021). When other conceptual models of emotion are considered as potentially valid, the legitimating function of BET as scientific rationalization begins to collapse in both the automotive context and more broadly (Barrett 2006a; 2017). If neither the experiential or scientific rationalizations for these technologies provide legitimate justification for their development, a major source of discursive legitimacy for the use of emotion technologies in cars and elsewhere becomes eroded.

Instrumental Rationalizations

The most common legitimating discourse across materials from all three companies centered on the theme of safety. Safety as a legitimizing *moral evaluation* served as the chief justification for the implementation of emotion tracking systems in automobiles. This finding supports McStay and Urquhart's similar observation that "the moral pressure saving lives" is a powerful justification for the deployment of these technologies (McStay and Urquhart 2022, 4). Appeals to driver and passenger safety suffuse company communications, patents, and marketing and investor materials. Smart Eye claims that "every 24 seconds a human life is lost in traffic" (SmartEye, n.d.-a) and Affectiva that, "9 people are killed every day and 1,000 are injured due to distracted driving" (*Affectiva's Mobile Lab* 2018). But though framed in moral terms, these statistics also served as discourses of legitimation through *instrumental rationalization*: they provide "a rationality of means and ends" that justifies these technologies' development and use according to quantifiable metrics (Leeuwen 2008, 113).

In the case of predictive technologies, such instrumental justifications are paradoxically difficult to pin down. All three companies situated their safety interventions as both reactive and predictive. In a press release for its Co-Pilot system, Cerence argues that "proactivity plays an important role in enhancing driver safety by, for example, alerting drivers to expected and unexpected maintenance issues such as a critically low oil pressure… and delivering real-time in-

formation like upcoming severe weather conditions and offering to put the car in the appropriate driving mode" (Cerence 2021a). Forewarning the driver before an accident can occur, or even recognizing a stressful state and suggesting an alternative route that is thought to be less stressful, by this standard become a new predictive baseline for driver safety. Predictive accuracy serves as another instance of justification via instrumental rationalization: the companies seek to be judged by stressful situations that they have diffused or avoided all together.

Appeals to Custom and Conformity

The discourses of instrumental rationalization we identified do not engage in broader *moral evaluation* of automobiles and their economic and social roles. Instead, they employ a further legitimation strategy: legitimation through *appeals to custom, conformity, and tradition*. Though this form of legitimation may seem counterintuitive for digital technology firms, it is firmly grounded with businesses' general association with *legitimation by authority,* whereby the power of capital and capitalism as a system inheres in individual firms. All three companies imply that nothing can or will change in contemporary transportation infrastructure, and that this infrastructure is intrinsically yet unavoidably dangerous. Cerence emphasizes the need for proactivity when "dangerous conditions are present (e.g., accident or road work nearby, inclement weather and road conditions, etc.)" (Cerence 2021b, 2). The company's word choices are significant: "dangerous conditions" are framed as situations entirely out of the control of the driver. Indeed, in all these examples, none of the "dangerous conditions involved" are the control of the driver—or anyone else. Affectiva claims in a 2019 patent that "accidents, inexperienced and incompetent vehicle operators, dangerous vehicle operators, and poorly maintained roads, among other inevitabilities, further complicate vehicular transportation" (Kaliouby et al. 2019, 17). The inevitability of danger is a common theme, suggesting not only that drivers will be better prepared to face the hazards of the road if equipped with emotion tracking technologies—but that there is no other solution other than those the company is selling.

A further feature of the safety justification concerns the other passengers in the car. Companies like Smart Eye specifically discuss the safety of children and pets in their marketing material, stating their technology plays a large role in "preventing fatal heatstroke in children or pets left in a hot car… [and] adapting traditional security functions like the activation of airbags or use of seatbelts" (SmartEye, n.d.-b). The moral weight of dependents such as children or pets is strong, and technology firms in other contexts have mobilized care as a legitimating discourse for the deployment of surveillance technologies such as in-home cameras (Stark and Levy 2018). It is also not clear whether these technical solutions are the most efficacious for protecting dependents and could be solved with other predictive measures unrelated to emotion-tracking in the car.

Even when the prevention of potentially harmful situations is in principle partially under the control of the driver, the solutions offered by the companies we surveyed almost always erred on the side of custom by supporting *more driving*. For example, Smart Eye reiterates that there are "thousands of accidents that can be prevented by[…] catch[ing] distraction… and understand[ing] what could be taking the driver's attention away from the road ahead" (SmartEye, n.d.-b). Indeed, all three companies justified the broader utility of their emotion recognition technologies by promising to combat drowsiness and distraction, two mental states with little to do with emotion *per se* (Grzelak and Brandao 2021) . One solution proposed by Cerence is to engage in "mentally non-taxing conversations (e.g., telling jokes) when the user is detected via various sensors to be sleepy" (Cerence 2021b, 3). Similarly, Affectiva claims its systems can "mitigate their boredom by engaging the participants in a conversation while they continue to perform the boredom-inducing task" (Samrose et al. 2020, 2). The notion that drivers ought not to drive in certain contexts, perhaps unsurprisingly given these companies' business models, is absent.

The Mythopoesis of Automotion

Finally, discourses around driver safety also served to advance another form of legitimation: *mythopoesis*, or storytelling with a moral (Leeuwen 2008, 117). In this case, the story is a cautionary tale about the dangers of the world outside the personal automobile, and the necessity of surveilling a driver's emotions to modulate and control their responses to that world. It is also a story that erases the reality of transportation infrastructure as both a public good and a social construct (Urry 2004). There are many areas of transportation policy that require coordination—indeed, traffic modulation and public cost saving were some of the initial goals of computer-equipped vehicles (Camus and Fortin 1995). Indeed, emotion-tracking AI systems have the potential to exacerbate problems such as rush hour traffic or erratic driving. The system's algorithm could recommend another route that has less traffic to calm the driver, but potentially simply deflects traffic, and stress, onto other drivers on other routes. By situating agency to address contemporary transportation infrastructure's problems solely in the individual driver, these companies tell a story that prioritizes the safety of the driver and ignores that of the broader public.

Personalization and Consumerist Role-Modeling

Personalization of the driving experience was the second major theme used to justify the deployment of emotion tracking and recognition systems in personal automobiles. All three companies argued that emotion tracking would further improve driving by modulating the interior space of the

car more seamlessly with the body and reactions of the driver. For example, Smart Eye writes that their technology can fine-tune "things like temperature, lighting, seats, and entertainment in real-time based on the physical, emotional, or cognitive changes of the people in the cabin" (SmartEye, n.d.-b). A Cerence technical paper emphasized that "when a driver's visual attention is taken away by an input modality, drivers are implicitly putting themselves in danger" (Funk, Tobisch, and Emfield 2020, 2). Riding in a car, Smart Eye suggests unironically, should become almost "as much about the journey as the destination" (SmartEye 2021; n.d.-b). Justifications for such personalization involve strong elements of instrumental rationalization (such as towards the ends of interacting with the car's controls without distraction); they also lean strongly on another form of legitimation by authority: that of an *appeal to role-models* (Leeuwen 2008, 107).

As van Leeuwen observes, appeals to role-models are inextricably tied to the "rapid turnover of consumer preferences" typical of contemporary consumerism. "After World War II," he notes, American popular culture spread the idea of the role model, encouraging young people across the world to take their cues from their peers and from popular culture, rather than from their elders and from tradition" (Leeuwen 2008, 108). As a major consumer purchase, the personal automobile was and continues to be a particularly potent palimpsest onto which to project consumer fantasies (Ross 1995; Hård and Knie 2011). These fantasies are often aspirational and disassociated from any one individual: instead, emotion tracking companies, like many other businesses, seek to appeal to prospects of pleasure and relaxation. Cerence claims its Co-Pilot product "transforms the in-car experience with guided tour experiences, karaoke, and more, designed specifically for the car" (Cerence, n.d.), and compares a car equipped with their technologies to a "movie theatre… a meeting room… [and] a lounge" (*Introducing Cerence* 2019). Unsurprisingly, legitimating appeals to consumer role-modeling are more common in the advertising and promotional material produced by the firms than in their patents, suggesting firms believe different legitimation strategies are more appropriate and effective for different audiences.

By emphasizing both safety and personalization in their legitimation appeals, the companies also connect their products with the broader gamification of the driving experience (Jagoda 2013; Steinberger, Schroeter, and Watling 2017). Mobile applications like Waze, a map service that allows users to track, record, and share various aspects of their trip such as gas prices, police sightings, and hazards on the road, have pioneered the reframing of driving as a mediated game, one in which the driver can collect points, badges and unlock different icons and cars to personalize one's experience and improve one's travel time (Laframboise 2020) Almost by definition, gamification entails legitimation and justification through discourses of instrumental rationalization, in this case focusing on means: applying game mechanics to non-game contexts is intended to make these situations less unpleasant. However, gamification also has the potential to enable more errors on the part of the driver. The goal of emotion tracking technologies is to ensure the driver maintains calm and focus on the road, and personalization options could serve as a distraction. This paradox is exemplary of a challenge for any group seeking to legitimate their actions through appeals to multiple different sources of legitimacy: at times, these justifications can be difficult to make commensurate.

Productivity and the Customs of Surveillance Capitalism

Discourses around worker and business productivity were a final area in which the company materials we analyzed sought to legitimate emotion recognition technologies with respect to implicit *appeals to custom* and the status quo. In their materials, the companies often made clear that discourses of personalization could also be applied to the decisions not of drivers but of automobile makers. Cerence claims their Co-Pilot product makes it possible for Original Equipment Manufacturers (OEMs)—the car companies—to "build the experience their way with a flexible architecture that can incorporate existing systems"("Cerence Co-Pilot: The Future of Mobility Assistants" 2022). As articulated in documents for Cerence's Initial Public Offering (IPO), the company's technologies allow for accommodation of "user preferences while still providing a unique and brand-specific experience" (Cerence 2019, 7). Cerence also advertises a fleet management offering, where their technology automates "manual tasks drivers must do throughout their shifts, from logging daily safety and maintenance reports to recording their hours" (Cerence 2022). These functionalities are part of legitimation appeals not to individual drivers, but to business owners.

These examples illustrate how emotion recognition technologies are part of a longer line of driver monitoring practices aimed at increasing productivity (Kern and Schmidt 2009). In her study of long-haul truck drivers, Levy observes that "as monitoring technologies continue to become lighter and cheaper, we can expect them to proliferate across workplaces and into new settings, where fine-grained control over employees' labor had previously been impracticable" (Levy 2015, 160). Cerence's promotional copy makes a focus on such vehicle control explicit. Its fleet service "pulls from in-car sensor data to create a digital twin, or real-time replication, of the car in the cloud... offer[ing] unprecedented insight into every fleet vehicle's software, maintenance reports, electronics and driver behaviors, showing everything from a truck's route and how much gas it has to whether or not the windshield wipers are on" (Cerence 2022). This example suggests that driver management is as much about instrumental rationalization expressed in economic terms as well as in purely discursive ones.

The easy integration and customization of options for the management of boredom and other mental states into driver monitoring systems, alongside route tracking and other forms of workplace surveillance, make these technologies enticing not only to car manufacturers but also for any company employing many workers who must drive as part of their jobs. Recording hours and being constantly surveilled by managers has the potential to create toxic work environments for drivers (Levy 2015). The sheer amounts of data being collected to train and enable systems also raises major privacy concerns. For example, Cerence's Drive product manages "content, [enables] access [to] third-party services, and save[s] their personal profiles," while also learning "each user's preferences, [and] drawing from diverse sources to personalize its recommendations" (Cerence, n.d.).

Analysis and recommendations made by these systems are also based on sensitive data: for example, Affectiva takes the cognitive state data to create a personal profile for the driver that includes information such as "any demographic, such as age, sex, marital status, literacy/education, employment status and occupation, geographical location, place of birth, language, religion, nationality, ethnicity, race, and citizenship, among others" (Kaliouby et al. 2020, 23) Likewise, Cerence claims that their situation assessment engine may receive third-party information from data providers, such as "current or immediately in the future weather conditions at or near (e.g., within a predefined distance that is specified by a developer or others) a current location, hazards (e.g., construction, accident, disabled vehicle, aggressive driving detected) at or near a current location, and/or other third party data may be used to assess a situational state" (Cerence 2021b, 8). It is difficult not to question the necessity for a car to know and store the driver's race or employment status in an all-encompassing digital profile, particularly if these data are accessible to other third-party apps. Emotion data is understood by users as particularly sensitive and private (Roemmich and Andalibi 2021; Andalibi and Buss 2020). There is a clear difference between using emotional data to adjust seats and lighting in the car and using it in partnership with third-party apps where the user has no idea how their data is being used beyond access to the app itself.

Businesses in the service sector are currently reaping the most benefits from in-car productivity features, and for fleet managers appeals to legitimation via economic productivity appear to be more than enough to justify potential privacy harms. However, emotion tracking firms are also interested in legitimating their products through appeals to productivity pitched at white-collar workers. The stated goal of these companies is to enable drivers to complete other tasks while the car takes care of driving. For the moment however, in-car virtual assistants like Cerence's Co-Pilot are limited in their capacities. Co-Pilot acts as a virtual assistant that can help with daily productivity: starting a team meeting, routing payment for gas, or turning on the lights in the house when the driver is ten minutes from home (*Cerence: AI for a World in Motion* 2021). Yet the prospect of white-collar productivity while driving is still a *mythopoetic narrative* for most white-collar drivers. Appeals to such narratives of ease and productivity mix elements of means-end rationalization, appeals to conformity and custom, and morality tales about the ideal driver: one in control of self and vehicle, and plugged into the mobile circuits of consumer capitalism. Given that these forms of legitimating discourse may conflict with one another, they can most easily coexist at the level of narrative: if emotion tracking and other driver management technologies become more widespread, the lived contradictions between personalization and productivity may become harder to ignore for both manufacturers and consumers alike.

Through our analysis of advertising, promotional materials, and patents from the leading automotive emotion tracking firms Cerence, Affectiva and Smart Eye, we identified a variety of discursive legitimation strategies including appeals to both theoretical and instrumental rationalization, to the authority of conformity, custom, and consumerist role modeling, and to mythopoetic narratives of the ideal driver. This "moral background" provides provisional answers to our [**RQ2**], through which we asked what sorts of social goals and actions were supported, implicitly or explicitly, by the legitimation discourses deployed by these firms (Abend 2014). The practical implications and effects of this array of legitimation strategies will likely conflict in the lived experience of actual drivers, passengers, pedestrians, and other participants in transportation networks. But as a set of rhetorical devices, this mix of legitimation discourses paints a coherent discursive picture of the desired social effects of emotion tracking in personal automobiles. Perhaps unsurprisingly, the goals implied by the legitimation discourses deployed by these emotion tracking firms in the context of their automotive applications are supportive of personal automobiles and the current structure of the car industry and transportation networks more broadly. Though these firms tout the novelty of their technical innovations, the legitimizing discourses they use are conservative: by appealing to economic and material systems as they already exist, these firms support the status quo, and by extension the power imbalances within the social systems enabled by private automobile use. Through the mobilization of discourses around instrumental rationalization, the firms also support utilitarian logics that align with neoliberal capitalist values. And while safety as a legitimating moral discourse is salutary, its narrow framing in new technical innovations meant to further surveil drivers suggests its use in this instance is more akin to that of securitization, through which concerns about safety and security are used by the powerful to remove certain topics from communal debate and make them the preserve of experts associated with the status quo (Hansen and Nissenbaum 2009; Nissenbaum 2005). In this context, emotion tracking and monitoring technologies support the legitimacy of this moral background by providing a

theoretical rationalization for the practices of monitoring and intervening on driver behavior—though the science supporting this rationalization is contested (Barrett et al. 2019). Indeed, without appeals to safety and consumer personalization, these systems are easier to recognize as coercive surveillance technologies, ones which are already familiar to service and transportation workers.

Limitations and Conclusion

Grounded in discourse analysis, this paper has assessed the legitimation discourses of leading technology firms developing emotion tracking technologies for the automotive market. Though the leading firms in this area are currently based in Europe and North America, these systems are being deployed around the world; future comparative work both on deployments and regulations of these technologies in various global contexts is much needed. Further work comparing legitimation discourses in company materials and those discourses articulated in other genres, such as the digital technology press or general news media, would be valuable in tracing the circulation of these legitimation discourses and how they are disseminated. And design research tools such as the app walkthrough method (Light, Burgess, and Duguay 2017) could be applied to material analysis of in-car systems themselves, to evaluate if and how these legitimation discourses are also expressed through the technologies themselves. Perhaps most importantly, this study has examined what technology firms claim about emotion tracking technologies, not how these technologies are actually used. Further qualitative and quantitative research on these technologies as they are tested and deployed is necessary, in part to understand when their use is categorically inappropriate (Stark and Hoey 2021). By documenting how the technology firms developing emotion monitoring technologies imagine the future of the personal automobile and legitimate their vision of its social role through a variety of discursive strategies, we seek to support further such work interrogating how digital technology firms frame emotion tracking and monitoring elements of their technical systems in social terms. In doing so, we have highlighted the fact that automotive technologies are not actors on their own: their legitimation by their designers and makers continues to shape their place in transportation networks for better or worse.

Acknowledgments

The authors would like to acknowledge the Undergraduate Summer Research Internship Program (USRI) at Western University, the Social Sciences and Humanities Research Council of Canada (SSHRC), and the Canadian Institute for Advanced Research (CIFAR) for their support of this project.

References

Abend, G. 2014. *The Moral Background*. Princeton, NJ: Princeton University Press.

Abuelsamid, S. 2019. Digital Voice Assistants Are the Future of In-Vehicle Control. *Automotive World*. www.automotiveworld.com/articles/digital-voice-assistants-are-the-future-of-in-vehicle-control/.

Ackerman, E. 2021. What Full Autonomy Means for the Waymo Driver. *IEEE Spectrum*. spectrum.ieee.org/full-autonomy-waymo-driver.

Affectiva. n.d. Our Origins. www.affectiva.com/about-affectiva/. Accessed 2022-09-08.

Affectiva. 2018. Affectiva's Mobile Lab. www.youtube.com/watch?v=zRbGSxcosfg. Accessed 2022-09-08.

Ames, M. 2019. *The Charisma Machine: The Life, Death, and Legacy of One Laptop per Child*. Cambridge, MA: The MIT Press.

Andalibi, N.; and Buss, J. 2020. The Human in Emotion Recognition on Social Media: Attitudes, Outcomes, Risks. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. New York: Association for Computing Machinery. doi.org/10.1145/3313831.3376680.

Article, 19. 2021. Emotional Entanglement: China's Emotion Recognition Market and Its Implications for Human Rights. www.article19.org/emotion-recognition-technology-report/. Accessed 2023-08-01.

Baria, K. V.; and Samant, R. M. 2011. GPS/GPRS Based System for Vehicle Tracking and Traffic Management. In Proceedings of the International Conference & Workshop on Emerging Trends in Technology. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/1980022.1980365.

Barrett, L. 2006a. Are Emotions Natural Kinds? *Perspectives on Psychological Science* 1(1): 28–58. doi.org/10.1111/j.1745-6916.2006.00003.x

Barrett, L. 2006b. Solving the Emotion Paradox: Categorization and the Experience of Emotion. *Personality and Social Psychology Review* 10(1): 20–46. doi.org/10.1207/s15327957pspr1001_2.

Barrett, L. 2017. *How Emotions Are Made: The Secret Life of the Brain*. New York: Houghton Mifflin Harcourt.

Barrett, L.; Adolphs, R.; Marsella, S.; Martinez, A.; and Pollak, S. 2019. Emotional Expressions Reconsidered: Challenges to Inferring Emotion from Human Facial Movements. *Psychological Science in the Public Interest* 20(1): 1–68. doi.org/10.1177/1529100619832930.

Boehner, K.; DePaula, R.; Dourish, P.; and Sengers, P. 2005. Affect: From Information to Interaction. In Proceedings of the 4th Decennial Conference on Critical Computing (CC '05). New York, NY, USA: Association for Computing Machinery. doi.org/ 10.1145/1094562.1094570.

Boehner, K.; DePaula, R.; Dourish, P.; and Sengers, P. 2007. How Emotion Is Made and Measured. *International Journal of Human-Computer Studies* 65:275–291. doi.org/10.1016/j.ijhcs.2006.11.016.

Bonnefon, J.F.; Shariff, A.; and Rahwan, I. 2016. The Social Dilemma of Autonomous Vehicles. *Science* 352(6293): 1573–76. doi.org/10.1126/science.aaf2654.

Braun, M.; Li, J.; Weber, F.; Pfleging, B.; Butz, A.; and Alt, F. 2020. What If Your Car Would Care? Exploring Use Cases for Affective Automotive User Interfaces." In Proceedings of 22nd International Conference on Human-Computer Interaction with Mobile Devices and Services. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3379503.3403530.

Braun, M.; Weber, F.; and Alt, F. 2022. Affective Automotive User Interfaces–Reviewing the State of Driver Affect Research and Emotion Regulation in the Car. *ACM Computing Surveys* 54(7): 1–26. doi.org/10.1145/3460938.

Buolamwini, J.; and Gebru, T. 2018. Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification. *Proceedings of Machine Learning Research* 81:1-15.

Burk, D.; and Reyman, J. 2014. Patents as Genre: A Prospectus. *Law & Literature* 26(2): 163–90. doi.org/10.1080/1535685x.2014.888193.

Burnett, G.; and Porter, J.M. 2001. Ubiquitous Computing within Cars: Designing Controls for Non-Visual Use. *International Journal of Human-Computer Studies* 55(4): 521–31. doi.org/10.1006/ijhc.2001.0482.

Picard, R.W. 2015. The Promise of Affective Computing. In *The Oxford Handbook of Affective Computing*, edited by R. Calvo, S, D'Mello, J. Gratch, and A. Kappas, online edition (Oxford Academic, 5 Dec. 2014). doi.org/10.1093/oxfordhb/9780199942237.013.013.

Camus, J.; and Fortin, M. 1995. Road Transport Informatics: Institutional and Legal Issues, Technical Report for European Conference of Ministers of Transport. rosap.ntl.bts.gov/view/dot/2463. Accessed: 2023-08-23.

Card, S.; Moran, T.; and Newell, A. 1983. *The Psychology of Human-Computer Interaction*. Hillsdale, NJ and London: Lawrence Erlbaum Associates.

Carey, N., and Lienert, P. 2022. Truly Autonomous Cars May Be Impossible without Helpful Human Touch. Reuters. www.reuters.com/technology/truly-autonomous-cars-may-be-impossible-without-helpful-human-touch-2022-09-12/. Accessed: 2023-07-23

Cerence. 2019. Introducing Cerence. www.youtube.com/watch?v=SBXpbk_9tcM.

Cerence. 2019. Form S1 - Cerence IPO Prospectus. Accessed: 2022-06-02.

Cerence. 2021a. Cerence Raises the Bar for Mobility with the Introduction of Cerence Co-Pilot, a Deeply Integrated, Ultra-Intelligent In-Car Assistant. www.globenewswire.com/news-release/2021/12/20/2355179/0/en/Cerence-Raises-the-Bar-for-Mobility-with-the-Introduction-of-Cerence-Co-Pilot-a-Deeply-Integrated-Ultra-Intelligent-In-Car-Assistant.html. Accessed: 2022-06-02.

Cerence. 2021b. System and method of conversational adjustment based on user's cognitive state and/or situational state, Patent 10,431,215, issued 2021.

Cerence. 2022. Making Voice Central to Fleet Success. www.cerence.com/news-releases/news-release-details/making-voice-central-fleet-success. Accessed: 2022-06-02.

Cerence. n.d. Cerence Products. www.cerence.com/cerence-products/core-technologies. Accessed: 2022-09-10

Cerence. 2021. Cerence: AI for a World in Motion. www.youtube.com/watch?v=UWJDKDPWx1Q. Accessed: 2022-09-10.

Cerence. 2022. Cerence Co-Pilot: The Future of Mobility Assistants. https://www.cerence.com/news-releases/news-release-details/cerence-co-pilot-named-cockpit-future-product-year-informa-tech. Accessed: 2022-09-10.

Cha, K.; Giacomin, J.; Lycett, M.; Mccullough, F.; and Rumbold, D. 2015. Identifying Human Desires Relative to the Integration of Mobile Devices into Automobiles. In Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '15), 142–149. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/2799250.2799252.

Cheney-Lippold, J. 2017. *We Are Data: Algorithms and The Making of Our Digital Selves*. New York: New York University Press.

Geary, T.; and Danks, D. 2019. Balancing the Benefits of Autonomous Vehicles. Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society, 181–86. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3306618.3314237.

Coppola, R.; and Morisio, M. 2016. Connected Car: Technologies, Issues, Future Trends. *ACM Computing Surveys (CSUR)* 49(3): 1–36. doi.org/10.1145/2971482.

Corvite, S.; Roemmich, K.; Rosenberg, T.; and Andalibi, N. 2023. Data Subjects' Perspectives on Emotion Artificial Intelligence Use in the Workplace: A Relational Ethics Lens. *Proceedings of the ACM on Human-Computer Interaction* 7 (CSCW1): 1–38. doi.org/10.1145/3579600.

Cowie, R.; Douglas-Cowie, E.; Tsapatsoulis, N.; Votsis, G.; Kollias, S.; Fellenz, W.; and Taylor, J. 2001. Emotion Recognition in Human-Computer Interaction. *IEEE Signal Processing Magazine* 18 (1): 33–80. doi.org/10.1109/79.911197

Davies, W. 2017. How Are We Now? Real-Time Mood-Monitoring as Valuation. *Journal of Cultural Economy* 10(1): 34–48. doi.org/10.1080/17530350.2016.1258000.

Delfanti, A.; and Frey, B. 2021. Humanly Extended Automation or the Future of Work Seen through Amazon Patents. *Science, Technology, & Human Values* 46(3): 655–82. doi.org/10.1177/0162243920943665.

DiBerardino, N.; and Stark, L. 2023. (Anti)-Intentional Harms: The Conceptual Pitfalls of Emotion AI in Education. In Proceedings of the 2023 ACM Conference on Fairness, Accountability, and Transparency (FAccT '23), 1386–1395. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3593013.3594088.

Dixon, T. 2012. "Emotion": The History of a Keyword in Crisis. *Emotion Review* 4(4): 338–44. doi.org/10.1177/1754073912445814.

D'Mello, S.; and Kory, J. 2015. A Review and Meta-Analysis of Multimodal Affect Detection Systems. *ACM Computing Surveys (CSUR)* 47(3): 1–36. doi.org/10.1145/2682899.

Dubljevic, V. 2020. Toward Implementing the Agent-Deed-Consequence Model of Moral Judgment in Autonomous Vehicles. In Proceedings of the AAAI/ACM Conference on

AI, Ethics, and Society, 243–243. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3375627.3375853.

Ekman, P.; Sorenson, E.; and Friesen, W. 1969. Pan-Cultural Elements in Facial Display of Emotion. *Science* 164 (April): 86–88.

Ellis, D.; and Tucker, I. 2021. *Emotion in the Digital Age; Technologies, Data and Psychosocial Life*. New York: Routledge.

Eyben, F.; Wöllmer, M.; Poitschke, T.; Schuller, B.; Blaschke, C.; Färber, B.; and Nguyen-Thien, N. 2010. Emotion on the Road—Necessity, Acceptance, and Feasibility of Affective Computing in the Car. *Advances in Human-Computer Interaction* 2010:1–17. doi.org/10.1155/2010/263593.

Funk, M; Tobisch, V; and Emfield, A. 2020. Non-Verbal Auditory Input for Controlling Binary, Discrete, and Continuous Input in Automotive User Interfaces. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3313831.3376816.

Furman, J.; Marchant, G.; Price, H.; Rossi, F.; London, A.; and Danks, D. 2018. Regulating Autonomous Vehicles. In Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society, 216–21. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3278721.3278763.

Gkikas, N., ed. 2013. *Automotive Ergonomics: Driver-Vehicle Interaction*. Boca Raton, FL: CRC Press/Taylor & Francis.

Goggin, G. 2012. Driving the Internet: Mobile Internets, Cars, and the Social. *Future Internet* 4(1): 306–21. doi.org/10.3390/fi4010306.

Granville, K. 2018. Facebook and Cambridge Analytica: What You Need to Know as Fallout Widens. *New York Times*, March 19. www.nytimes.com/2018/03/19/technology/facebook-cambridge-analytica-explained.html. Accessed: 2022-09-01

Greene, D.; A. Hoffmann; and Stark, L. 2019. Better, Nicer, Clearer, Fairer. In Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS), edited by T X Bui and R H Sprague, 2122–31. hdl.handle.net/10125/59651.

Grill, G., and Andalibi, N. 2022. Attitudes and Folk Theories of Data Subjects on Transparency and Accuracy in Emotion Recognition. In Proceedings of the ACM on Human-Computer Interaction 6 (CSCW1): 1–35. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3512925.

Grzelak, J.; and Brandao, M. 2021. The Dangers of Drowsiness Detection: Differential Performance, Downstream Impact, and Misuses. In Proceedings of the 2021 AAAI/ACM Conference on AI, Ethics, and Society, 525–31. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3461702.3462593.

Guo, X.; Yang, J.; and Zhang, J. 2022. Research on User Behavior Oriented Intelligent Interactive Design of Automobile Cockpit." In Proceedings of the 5th International Conference on Information Technologies and Electrical Engineering (ICITEE '22), 521–525. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3582935.3583022.

Hansen, L.; and Nissenbaum, H. 2009. Digital Disaster, Cyber Security, and the Copenhagen School. *International Studies Quarterly* 53:1155–75.

Hård, M.; and Knie, A. 2011. The Cultural Dimension of Technology Management: Lessons from the History of the Automobile. *Technology Analysis & Strategic Management* 13(1): 91–103. doi.org/10.1080/09537320120040464.

Holmes, A.; and Darwin, G. 2020. Researcher Positionality - A Consideration of Its Influence and Place in Qualitative Research - A New Researcher Guide. *Shanlax International Journal of Education* 8(4): 1–10. doi.org/10.34293/education.v8i4.3232.

Hong, J.; Bures, M.; Park, J.; Cerny, T.; Ribeiro, Q.; Ribeiro, M.; and Castro, J. 2022. Requirements Engineering for Autonomous Vehicles. In Proceedings of the 37th ACM/SIGAPP Symposium on Applied Computing, 1299–1308. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3477314.3507004.

Hsieh, H.; and Shannon, S. 2016. Three Approaches to Qualitative Content Analysis. *Qualitative Health Research* 15(9): 1277–88. doi.org/10.1177/1049732305276687.

Jagoda, P. 2013. Gamification and Other Forms of Play. *Boundary 2* 40(2): 113–44. doi.org/10.1215/01903659-2151821.

Kaliouby, R.; Abdelrahman, M.; Taniya, M.; Todd, Z.; and Zijderveld, G. 2019. Directed Control Transfer for Autonomous Vehicles, Patent US20190152492A1, issued 2019.

Kaliouby, R.; Abdelrahman, M.; Seyedmohammad, M.; and Zijderveld, G. 2020. Personal Emotional Profile Generation for Vehicle Manipulation, Patent US10796176B2, issued 2020.

Karppi, T. 2018. *Disconnect: Facebook's Affective Bonds*. Minneapolis: University of Minnesota Press.

Kaur, H.; McDuff, D.; Williams, A.; Teevan, J.; and Iqbal. S. 2022. "I Didn't Know I Looked Angry"; Characterizing Observed Emotion and Reported Affect at Work. In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3491102.3517453.

Kaye, J.; Druin, A.; Lampe, C.; Morris, D.; Hourcade, J.; Meschtscherjakov, A.; and Tscheligi, M. 2016. HCI and Autonomous Vehicles. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems, 3542–49. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/2851581.2856489.

Kazmi, S.; Dang, T.; Yaqoob, I.; Ndikumana, A.; Ahmed, E.; Hussain, R.; and Hong. C. 2019. Infotainment Enabled Smart Cars: A Joint Communication, Caching, and Computation Approach. *IEEE Transactions on Vehicular Technology* 68(9): 8408–20. doi.org/10.1109/tvt.2019.2930601.

Kern, D.; and Schmidt, A. 2009. Design Space for Driver-Based Automotive User Interfaces." In Proceedings of the 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '09), 3–10. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/1620509.1620511.

Kline, R.; and Pinch, T. 1996. Users as Agents of Technological Change: The Social Construction of the Automobile

in the Rural United States. *Technology and Culture* 37(4): 763. doi.org/10.2307/3107097.

Koopman, P.; and Osyk, B. 2019. Safety Argument Considerations for Public Road Testing of Autonomous Vehicles. *SAE International Journal of Advances and Current Practices in Mobility* 1(2): 512–23. doi.org/10.4271/2019-01-0123.

Kramer, A.; Guillory, J.; and Hancock, J. 2014. Experimental Evidence of Massive-Scale Emotional Contagion through Social Networks. *Proceedings of the National Academy of Sciences* 111(24): 8788–90. doi.org/10.1073/pnas.1320040111.

Laframboise, S. 2020. Waze: A Beautiful Marriage of Tech, Gamification & Product Design. LinkedIn. www.linkedin.com/pulse/waze-beautiful-marriage-tech-gamification-product-sheldon-laframboise. Accessed: 2023-08-23.

Lee, E.; Gerla, M.; Pau, G.; Lee, U. and Lim, J. 2016. Internet of Vehicles: From Intelligent Grid to Autonomous Cars and Vehicular Fogs. *International Journal of Distributed Sensor Networks* 12(9): 1550147716665500. doi.org/10.1177/1550147716665500.

Leeuwen, T. 2008. *Discourse and Practice: New Tools for Critical Discourse Analysis (Oxford Studies in Sociolinguistics)*. Oxford: Oxford University Press.

Levy, K. 2015. The Contexts of Control: Information, Power, and Truck-Driving Work. *The Information Society* 31(2): 160–74. doi.org/10.1080/01972243.2015.998105.

Leys, R. 2011. The Turn to Affect: A Critique. *Critical Inquiry* 37(3): 434–72.

Leys, R. 2017. *The Ascent of Affect*. Chicago: University of Chicago Press.

Light, B.; Burgess, J.; and Duguay, S. 2017. The Walkthrough Method: An Approach to the Study of Apps. *New Media & Society* 12(7): 881-900. doi.org/10.1177/1461444816675438.

Liu, D.; Huang, W.; and Xing, G. 2021. Research on 5G Technology Competition Situation Based on Patent Analysis. In Proceedings of the 2021 2nd International Conference on Artificial Intelligence and Information Systems, 1–10. doi.org/10.1145/3469213.3470695.

Maffei, L. 2020. Burlington Automotive Software Firm Cerence Thrives Even as Car Sales Fall. Boston Business Journal, August 4. www.bizjournals.com/boston/news/2020/08/04/shares-of-car-software-maker-soar.html. Accessed: 2022-09-03

Marchand, R. 1985. *Advertising the American Dream: Making Way for Modernity, 1920–1940*. Berkeley and Los Angeles: University of California Press.

Martin, E. 2007. *Bipolar Expeditions*. Princeton, NJ: Princeton University Press.

Marx, P. 2023. Big Tech Is Watching You as You Drive. The New Republic, July 15. newrepublic.com/article/174089/big-tech-watching-drive?utm_medium=social&utm_source=Twitter&utm_campaign=SF_TNR. Accessed: 2023-08-24

McStay, A. 2016. Empathic Media and Advertising: Industry, Policy, Legal and Citizen Perspectives (the Case for Intimacy). *Big Data & Society* 3(2). doi.org/10.1177/2053951716666868.

McStay, A. 2018. *Emotional AI: The Rise of Empathic Media*. New York and London: SAGE.

McStay, A. 2019. Emotional AI and EdTech: Serving the Public Good? *Learning, Media and Technology* 45(3): 270-283. doi.org/10.1080/17439884.2020.1686016.

McStay, A. 2020. Emotional AI, Soft Biometrics and the Surveillance of Emotional Life: An Unusual Consensus on Privacy. *Big Data & Society* 7(1). doi.org/10.1177/2053951720904386.

McStay, A.; and Pavliscak, P. 2019. Emotional Artificial Intelligence: Guidelines for Ethical Use. emotionalai.org/. Accessed: 2023-08-22

McStay, A.; and Rosner, G. 2021. Emotional Artificial Intelligence in Children's Toys and Devices: Ethics, Governance and Practical Remedies. *Big Data & Society* 8(1). doi.org/10.1177/2053951721994877.

McStay, A.; and Urquhart, L. 2019. 'This Time with Feeling?' Assessing EU Data Governance Implications of out of Home Appraisal Based Emotional AI. *First Monday* 24(10). doi.org/10.5210/fm.v24i10.9457.

McStay, A.; and Urquhart, L. 2022. In Cars Are We Really Safest of All: Interior Sensing and Emotional Opacity. *International Review of Law, Computers & Technology* 36(3): 470-493. doi.org/10.1080/13600869.2021.2009181.

Mercedes-Benz. n.d. 1885–1886: The First Automobile. group.mercedes-benz.com/company/tradition/company-history/1885-1886.html. Accessed: 2022-09-03

Miller, J. 2014. The Fourth Screen: Mediatization and the Smartphone. *Mobile Media & Communication* 2(2): 209–26. doi.org/10.1177/2050157914521412.

Minsky, M. 2006. *The Emotion Machine*. New York: Simon & Schuster.

Murali, P.; Kaboli, M.; and Dahiya. R. 2022. Intelligent In-Vehicle Interaction Technologies. *Advanced Intelligent Systems* 4(2): 2100122. doi.org/10.1002/aisy.202100122.

Nagy, J. 2022. Autism and the Making of Emotion AI: Disability as Resource for Surveillance Capitalism. *New Media & Society* 26(7): 3989-4007. doi.org/10.1177/14614448221109550.

Nissenbaum, H. 2005. Where Computer Security Meets National Security. *Ethics and Information Technology* 7:61–73. doi.org/10.1007/s10676-005-4582-3.

Noble, S. 2018. *Algorithms of Oppression: How Search Engines Reinforce Racism*. New York: New York University Press.

O'Neil, C. 2017. *Weapons of Math Destruction*. New York: Broadway Books.

Picard, R. 2000. *Affective Computing*. Cambridge, MA: The MIT Press.

Pierson, E.; Simoiu, C.; Overgoor, J.; Corbett-Davies, S.; Jenson, D.; Shoemaker, A.; Ramachandran, V. et al. 2020. A Large-Scale Analysis of Racial Disparities in Police Stops across the United States. *Nature Human Behaviour* 4(7): 736–45. doi.org/10.1038/s41562-020-0858-1.

Raifman, M.; and Choma, E. 2022. Disparities in Activity and Traffic Fatalities by Race/Ethnicity. *American Journal of Preventive Medicine* 63(2): 160–67. doi.org/10.1016/j.amepre.2022.03.012.

Raji, D.; Gebru, T.; Mitchell, M.; Buolamwini, J.; Lee, J.; and Denton, E. 2020. Saving Face: Investigating the Ethical Concerns of Facial Recognition Auditing. In Proceedings of the 2020 AAAI/ACM Conference on AI, Ethics, and Society. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3375627.3375820.

Rhue, L. 2018. Racial Influence on Automated Perceptions. papers.ssrn.com/sol3/papers.cfm?abstract_id=3281765&download=yes.

Roemmich, K.; and Andalibi, N. 2021. Data Subjects' Conceptualizations of and Attitudes Toward Automatic Emotion Recognition-Enabled Wellbeing Interventions on Social Media. In Proceedings of the ACM on Human-Computer Interaction 5 (CSCW2): 1–34. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3476049.

Roemmich, K.; Rosenberg, T.; Fan, S.; and Andalibi, N. 2023. Values in Emotion Artificial Intelligence Hiring Services: Technosolutions to Organizational Problems. In Proceedings of the ACM on Human-Computer Interaction 7 (CSCW1): 1–28. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3579543.

Roemmich, K.; Schaub, F.; and Andalibi, N. 2023. "Emotion AI at Work: Implications for Workplace Surveillance, Emotional Labor, and Emotional Privacy. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3544548.3580950.

Ross, K. 1995. *Fast Cars, Clean Bodies: Decolonization and the Reordering of French Culture*. Cambridge, MA: The MIT Press.

Russell, J. 2003. Core Affect and the Psychological Construction of Emotion. *Psychological Review* 110(1): 145–72. doi.org/10.1037/0033-295x.110.1.145.

Saltzman, M. 2022. Self-Driving Cars Are a Thing of the Future. But Is That Future Right around the Corner? USA Today, August 29. www.usatoday.com/story/tech/2022/08/29/self-driving-cars-future-gm-tesla/7896389001/. Accessed: 2022-08-30.

Samrose, S.; Anbarasu, K.; Joshi, A.; and Mishra, T. 2020. Mitigating Boredom Using an Empathetic Conversational Agent. In Proceedings of the 20th ACM International Conference on Intelligent Virtual Agents, 1–8. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3383652.3423905.

Sarala, S.; Yadav, D.; and Ansari, A. 2018. Emotionally Adaptive Driver Voice Alert System for Advanced Driver Assistance System (ADAS) Applications. In Proceedings of the 2018 International Conference on Smart Systems and Inventive Technology (ICSSIT) 00:509–12. doi.org/10.1109/icssit.2018.8748541.

Scheutz, M. 2012. The Affect Dilemma for Artificial Agents: Should We Develop Affective Artificial Agents? *IEEE Transactions on Affective Computing* 3(4): 424-433. doi.org/10.1109/T-AFFC.2012.29.

Schmidt, A.; Paradiso, J.; and Noble B. 2011. Automotive Pervasive Computing. *IEEE Pervasive Computing* 10(3): 12–13. doi.org/10.1109/mprv.2011.45.

Schudson, M. 1984. *Advertising, the Uneasy Persuasion*. New York: Basic Books.

Schuller, K. 2018. *The Biopolitics of Feeling*. Durham, NC: Duke University Press.

Seitz, P. 2021. Automotive Artificial Intelligence Provider Drives Past Quarterly Targets. Investor's Business Daily. www.investors.com/news/technology/crnc-stock-cerence-beats-fiscal-q3-targets/. Accessed: 2022-09-02.

Siegel, E.; Sands, M.; Noortgate, W.; Condon, P.; Chang, Y.; Dy, J.; Quigley, K.; Barrett, L. 2018. Emotion Fingerprints or Emotion Populations? A Meta-Analytic Investigation of Autonomic Features of Emotion Categories. *Psychological Bulletin* 144(4): 343–93. doi.org/10.1037/bul0000128.

Simon, H.; and Newell, A. 1971. Human Problem Solving. *American Psychologist*, 145–59.

SmartEye. 2022. Smart Eye Automotive Interior Sensing - Overview. www.youtube.com/watch?v=jRdMaL0nkSI. Accessed: 2022-09-15.

SmartEye. 2021. Smart Eye Annual Report 2021. Gothenborg, Sweden. https://www.smarteye.se/wp-content/uploads/2022/06/Annual-Report-2021.pdf. Accessed: 2022-09-10.

SmartEye. n.d.-a. Driver Monitoring System. smarteye.se/solutions/automotive/driver-monitoring-system/. Accessed: 2022-09-06.

SmartEye. n.d.-b. Interior Sensing. smarteye.se/solutions/automotive/interior-sensing/. Accessed: 2022-08-31

SmartEye. n.d.-c. Our Story. smarteye.se/about-us/our-story/. Accessed 2022-09-06.

Souza, J.; Pessin, G.; Eboli, G.; Mendes, C.; Osório, F.; and Wolf, D. 2012. Vision and GPS-Based Autonomous Vehicle Navigation Using Templates and Artificial Neural Networks. In *Proceedings of the 27th Annual ACM Symposium on Applied Computing - SAC '12*, 280–85. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/2245276.2245332

Stanford Open Policing Project. n.d. Findings. openpolicing.stanford.edu/findings/. Accessed: 2022-09-15.

Stark, L. 2016. The Emotional Context of Information Privacy. *The Information Society* 32(1): 14–27. doi.org/10.1080/01972243.2015.1107167.

Stark, L. 2018a. "Algorithmic Psychometrics and the Scalable Subject." *Social Studies of Science* 48(2): 204–31. doi.org/10.1177/0306312718772094.

Stark, L. 2018b. "Facial Recognition, Emotion and Race in Animated Social Media." *First Monday* 23(9). doi.org/10.5210/fm.v23i9.9406.

Stark, L. 2019. "Affect and Emotion in DigitalSTS." In *DigitalSTS: A Field Guide for Science Technology Studies*, edited by J. Vertesi and D. Ribes, 117–35. Princeton, NJ: Princeton University Press.

Stark, L. 2020. "The Emotive Politics of Digital Mood Tracking." *New Media & Society* 22(11): 2039–57. doi.org/10.1177/1461444820924624.

Stark, L.; and Hoey, J. 2021. The Ethics of Emotion in Artificial Intelligence Systems. In Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency, 782–93. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/3442188.3445939.

Stark, L.; and Levy K. 2018. The Surveillant Consumer." *Media, Culture & Society* 105(5): 1202-1220. doi.org/10.1177/0163443718781985.

Steinberger, F.; Schroeter, R.; and Watling, C. 2017. From Road Distraction to Safe Driving: Evaluating the Effects of Boredom and Gamification on Driving Behaviour, Physiological Arousal, and Subjective Experience. *Computers in Human Behavior* 75:714–26. doi.org/10.1016/j.chb.2017.06.019.

Suchman, L. 2006. *Human-Machine Reconfigurations: Plans and Situated Actions*. Cambridge, UK: Cambridge University Press.

Tan, H., Zhu, Y.; and Zhao, J. 2012. Development of an Automotive User Interface Design Knowledge System. 2021. In Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 201–208. AutomotiveUI '12. New York, NY, USA: Association for Computing Machinery. doi.org/10.1145/2390256.2390291.

United States Department of Transportation. 2021. Automated Vehicles: Comprehensive Plan. www.transportation.gov/av/avcp/5. Accessed 2023-08-23

Urry, J. 2004. The 'System' of Automobility. *Theory, Culture & Society* 21(4–5): 25–39. doi.org/10.1177/0263276404046059.

Wachter, F. 2019. Emotional Driving in AI-Powered Cars; Driver and Traffic Safety. Chalmers University of Technology/University of Gothenburg.

Williamson, B. 2017. Moulding Student Emotions through Computational Psychology: Affective Learning Technologies and Algorithmic Governance. *Educational Media International* 54(4): 1–22. doi.org/10.1080/09523987.2017.1407080.

Williamson, B. 2019. "Psychodata: Disassembling the Psychological, Economic, and Statistical Infrastructure of 'Social- Emotional Learning.'" *Journal of Education Policy* 36(1): 129-154. doi.org/10.1080/02680939.2019.1672895.

Wu, A. 2022. The Ambient Politics of Affective Computing. *Public Culture* 34(1).

Yang, F.; and Jingjing, J. 2021. Research on the Development Trend of Global Face Recognition Industry on the Basis of Patent Analysis. In Proceedings of the 2021 12th International Conference on E-Business, Management and Economics, 121–27. doi.org/10.1145/3481127.3481259.

Zepf, S.; Hernandez, J.; Schmitt, A.; Minker, W.; and Picard, R. 2020. Driver Emotion Recognition for Intelligent Vehicles. *ACM Computing Surveys (CSUR)* 53(3): 1–30. doi.org/10.1145/3388790.