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## Macro and Exogenous Factors in Computational Advertising: Key Issues and New Research Directions

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### ABSTRACT

To advance the emerging research field of computational advertising this article describes the new computational advertising ecosystem, identifies key actors within it and interactions among them, and discusses future research agendas. Specifically, we propose systematic conceptualization for the redefined advertising industry, consumers, government, and technology environmental factors, and discuss emerging and anticipated tensions that arise in the macro and exogenous factors surrounding the new computational advertising industry, leading to suggestions for future research directions. From multidisciplinary angles, areas of tension and related research questions are explored from advertising, business, computer science, and legal perspectives. The proposed research agendas include exploring transparency of computational advertising practice and consumer education; understanding the trade-off between explainability and performance of algorithms; exploring the issue of new consumers as free data laborers, data as commodity, and related consumer agency challenges; understanding the relationship between algorithmic transparency and consumers' literacy; evaluating the trade-off between algorithmic fairness and privacy protection; examining legal and regulatory issues regarding power imbalance between actors in the computational advertising ecosystem; and studying the trade-off between technological innovation and consumer protection and empowerment.

Ever since the birth of modern advertising at the turn of the 20th century, advertising has been constantly evolving in response to changing media and market environments. Until very recent years, however, the overall advertising business ecosystem and key actors within it have hardly changed, including the mass media industry that is financially supported by advertising revenues; the advertising industry whose business is creating, planning, and executing advertising campaigns for clients; advertisers that hire advertising agencies and spend money on advertising campaigns; consumers who are the target audience of advertising;

and the government that regulates advertising. When the advertising industry is discussed and examined in the research literature, it usually refers to advertising agency business. Thus, in the long tradition of academic research about the advertising industry, research has mostly focused on advertising agencies, examining agency creative philosophy, practitioner theories of advertising, agency ethics, and agency–client relationships, among others (e.g., Childers, Haley, and McMillan 2018).

However, due to the recent digital technology revolution and advent of big data, advertising and its

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ecosystem has transformed in fundamental ways, demanding completely new conceptualizations of what “advertising” is and what constitutes the “advertising industry.” The most remarkable changes in the new definitions of advertising are that the “paid” and “mass media” elements have been dropped, and the roles of consumers have expanded (Dahlen and Rosengren 2016; Thorson and Rodgers 2019). The latest attempts to redefine advertising conceptualizes advertising as “brand-initiated communication intent on impacting people” (Dahlen and Rosengren 2016, 343) and “all types of brand communication, paid and nonpaid, as well as brand- and consumer-initiated” (Malthouse and Li 2017, 227). While the first definition apparently entails who initiates communication, what the communicator’s intent is, and targeted effects, the second contains neither the “intention” or “effect” element. These new definitions highlight that advertising now includes all different types of communication delivered via paid<sup>1</sup>, earned<sup>2</sup>, and owned<sup>3</sup> media, through vastly different mechanisms and practices initiated by both businesses and consumers, and call for revolutionary changes in our thinking of the advertising ecosystem and key actors in it.

Especially with the growth of big data and advancements in computational systems, today’s advertising message creation, targeting, and delivery take whole new forms, processes, and routes, and many new actors now take part in the advertising ecosystem. Computational advertising, which depends on granular-level data collection, mining, aggregation, and ad serving, is highly individualized and pervasive. Looking at the data- and technology-driven transformations in advertising over the past few decades, Li (2019) identified three main phases of the evolution of digital advertising, including the early interactive advertising phase, the current programmatic advertising phase, and the intelligent advertising phase coming in the future. The early interactive advertising phase refers to the period ranging from the beginning of Internet advertising in the early 1990s, followed by development of diverse forms of online advertising with interactivity, up to the emergence of programmatic advertising. The programmatic advertising phase started with advertising automation technology and algorithms enabling the ad-buying process to automate and optimize in real time (see Interactive Advertising Bureau [IAB] Glossary of Terminology, <https://www.iab.com/insights/glossary-of-terminology/#index-5>).

Intelligent advertising is conceptualized as automated digital advertising that is enhanced with innovative artificial intelligence (AI) technologies, such as natural

language processing and machine learning, to perform various tasks in response to consumers’ input or assess consumers’ preferences, needs, and wants to serve hyper-personalized ads or product recommendations to each individual consumer (Li 2019). The key driver and underlying force in the current advertising transformation, both programmatic and intelligent advertising, is data. Consumer data are indeed considered new oil, currency, and power in today’s advertising ecosystem.

To help advertising scholars and practitioners to fully understand the computational advertising ecosystem and emerging research issues, and to stimulate and guide future research development on computational advertising, we propose a conceptual framework for examining and understanding the computational advertising ecosystem and macro and exogenous factors impacting computational advertising and key actors and suggest research agendas. We begin with a definition of the new computational advertising industry and introduce key actors interconnected to the new advertising industry. Then, we present emerging critical issues and propose research agendas.

## **New Advertising Ecosystem and Key Actors**

### ***Conceptualization of the New Advertising Industry***

In the new computational advertising ecosystem, we propose any business entities that generate revenues from consumer data and advertising should be considered a part of the new advertising industry. What is considered “advertising” is based on the previous research on advertising practitioners’ and scholars’ viewpoints of what advertising is and is not (e.g., Dahlen and Rosengren 2016; Malthouse and Li 2017; Thorson and Rodgers 2019). Applying this conceptualization, the new advertising industry includes three broad categories: (1) new ad content creators that generate ad messages; (2) new media platforms and media content providers that function as a channel for ad delivery; and (3) new advertising technology infrastructure providers that facilitate data collection, analysis, and data-based ad delivery. Our conceptualization seems well aligned with the current view of advertising practitioners, given that the IAB, a leading industry organization in the United States, defines its membership base as “media companies, brands, and the technology firms responsible for selling, delivering, and optimizing digital ad marketing campaigns” (see <https://www.iab.com/our-story/>).

### ***New Ad Content Creators***

For a long time, advertising agencies have been the sole actor in the advertising ecosystem that fulfill this role. However, consumers are now participating in

advertising content creation in forms of user-generated branded content, electronic word of mouth (eWOM), social influencer marketing, and so on. As argued in Liu-Thompkins et al. (2020) in this issue, users now also play the roles of creators, metavoicers, and content propagators. The earned media categories in particular have become especially important, as they are linked to the revolutionary “new consumer” concept, viewing consumers as active contributors generating and sharing ad content (Thorson and Rodgers 2019). Another emerging player in this category is technology companies that supply AI tools for automated ad message creation (Qin and Jiang 2019).

### ***New Media Platforms and Content Providers***

This category includes not only traditional media companies but also websites, search engines, social media, e-commerce sites, and mobile apps, any of which could serve as data collection points and aggregators, as well as the mechanism for advertising delivery. These different types of advertising platforms are now accessed by consumers through many different types of devices and Internet of Things (IoT).

The new media platform companies—such as search engines like Google and Bing; social media platforms like Facebook, Instagram, and Twitter; online videosharing platforms like YouTube and TikTok; and on-demand video streaming services like Hulu—have been considered technology companies rather than advertising companies. However, their revenue structure certainly shows that the lion’s share of their revenues is generated from advertising (MarketWatch 2019). For example, according to Google’s 2018 Annual Report (<https://abc.xyz/investor/other/annual-meeting/>), Google made more than \$116 billion in 2018 from advertising, which is over 85% of the company’s total annual revenues. These new kinds of media and advertising companies have growing influence in the worldwide advertising market and have become de facto market leaders.

### ***New Advertising Technology Infrastructure***

The third category is new to the advertising business and represents a new type of advertising company. This category includes (1) hardware companies that develop, manufacture, and market electronic devices through which consumers access media and various IoT products (e.g., Amazon Alexa, smart fridges, smart phones, smart watches) that function as data collection points; (2) advertising technology companies that provide various technological support

enabling computational advertising; and (3) data-aggregating/mining/algorithm companies that provide technological support enabling both programmatic advertising and AI-driven intelligent advertising by converting potential audience views into actual ad exposure and product sales effects.

The hardware companies, such as Apple, Samsung, and Bose, are somewhat tricky to conceptualize as a part of the new advertising industry. Although they play an increasingly important role in the computational advertising ecosystem as consumer data-collection points, because their primary business is development, manufacturing, and marketing of hardware products their revenues do not acknowledge or specify advertising revenues. However, the role and influence of these hardware companies in computational advertising will only increase in the future, as many of them are exploring advertising-based revenue models.

Second, a variety of advertising technology companies have been emerging in recent years especially with the rise of programmatic advertising. Programmatic advertising began as a system that automates buying and selling of unsold online display advertising inventories, but it has evolved into much more than that. Today’s programmatic advertising is applied to all kinds of advertising creation and delivery using sophisticated real-time bidding (RTB) algorithms. Enabled by data-driven consumer profiling and precision bidding techniques, programmatic advertising enables fine-grained targeting and real-time ad message creation by assembling premade digital ad message elements or stock photos or videos into personalized ads based on data (Kumar and Gupta 2016; Li 2019).

The key players in this category include various ad technology companies such as demand side platforms (DSPs), supply side platforms (SSPs), ad servers, and data management platforms (DMPs). DSPs are technology platforms that function as an intermediary between advertisers who wish to purchase advertising inventory and the ad exchange platform, allowing advertisers to purchase advertising inventory via real-time auctions. SSPs are technology platforms that facilitate publishers, who create and offer advertising inventory, to sell to advertisers and to interact efficiently with ad exchanges, automatically optimizing advertising inventory performance. Ad servers are technology platforms that manage the delivery of ads in various formats. DMPs are technology platforms that collect, process, and analyze market segmentation data from various sources, such as demographic,

geographic, media consumption, preferences, and shopping data of audiences, either at the household or individual consumer level, using machine-learning algorithms (Gonzalez-Cabañas and Mochón 2016; Sinclair 2016). These technology companies provide fundamental technological infrastructure for computational advertising. Because data are key in computational advertising, these business entities involved in collecting, aggregating, sharing, analyzing, and utilizing data for advertising purposes are part of the advertising industry.

Third, emerging technology companies developing AI tools represent another new type of advertising industry. As AI-based intelligent advertising is emerging as the next evolution of digital advertising (Li 2019), these AI companies will play an increasingly important role in the future of advertising. AI-driven consumer insight discovery, ad content creation, granular targeting, and media planning and buying will open another notable transformation chapter in the evolution of advertising (Qin and Jiang 2019). Automated brand-generated content based on consumer data and delivered through a growing number of touch points with some level of automation is an example of the rising importance of AI (for a detailed discussion, see van Noort et al. (2020) in this issue).

### **Other Key Actors and Primary Focus**

Surrounding the new advertising industry are redefined stakeholders, including advertisers, consumers, consumer advocates, and government. The computational advertising ecosystem and various actors in it are presented in Figure 1. Using this conceptual framework of new advertising ecosystem as the guidance, the rest of this article discusses reconceptualization of each of the actors connected to the computational advertising industry and the interconnections among the actors and tensions arising from them, and propose research agendas linked to the tensions in the field of computational advertising. The other actors' connections that are not covered in this article are discussed in the other articles included in the Special Section.

## **Issues Involving Consumers**

### **Redefined Consumers**

Consumers in the computational advertising ecosystem are not only media content receivers and target audience of ads but also take more active roles, namely, the role of the advertiser or creator and active distributor of ad content (for detailed conceptualizations of different

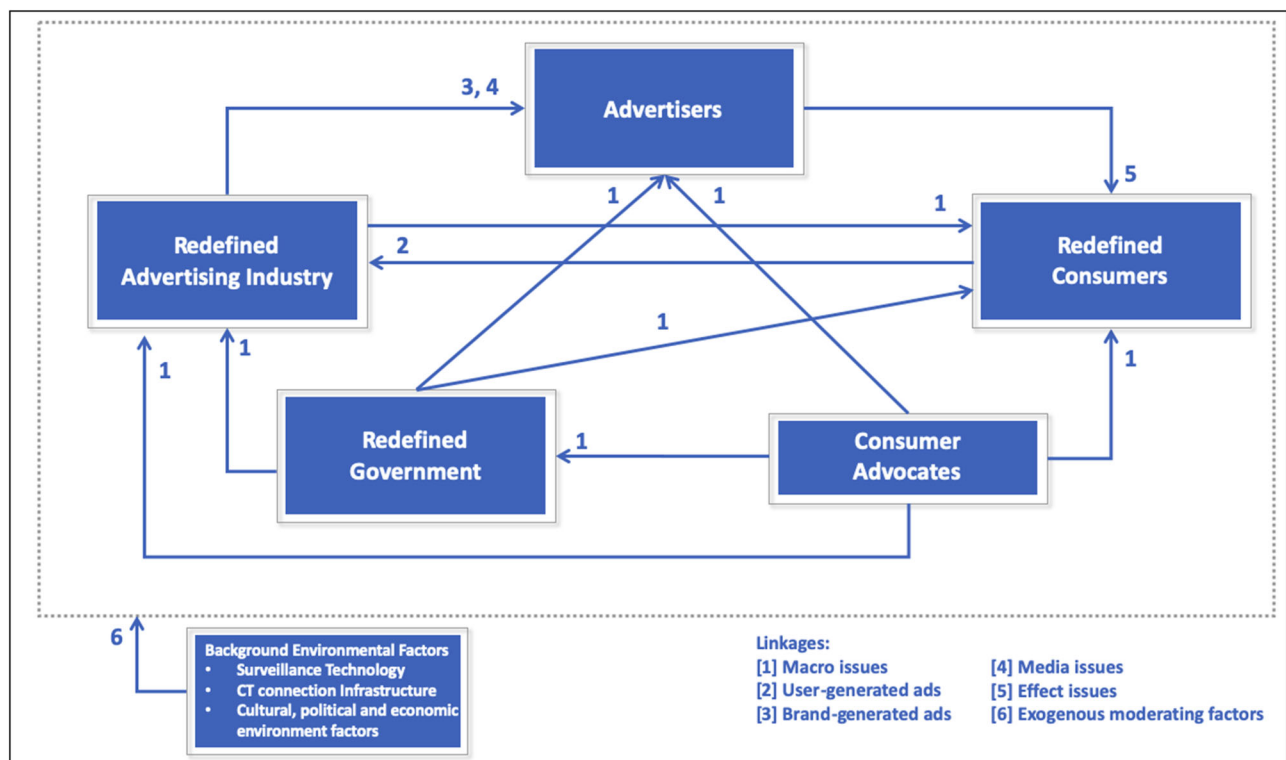
consumer roles, see Liu-Thompkins et al. (2020) in this issue). To some extent, this means that consumers are more influential than before because the implicit and observed data they generate, which are inferred from observed behavior rather than data supplied by consumers themselves, are critical input and enablers for the algorithmic processes and feedback loops that help to adjust advertising to personal preferences. The increased focus on individual consumers, and their growing influence on the algorithmic advertising process, however, does not automatically translate to enhanced agency, as many of these processes operate on the basis of inferred data, and users are able to control data flow only to a limited extent. To the contrary, the growing trend toward hyperpersonalized advertising based on algorithms can decrease consumer agency by reducing choice and awareness of competing products and services that are not being recommended, making it more difficult for providers of alternative services and products to reach consumers.

From a normative point of view, the increasing focus on data-driven advertising, in combination with offering so-called free services (with the goal to generate more data), has raised difficult questions regarding the legal qualification of “consumers.” The legal notion of consumers is typically associated with transfer of money, either between consumers and product/service providers, or between product/service providers and advertisers. At least in Europe, this discussion has only been concluded very recently with the adoption of the Digital Content Directive that, among other things, explicitly includes consumers of so-called free services (services where the counterperformance is about data, not money) into the consumer protection framework.

As consumers increasingly take the role of the advertiser, creator of ad content, or active distributor of such content, legal distinctions between advertisers and consumers become less obvious. This creates challenges for regulatory authorities when applying rules that were traditionally aimed at the advertising industry and advertisers, as well as data protection challenges—for example, how to treat individual usage of personal data of friends for what traditionally would be classified as advertising content or distribution.

### **Tension between the Advertising Industry and Consumers, and New Research Agendas**

The new advertising industry and consumers are intertwined in a two-way connection of data exchange for advertising content creation and delivery. Because



**Figure 1.** The computational advertising ecosystem and key actors.

*Note:* The current paper primarily focuses on the issues related to Links #1 and #6; Link #2 is discussed in Liu-Thompkins et al. (2020); Link #3 is discussed in van Noort et al. (2020); Link #4 is discussed in Araujo et al. (2020); and Link #5 is discussed in Yun et al. (2020).

novel forms of data-driven advertising are not always well understood by consumers (Smit, van Noort, and Voorveld 2014), tension tends to arise in the link between the advertising industry and consumers, primarily due to a lack of transparency in advertising and consumers' limited understanding about why they are seeing certain ads (Hudders, van Reijmersdal, and Poels 2019).

While consumers historically have accepted advertising as a means to get free or discounted access to mass media content, the loss of control over personal data and privacy was not considered a part of the deal. Advertising industry, advertisers, and media companies gathered limited audience information, but such data collection and analysis were done at an aggregate level, and advertising was mass-targeted. Therefore, consumers never felt that their personal data were collected or their privacy was compromised when encountering ads during media consumption. Although market segmentation and advertising targeting have become narrower over time, they did not reach the individual level of targeting that is present now. With the new advertising industry being driven by data, however, much of the exchange of data for free services is done by tracking and processing users'

personal data and by combining data from different sources, in combination with the development of psychographic profiles, which can serve as the basis for new targeting strategies.

Nonetheless, many consumers are neither fully aware nor accepting of the extent and consequences of data-sharing online. Due to the difficulty of attributing a particular (economic) value to consumer data, it is also very difficult, if not impossible, for consumers to assess whether the exchange of data as counter-performance in exchange for services is fair, or whether the amount of data requested is excessive. It is worth noting that consumers are far more vocal about their concerns for privacy than their behavior indicates, which is referred to as the "privacy paradox" (Norberg, Horne, and Horne 2007). One explanation for the divergence may be that individuals are unable to correctly assess the monetary impact of the information disclosure or unable to correctly estimate the probabilities of theft.

### *Issues Arising from Online Behavioral Advertising and Other Computational Advertising*

The typical type of data-driven advertising created and targeted at individual consumers through

monitoring people's online behavior is called online behavioral advertising (OBA) (Boerman, Kruikemeier, and Zuiderveen Borgesius 2017). As a form of computational advertising, which depends on granular-level data collection, mining, aggregation, and ad serving, OBA is substantively different from traditional advertising in that it is hyperindividualized to enhance personal relevance.

The definition of OBA includes the word *monitoring*, which can be interpreted as surveilling. While these terms can be used interchangeably, we distinguish between systematic and routine observation of consumer behavior to improve services (we term this monitoring) and more strategic forms of targeted observation with the goal to monetize beyond improving the technology and to exercise power and control (which we term as surveillance). The knowledge advertisers and advertising firms amass about individual consumers by tracking consumers' behaviors online over time can become quite extensive and precise.

Based on the combined data of search terms entered, web pages visited, products clicked on, articles read, and videos watched, ads can be composed of specific information and images compiled about an individual consumer across a network, making them precisely attractive to the individual and personally relevant. However, as many consumers are not fully aware of how online behavioral data tracking and OBA works, they might not clearly understand the extent to which they are targeted and influenced. This is why, for instance in Europe, the General Data Protection Regulation (GDPR) requires informing consumers not only about the fact that data are being collected about them and for what purpose but also that they are being profiled, the logic behind automated profiling, and potential consequences for consumers. When consumers are not aware that ads come from data-driven sources, it may affect the way they react to these ads. Consumers may be persuaded by disguised advertising messages and/or provide personal information while not being aware of the uses of their data that will pose threats to their privacy. Such advertising may even trigger individual biases, desires, fears, and other emotions, which creates new power imbalances and potential for undue influence and manipulation of the autonomous choices of consumers (Finn and Wadhwa 2014). The lack of transparency and consumers' limited ability to understand computational advertising mechanisms and processes may affect outcomes attributed to computational advertising.

Concerns about OBA can increase with new technologies that extend the collection of data from different

sources and such data being augmented with data collected in traditional OBA efforts. Such efforts might include capturing voice conversations from Alexa-like devices or the tracking of consumers' movements through retail stores based on beacon technologies on cell phones (Walker, Milne, and Weinberg 2019). Furthermore, AI and machine learning are now starting to be brought into computational advertising. Because AI-powered machines allow processing large amounts of information for predictions and inferences, they can perform certain cognitive tasks better or on a larger scale than humans. AI will be used to create and deliver ads; predict the ads' performance; assess consumers' emotional pitch; and provide faster and deeper feedback. The use of AI technology, such as chatbots and voice assistants, suggests three particular implications: (1) the trust that people place in machines because they think these are more objective, which could have implications for persuasiveness of personal advertising; (2) the kind and quality of data collected because of the integration of these systems into the personal life of consumers; and (3) transparency notification format without written text.

The advertising industry and consumers will continue to face tensions, which give rise to future directions for research. Much of this is due to the rising sophistication of both the technology used by advertisers and the consumers themselves. For example, while transparency is often found to be a positive factor for improving consumer reactions to ads, this is not always the case. Sometimes, transparency in the form of privacy notices is not necessarily desirable because notices can interrupt how information flows (Kim, Barasz, and John 2019). Consumers increasingly desire convenience and smooth transactions online. The use of privacy notices may introduce a roadblock to convenience and efficiency.

From the advertiser's perspective, the use of AI technology presents a great opportunity for efficiency in the ad-development process. While the use of AI technology is promised to help eliminate the waste attributed to the creative funnel (the process of attraction, conversion, and retention), it will also raise further data privacy concerns and tension between the advertising industry and consumers. In addition to privacy concerns, new data-driven targeting strategies can also create challenges regarding fair competition, consumers' ability to exercise choice, and a certain level of polarization in consumptive choices—particularly to the extent that targeting has the effect of bringing some products to consumers' attentions while obfuscating others. The tensions in connection

to the issues of transparency and fairness have generated increasing research attention in the computer science field. Addressing transparency and fairness issues and efficiency and privacy trade-offs in the computational advertising industry will be a fruitful area of future research.

### ***Issues Arising from the New Consumers' Role As Data Laborer***

As mentioned, today's consumers perform multiple roles. One of the most unique roles is providing free data and attention (e.g., in the form of sharing and liking ads) that fuel the new data economy and computational advertising. While large global technology and advertising companies, such as Google and Facebook, earn billions of dollars every year from computational advertising, the revenues are never shared with consumers who enable such lucrative business. Finn and Wadhwa (2014) called this situation "exploitation of free labor" of consumers, who often do not have much choice to opt out from such a relation as, for example, much of their social network remains embedded within these potentially exploitative relationships through social network platforms.

In recognition of the critical role consumers play as "free workers" in generating free data, economists Arrieta-Ibarra et al. (2018) and Posner and Weyl (2018) have tried to price consumers' behavioral data. The central argument is twofold. First, to create a successful marketplace for ads using consumer behavioral data, companies use sophisticated machine-learning models known as deep neural networks that require large amounts of data to train them. The firms collect such data from individuals who use the firms' "free" services. Second, estimates of labor income as fraction of revenues of these companies by Arrieta-Ibarra et al. (2018) indicates that the fraction is around 1% to 2%, as opposed to the more historical 60% to 70% (e.g., Walmart). Arrieta-Ibarra et al. (2018), and later Posner and Weyl (2018), argue that the missing "labor" is in fact done by ordinary consumers and that the corporations need to compensate consumers for their services. The challenge is to determine the marginal value of the labor, as the value of a behavior is time dependent—for example, when an adolescent visits a beach resort with her parents and takes photos there and chooses to post them on social media, her visit may become valuable only when she becomes an adult with independent income and purchasing power. Thus, a person's labor generating data that can result in advertising revenue could be of different values at different times and in different situations.

Considering this, some of the new research directions include pricing labor and facilitating the creation of new virtual unions and data markets. Pricing the marginal value of digital artifacts (e.g., posting content, tagging a photo with other friends, commenting, embedding GPS locations in photos) is difficult but central to the question of compensation. One of the challenges lies in the observation that the value of an artifact changes over time; for example, the knowledge that a photo shows the location and the identity of an individual may become more valuable when the individual visits the same location later. Accounting for these price fluctuations will be important. Because consumers form the basis for this "new labor," we need research on mechanisms that enable unionization and negotiation. As a corollary, if there is an ability for individuals to unionize, we would need infrastructures for anonymous data markets where groups could collectively sell verified behavioral traces of their online activity.

Another important future research consideration is that, while recognizing the value of data provided by consumers is one of the solutions to the issue of free labor, this labor-focused economic approach has also criticisms. First, when consumers are (potentially financially) compensated for the information which they share and which is collected about them, this should not result in a situation where consumers can sell their data. In fact, personal data, at least under European law, cannot be considered commodities that users are free to sell. Furthermore, from a legal perspective, the labor focus is considered too limited and not very accurate because of the lack of many of the characteristics that characterize a labor relationship. Often, users are the subject to computational experimentation rather than actively and knowingly participating in a labor relationship.

The rising tension between the new advertising industry and consumers could be reduced, or at least partly resolved, through consumer advocacy and education. Therefore, redefined consumer advocacy and the renewed importance of the role of education for both training the next generation of advertising professionals and educating consumers are important issues. The next section addresses this area.

### **Issues Involving Consumer Advocates**

#### ***Redefined Consumer Advocates***

In light of growing tensions and power imbalances between consumers and the industry discussed, the role of consumer advocacy gains importance in the



computational advertising ecosystem for at least three reasons: (1) individual consumers lack the organization and negotiation power that professional (networks of) consumer advocates possess; (2) specialized consumer advocates have the ability to invoke and bundle expertise which the typical consumer may not have but which is pivotal to understanding the highly complex new advertising landscape; and (3) unlike consumers, who will primarily focus on their own personal interests and situations, consumer advocates can also take into account the broader consumer interest and the wider political and economic context.

The extant research proposes a binary role for consumer advocates. On one hand, they exercise pressure on the industry and on the government to adhere to (self-)regulation and a high level of consumer protection. Closely related to that is a monitoring role to observe potential new consumer challenges and gaps in protection. On the other hand, many advocacy groups educate consumers—for example, regarding their privacy or consumer rights (Rust, Kannan, and Peng 2002). Giving voice to consumers and educating them become even more important in an environment that is technologically complex and characterized by powerful, often foreign or multinational players, and where advertising practices affect the interests of consumers in many ways that are not immediately obvious to them. For example, Privacy International, one of major advocates for consumer privacy, focuses on being the voice for consumers by running campaigns targeting government and companies and undertaking legal actions to defend and enhance privacy rights of consumers.

### ***Tension between the Advertising Industry and Consumer Advocates, and Research Agenda***

As discussed, transparency is critical to computational advertising, and this issue is also applied to algorithms used for computational advertising and recent regulations, such as the GDPR. While many believe computer algorithms to be value-neutral and unbiased, that is not the case in reality, as can be seen in the Facebook algorithm scandal which resulted in a lawsuit accusing the company of housing discrimination. While section 230 of the Communication Decency Act shields online platforms from lawsuits based on content uploaded by third parties, including the advertising shown on such sites by designating them as third-party neutral platforms, these platforms and ads shown on them can run afoul of other laws (Datta et al. 2018). As a consequence, online platforms

are fully liable under data protection and advertising law as regards their own commercial activities, including unfair commercial practice regulation, such as the Fair Housing Act (Asplund et al. 2020).

Some recent work in computer science examined algorithmic explainability in relation to advertising. Algorithmic explainability is an emerging interdisciplinary subfield in computer science that focuses in part on understanding why algorithms make the decisions they do. According to this research literature, advertising algorithms often generate consumers' false beliefs. For example, Ur et al.'s (2012) in-depth interviews revealed a mismatch between mental models of OBA held by participants and actual OBA practices. While many felt that the tailored ads might be useful, they did not understand the existing choice and notice mechanisms. Andreou et al. (2018) examined Facebook's ad explanations (e.g., "Why am I seeing this ad?") and data explanations (e.g., "What have you inferred about me?") and found that both types of explanations were often incomplete and sometimes misleading. Eslami et al. (2018) point out that ad explanations should not be deceptive and ought to help consumers understand how OBA affects their privacy or consumer rights. They also suggest that explanations ought to reveal algorithmic fallibility (i.e., the algorithm may make mistakes) and be designed to encourage consumer engagement with the explanations.

Research into designing advertising that supports an individual's agency to understand why he or she was shown a certain ad is essential. While there is early research in the computer science community on online ads, a significant portion of advertising expenditures still occur in traditional media. In these media, the consumer cannot easily interact with the ad, as might be the case online. Designing for consumer interrogability—in other words, ways to allow consumers to ask questions about the ads they are exposed to—in these media, when ads become algorithmically generated, will become important. Furthermore, the communication of any explanation must emphasize algorithmic fallibility. How to do all of this effectively, across all ad platforms, is an open question.

From the perspective of the industry, explainability and fairness of algorithms is challenging not only when it comes to what information needs to be provided to consumers and how it should be delivered but also regarding the design of the algorithms. More specifically, algorithmic transparency scholars have identified a number of trade-offs that take place when one focuses on understanding and explaining why algorithms make the decisions they do. First, some

scholars and the industry warn about a trade-off between interpretability and explainability of an algorithm and its performance: “more complex models enjoy much more flexibility than their simpler counterparts, allowing for more complex functions to be approximated” (Barredo Arrieta et al. 2020, p. 30). This means that explaining the workings and decision making of an algorithm becomes more difficult when the algorithm gains complexity. At the same time, complexity often goes hand in hand with precision and performance. Research in computer science currently focuses on developing algorithms that will be explainable to the end user and, at the same time, will provide the industry with high performance. Explainability of computational advertising algorithms should also become a crucial research field for advertising scholars, as studying the consumer view on this issue is necessary to further understand and try to mitigate this trade-off.

Second, experts also warn about a trade-off when it comes to fairness of an algorithm and privacy issues related to training data used. In general, unfairness in predictions made by algorithms often occurs when the training sample used to build the model does not fully represent the population of consumers for which the model is being built (Haas 2019). In fact, this is often the case that some groups are over- or underrepresented in training data. Computer scientists propose different ways to mitigate this bias by either focusing on the data used for training or on the working of the algorithm itself. Using more diverse representative data for training could potentially help solve the bias. However, such an approach of including more data points when training algorithms has consequences for consumers’ privacy and is in direct conflict with the notion of data minimization. Also, computer science research suggests that including specifically sensitive data such as gender, age, race, and religion would help create fair algorithms (nondiscriminatory on the grounds of these data) (Galdon Clavell et al. 2020), which is also in conflict with protecting and respecting the privacy of consumers. How to meet both privacy and fairness requirements simultaneously in algorithms is an emerging field in computer science (Xu, Yuan, and Wu 2019). However, this question also needs to be addressed by advertising scholars. Technological solutions as well as consumer research and dialogue with the industry are needed to find the right balance between privacy, fairness, explainability, and performance of algorithms that affect consumers.

More research on algorithmic transparency and related consumer literacy education certainly will be

beneficial and important. Nonetheless, transparency and consumer education may not be sufficient as a solution for consumer protection. As some forms of abuse of data and manipulation power held by the new advertising industry cannot be adequately remedied by education and transparency, they should be subject to regulation. Furthermore, focusing only on education and transparency would lay the onus of (self-)protection on the consumer entirely, which is unfair. Therefore, the roles of governments and regulatory authorities become that much more critical in the new computational advertising ecosystem.

## Issues Involving the Government

### *Redefined Government*

Government has for decades been an important actor in the advertising ecosystem. Advertising around the world is regulated either in the form of formal government regulation (ex ante or ex post) or through forms of co- or self-regulation by the industry. Contrary to formal regulation, self-regulation implies the creation of codes of conduct, standards, or professional rules by the industry (self-regulation) or under the auspice of a government authority (coregulation or regulated self-regulation) (Kleinsteuber 2004). Examples of self-regulatory bodies for the advertising industry are the IAB in Europe and the Advertising Self-Regulatory Council (ASRC) in the United States. Sometimes regulatory agencies can inform self-regulation as well as compliance with formal laws through issuing further guidance on the interpretation of the relevant legal rules, such as the European Commission’s Guidance on the Unfair Commercial Practice Directive (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016SC0163>) or the Dutch consumer authorities’ recent guidance document (<https://www.acm.nl/nl/publicaties/leidraad-bescherming-online-consument>) on the protection of the online consumer. In the United States the Federal Trade Commission (FTC) encourages compliance with existing fair-trading practice rules through issuing nonbinding guidelines or opinions on various marketing and advertising issues (Boerman, Kruikemeier, and Zuiderveen Borgesius 2018).

The aim of government regulations of advertising and advertising industry self-regulations is fairness in advertising. This includes in relation to consumers that advertising is truthful and does not mislead or deceive consumers, and that all claims made in advertising are adequately substantiated. In addition to protecting consumers, fairness in advertising rules also has an important role in protecting fairness in competition vis-à-vis

other advertisers, making sure that misleading or deceptive forms of advertising do not result in unfair advantages of one advertiser over another. While the importance of truthful advertising does not diminish in the computational advertising ecosystem, consumer data that lie at the heart of computational advertising and enable such advertising, add new challenges and consideration for redefined government, regulatory authorities, and their roles.

Data security, consumer protection, and privacy protection are of central interest to the government in the computational advertising ecosystem. This interest of the government causes the need for reconceptualization of the government's role in the advertising ecosystem that goes beyond ensuring truthfulness of advertising but also focuses on regulating how data flow through the ecosystem and who controls data streams. Indeed, the increasing integration of data into the advertising ecosystem puts into question the existing divisions of tasks between regulatory authorities responsible for data and for consumer protection. With the increasing integration of advertising and data, the need to reconceptualize the roles and also the cooperation between these different authorities becomes ever more pressing, as does the need to arrive at joined interpretations of notions such as fairness, consent, and undue influence. With enough cooperation, the redefined government role has the potential to exercise significant influence on the new advertising industry, advertisers, and consumers.

First, how and what data can be collected and processed by the industry is defined by data protection laws and regulations. Second, regulators (at least in Europe and more recently in California in the United States) aim to empower consumers who, in the new advertising ecosystem, are not only media content receivers but also data producers, which has significant consequences for their position in the ecosystem, as discussed earlier. This section draws a picture of this new redefined government role, examines its impact on other actors in the computational advertising ecosystem, discusses challenges that the government will have to face in the future of computational advertising, and proposes research agendas on this issue.

### ***Government's Influence on the Advertising Industry***

Regulating how much data can be collected, processed, and analyzed by the industry is one of the most obvious ways in which the government influences the new advertising ecosystem. Regulatory initiatives, such as the introduction of the GDPR in Europe and the California Consumer Privacy Act (CCPA) in the United States,

impact how online data collection is designed, what data are collected, and how consumers are informed about these practices (Tankard 2016). A number of requirements introduced in these initiatives have changed—at least in theory—the workings of the industry as it is obliged to implement appropriate technical and organizational measures to ensure data protection by design and by default (Voss 2016). Examples of such requirements include, so-called privacy protection by design (i.e., integrating data protection principles into the design of a product or service; article 25(2), GDPR), the need to produce data protection impact assessments (an ex ante assessment of the impact of the envisaged processing operations on the protection of personal data; article 35, GDPR) or the principle of data minimization (i.e., the requirement to collect only data that are adequate, relevant, and limited to what is necessary in relation to the purposes for which they are processed; article 5(1), GDPR). Such legal obligations, in fact, can have a significant impact on the advertising ecosystem by making the advertising industry and advertisers more aware of privacy and ethical issues. As a result, questions concerning privacy and ethics resonate in the industry, which looks for answers to them by, for example, introducing ethical boards and creating various certifications that ensure transparency toward the consumer (Strycharz, van Noort, Helberger, et al. 2019).

Transparency is central in the requirements put forward by the government toward the advertising industry, both in data protection and in unfair commercial practice law. Such transparency requirements aim to provide a level playing field for consumers and the industry. This transparency requirement has been commonly dreaded by the industry as it expects such transparency to have negative impacts on computational advertising effects and effectiveness, and to lead to massive rejection of data-driven advertising by consumers, thus substantially distorting the computational advertising ecosystem (Tankard 2016). It seems that these worst-case scenarios have not come true with the introduction of stricter data and privacy protection laws. In fact, recent research suggests that the redefined consumers do not necessarily react negatively when they learn about details of data collection and processing for computational advertising, but they show higher understanding of workings of computational advertising and feel that these practices are less threatening and more acceptable. Thus, being transparent about data collection and processing not only is necessary to fulfill legal requirements but also can be beneficial for relationships with consumers (Strycharz, van Noort, Smit, et al. 2019).

### ***Government's Influence on Consumers***

One of the main roles of the government is to ensure a level playing field for all of the actors in the computational advertising ecosystem. The redefined advertising industry holds a powerful position in the new advertising ecosystem, as it makes decisions about data collection and processing. Thus, to ensure a level playing field, the government strongly focuses on empowering consumers. In fact, as Boerman, Kruikemeier, and Zuiderveen Borgesius (2017) argue, the governments in many countries tends to aim more at consumer empowerment and less at protection. Examples of current empowerment measures are the individual rights granted to consumers by the GDPR (e.g., right of access to personal information collected by the industry or the right to be forgotten) or the CCPA (e.g., the right to ask for consumer records be shared with them [similar to right of access] or deleted [which corresponds with right to erasure of data]).

While the governments' measures aim at making the advertising ecosystem and the relations among its actors more equitable, scholars have been raising questions about the effectiveness of such empowerment measures employed by governments. In fact, consumers tend to have high perception of risk and low perception of self-efficacy when it comes to sharing their personal data with online platforms and advertisers. They also do not believe in privacy protection tools or rights: Perceived efficacy of cookie notices, opt-out tools, and individual rights is rather low (Boerman, Kruikemeier, and Zuiderveen Borgesius 2018; Strycharz, van Noort, Smit, et al. 2019). While the extant research on this issue is just emerging and more needs to be examined, a lack of empowerment of the redefined consumers and the need for more protective measures, including command-and-control measures, is certainly an important issue that needs to be tackled by the government in the future.

### ***Tension between the Advertising Industry and the Government, and Research Agenda***

Although the centrality of data in the computational advertising ecosystem has already led to significant changes in the role of the government, a number of challenges and tensions arise for the future. While the government's role will remain to set boundaries for the industry and empower and protect consumers, it is important to note that it is not in the government's interest to impede innovations and advancements in computational advertising and the nation's economic

development. Balancing the often-conflicting interests and needs of the government, platforms, the advertising industry, and consumers will be a critical challenge in the future, raising several research questions.

First, how the government will define the relationship among the industry (both advertisers and the advertising industry), platforms, and consumers needs to be further reconceptualized. Consumer empowerment has emerged as one of the main aims of the redefined government, but the redefined consumer is still not an equal actor in the computational advertising ecosystem. Advertising and legal scholars ascribe this situation to such issues as the monopoly of digital media tech companies and lack of alternatives for consumers. These concerns will, thus, require attention from the government. Recently, legal developments have been observed across different countries, aiming at tackling such issues by, for example, applying the anti-trust laws to so-called data monopolies who use their powerful market position to lower the quality of their services, particularly when it comes to privacy violations (Srinivasan 2018) and crowding out alternative, potentially less data-hungry and more privacy-friendly competitors. Such regulatory initiatives have the potential to enhance competition within the industry and possibly lead to a power shift in the advertising ecosystem by indirectly benefiting consumers, who will enjoy the benefit of enhanced competition and have a real choice when it comes to sharing their data with the advertising industry and advertisers. However, such initiatives are useful only if the industry takes its responsibilities seriously and offers consumers a real choice and if governments take a proactive stance in promoting alternatives and reducing dependency on a handful of dominant players. Moreover, these initiatives can be successful only if scholars and regulators succeed in redefining competition law in a way that it is able to effectively deal with the abuse of data power (instead of the traditional market power approach) (Graef 2016). The regulatory strategies for fostering power shifts within the new advertising industry and between the actors in the computational advertising ecosystem are an important avenue for future research.

Second, the current focus of government regulations on empowering consumers has received much criticism in the light of the unequal position of the consumer versus advertising industry. In response, some legal scholars argue for more protective and proactive approaches to improve the consumers' position in the computational advertising ecosystem. For example, privacy nudges have been proposed as an

alternative regulatory tool to informed consent. Such nudges are concrete design measures that aim to steer users toward improved decision making in the context of privacy (Soh 2019). While traditional privacy notices rely on text to convey information to users, nudges rely on consumers' experience of the product or service as a way to warn or inform (Calo 2012).

The concept of informed consent is based on the assumption that consumers have sufficient knowledge and self-efficacy. Past advertising research, however, shows information asymmetry in the ecosystem; consumers lack knowledge about how data flow through it and do not believe in the efficacy of different measures (Boerman, Kruikemeier, and Zuiderveen Borgesius 2018), which may result in unintended data disclosures. This issue requires further research to advance our understanding of consumers' data-related knowledge and perceived efficacy of their data and privacy protection actions and to examine how more proactive government approaches would impact the industry and computational advertising practice.

Third, how to promote technological innovations and stimulate the new data economy is another critical challenge facing the government. It is in the interest of the government to regulate data flows in a way to facilitate, rather than hamper, innovation and economic growth. In fact, fostering trust in the data economy (which is the backbone of computational advertising development) is one of the aims of many government legislations and actions (e.g., promoting the free flow of personal data is an explicit objective of the GDPR [article 1(1)], a goal which remains central in the new European Commission's digital data strategy [<https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy>]). Especially given the aforementioned tension between the advertising industry and consumers, the role of government can be particularly tricky. On one hand, innovation, access to data, and usage of effective algorithms by the industry should be fostered; on the other hand, consumer protection, transparency, and empowerment need to be promoted. Resolving this tension will keep gaining importance. Studying this tension and identifying the critical tipping point is also an avenue for fruitful future research into the role of government in the computational advertising ecosystem.

Finally, consumer empowerment will only help protect consumers from the abuse of targeting strategies. While data-driven advertising is in principle a legitimate and potentially useful form of advertising, abuse of the knowledge about consumers' preferences,

fears, and other emotions, coupled with the ability to translate that knowledge into targeted advertising strategies, can create new digital vulnerabilities (Bol et al. 2020) and result in unfair business practices. One major challenge for normative and empirical research in the years to come will be to critically reassess the abstraction of the "reasonably circumspect consumer" as the lead figure in the application of advertising and consumer law, as well as the concept of the "vulnerable" consumer, and help draw the line between legitimate and unlawful computational advertising.

## Issues Involving Environmental Factors

### *The Role of Surveillance Technology and Research Agenda*

The relationships between the new advertising industry and consumers are being moderated by surveillance technology, which is the technological infrastructure constituting environmental factors in the computational advertising ecosystem. The interactions between advertising/advertiser industries and consumers are two-way and they can be enacted by either party, and the moderation of their relationships through technology is changing the manner in which business is conducted (Yadav and Pavlou 2020). Leading the change in these relationships is the role of AI (Davenport et al. 2020). For example, consumers will be able to interact with data bots in the shopping environment that are designed not only to respond to consumers' queries but also to collect information, and these interactions will provide marketers with new ways to communicate with consumers on a personal level.

Surveillance, as Zuboff (2019) points out, is central to today's computational advertising. By providing free services (e.g., web search, social networks, and chatbots) for individuals to use, corporations develop behavioral profiles of individuals that use their services and use or sell such information to other companies, either in the form of data or as market segments tailored for ad placement. Recent research has documented such surveillance and found that surveillance technology use is extensive (Narayanan and Reisman 2017), dominated by a few advertising companies (Karaj et al. 2018), and that such surveillance technology can compromise private, sensitive information (Papadopoulos, Kourtellis, and Markatos 2019). Despite data security and privacy concerns, surveillance will likely continue increasing because tracking individuals as they use the Internet allows

corporations to develop more nuanced behavioral profiles of individuals that can be used for enhanced personalized advertising among other usages.

Future surveillance technology innovations have particularly strong implications for how consumer data are gathered and used for advertising in the contexts of mobile technology (Tong, Luo, and Xu 2020), in-store interactions (Grewal et al. 2020), and social media (Appel et al. 2020). Increased mobile use by consumers driven by technological and content innovations will permit the industry to leverage its unique data-tracking capabilities and deliver personalized ads drawing on both in-store and online data. For example, AI embodied in robots has the potential to improve in-store services by drawing on stored customer data to better personalize interactions. Also, through new in-store surveillance technologies that use Bluetooth beacon and consumer apps, marketers will be able to monitor and react to consumers' needs and demands and push more real-time display ads based on store location and past purchases (Kwet 2019).

Social media is another critical consumer touch point where surveillance technology plays a key role in the rapid expansion of computational advertising. While social media data surveillance has raised consumers' privacy concerns, particularly due to recent high-profile social media scandals, advertising industry and advertisers see great advantages in that they will be able to provide integrated, personalized ad messages across multiple devices based on data obtained from the increasingly more sophisticated surveillance technology. For example, research on geotargeting in the restaurant industry (Lian, Cha, and Xu 2019) found that shorter distances, good timing, matching with users' preference or service type, and users' recent food website visits all increased ad click-through rates. The results also show that online and offline strategies interact: Preference for on-site service intensified the distance effect, while recency of food website browsing mitigated the distance effect. Such research is enabled by the expansive data surveillance on social media.

The future will also provide the industry with information from new sources, such as IoT (Weinberg et al. 2015). IoT systems, such as the smart home, smart car, and smart city, will all provide constant surveillance and data that can be used to tailor advertising targeted at individual consumers. The advantage of IoT is derived from autonomous AI software that analyzes the data collected from IoT devices. By leveraging so much data, the algorithmic platforms will

offer cognitive computing (i.e., software and hardware that learns and automates cognitive tasks) that facilitates communications with consumers. These sophisticated consumer interface platforms would significantly reduce the need for human intervention (Yadav and Pavlou 2020).

Particularly in the area of indoor surveillance, there is extensive work in the computer science field on efficient mechanisms to localize indoor space either using Wi-Fi (Chintalapudi, Iyer, and Padmanabhan 2010; Rai et al. 2012) or using IoT (De et al. 2017). Such localization techniques become necessary because GPS-based tracking fails to work reliably indoors. Bluetooth-based localization schemes are also used to understand consumers' proximity and manner of interaction with products (Harris, Sundaram, and Kravets 2016).

A special challenge for consumers with tracking in both online and offline world, as well documented in media reports (Manjoo 2019), is that ordinary consumers have limited recourse to relief from the surveillance. Even more troubling is that there is extensive work to integrate data from individuals' physical interactions (shopping at the grocery store or IoT tracking) with what they do online, thereby creating a complete behavioral profile of each individual.

The surveillance paradigm has led to research on countermeasures to protect consumers. In their seminal work, Howe and Nissenbaum (2009) identified a technique involving sending multiple fake queries to Google that potentially allows for individuals to deceive the search engine into developing an inaccurate behavioral profile. Countermeasures that protect individual privacy in indoor localization are also beginning to emerge. In recent work, Harris, Sundaram, and Kravets (2016) and Kravets, Tuncay, and Sundaram (2015) highlight mechanisms for individuals to "vanish" in the physical space. The central idea is to use system identifiers in conjunction with encryption techniques that prevent IoT computing infrastructures from tracking individuals (should they so desire) in physical spaces. For example, if individuals feel that a retail store that may be tracking them does not provide them with useful recommendations, they could choose anonymity.

An important direction for future research will be research on advertisers' use of surveillance technologies. How will conversational agents alter the advertising process? If indeed some segments of consumers in the future are more vigilant of their privacy and operate in dark web environments (not indexed by search engines; see Thomaz et al. 2020), to what extent will

conversational agents be able to nudge consumers to divulge personal information in the promise of hyper-personalization? Currently, because most consumers are willingly giving up information on social media, advertisers are able to build extensive profiles of those who utilize social media using surveillance technology. In the future, however, surveillance will also be incorporated not only in social media and online environments but also in businesses, in cars, in cities, and in home environments. How will this expanded surveillance of consumers alter the ability of advertisers to meet the need of consumers?

Moreover, important questions arise regarding whether consumers will employ technologies of their own to shield themselves from the surveillance from advertisers. In this future line of research, computer science research can make important contributions toward addressing the issues of surveillance and information asymmetry in advertising. Future research could extend the initial work by Harris, Sundaram, and Kravets (2016) and Kravets, Tuncay, and Sundaram (2015) to web browsing to preserve and to characterize the degree to which algorithms can preserve individual anonymity. More research is also needed to examine how best to present information, as well as how best to develop consumer-side controls that allow individuals to have agency over their behavioral data. For example, while individuals currently cannot easily form collectives to characterize the degree of surveillance, technological infrastructures could be developed to support individuals' sharing of behavioral traces to allow them to understand the granularity of surveillance and develop effective coping strategies.

### ***The Role of Communication Technology Infrastructure and Research Agenda***

Another important environmental factor in the computational advertising ecosystem is the communication technology (CT) connection infrastructure, which determines the speed and reach of Internet connections that impact the advertising industry's ability to reach consumers. Wide availability of broadband Internet connections and high-speed wireless technology are essential for computational advertising, but the penetration rates of such infrastructure vary greatly from country to country and in different communities within a country.

One of the unique characteristics of the CT connection infrastructure in the computational advertising ecosystem is the increasingly active and important

role played by major advertising industry players (e.g., Google, Facebook, Amazon) in providing such infrastructure, oftentimes free of charge. For example, in 2010 Google announced Google Fiber, which resulted in communities competing to have this brought to them. Google's entrance into the Internet service provider (ISP) market brought an excitement to the market, which led to rapid adoption that beat all projections set forth in the Federal Communications Commission's National Broadband Plan. Looking toward the future, Amazon has plans to launch 3,236 Internet-enabled satellites that would enable all people in the world to have Internet access (Sheetz 2019). The primary motivation of such initiatives by the major advertising companies seems to be gaining access to data and the profit of reaching 4 billion new customers with their advertising.

As the future of advertising is directly tied to Internet speed and wireless networks, the trends of CT connection infrastructure offered by large advertising companies are likely to continue. Furthermore, with the rollout of 5G networks by AT&T and Verizon, and future satellite plans by Amazon, consumers will eventually experience much faster wireless connectivity. Rural areas will benefit the most from these changes as they are most dependent on wireless networks. With faster speeds everywhere, more devices will be able to be connected and participate in the computational advertising world. Emerging questions, however, are whether this is all positive and beneficial to consumers and the public, and whether there might be unforeseen negative impacts. Future computational advertising researchers should pay close attention to the growing role and influence of the new advertising industry in the expansion of CT connection infrastructure around the world and investigate potential impacts and emerging issues in connection to the various tensions and power imbalances between the advertising industry and other actors in the computational advertising ecosystem.

### **Concluding Comments**

Data-driven computational advertising is rapidly expanding and forcing fundamental transformations in advertising research and theory building, as well as in the practice of advertising. While advertising scholars have been paying attention to this emerging trend, systematic research is still in its infancy and there are many unexplored research avenues. To advance the emerging research field of computational advertising, this article describes the new computational

advertising ecosystem, identifies key actors within it and their interactions, and discusses future research agendas. Specifically, we propose systematic conceptualizations for the redefined advertising industry, consumers, government, and technological environmental factors, and discuss emerging and anticipated tensions that arise in the macro and exogenous factors surrounding the new computational advertising industry, leading to suggestions for future research directions.

From multidisciplinary angles, areas of tension and related research questions are explored from advertising, business, computer science, and legal perspectives. This exploration resulted in a proposed research agenda that includes the following research topics: transparency of computational advertising practice and consumer education; understanding the trade-off between explainability and performance of computational advertising algorithms; exploring the issue of new consumers as free data laborers, data as commodity, and related consumer agency challenges; understanding the relationship between algorithmic transparency and consumers' algorithmic literacy; evaluating the trade-off between algorithmic fairness and privacy protection; examining legal and regulatory issues regarding power imbalance between actors in the computational advertising ecosystem; studying the trade-off between technological innovation and consumer protection and empowerment; and further developing the complex issues surrounding the evolving data surveillance technology and CT connection infrastructure. Conducting research on this agenda, plus other important issues pertaining to computational advertising, should advance our understanding of advertising. Furthermore, due to the different economic, political, and technological environments in different countries, there seems to be an ongoing natural experiment among the United States, European Union countries, and China in terms of regulation (e.g., GDPR, CCPA) and computational advertising practices. This subject is ripe for research, and we encourage future cross-national comparative research.

This article contributes to advertising research and theory development in three specific ways. First, our proposed computational advertising ecosystem model provides a systematic overview of the computational advertising field and clear conceptualization of redefined key actors, which should serve as a solid foundation and roadmap for future research development in this area. Second, this article expands the boundaries of advertising scholarship and what are considered legitimate questions that advertising researchers should contemplate by exploring the areas that have

never been considered in the previous advertising research. Third, this article presents compelling arguments for multidisciplinary research approaches across previously disconnected disciplines and demonstrates the benefits of such an approach.

As computational advertising is gradually taking over the advertising world, future advertising research should consider the changing boundaries and dynamics of the redefined advertising industry, consumers, governments, and environmental factors. We hope that the ideas presented in this article help foster exciting new research and advance new theory development that will help enhance our understanding of the practice and effects of advertising in today's world and in the future, as well as help foster the development of well-informed public policies and innovative and socially responsible advertising practice.

## Notes

1. *Paid media* refer to any media that are paid for by advertisers to place their ads or to drive traffic to their owned media properties.
2. *Earned media* refer to the kind of communication channels generated when people or mass media speak about a brand or a company either in response to content a company shared or through voluntary mentions.
3. *Owned media* refer to a company or brand's own content or communication channel that it creates and has control over (IAB Glossary of Terminology, <https://www.iab.com/insights/glossary-of-terminology/#index-5>).

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