Equality of Fit in Digital Typography

Thomas Jockin[1]

Responsive typography according to cognition could provide a more humane access to knowledge and experience previously blocked to many readers. However, such a potential requires deliberation on when and how much this capacity should be implemented. The implementation of Internet of Things and machine learning into typography will, if only imperceptibly, nudge the outcome for our civil society in the 21st century.
— *Thomas Jockin, US*

The essential difference between digital typography and all other kinds of typography is its capacity to respond to data. Data can be the device the user is using, the lighting conditions in the room, or even the attention of the reader. This essay has a three-part structure: first, we will trace a genealogy of responsive typography on the web; second, is a literature review on reading and eye-tracking research; and third, a summary of the ethical and moral implications of using algorithms that direct the individual visual presentation of text. It is the hope of the author that web-design practitioners consider how currently available technology allows typography to have the same degree of responsiveness to individual user cognition as is currently applied to external environments and devices. For thought leaders and educators, the author hopes this chapter will aid the reader to articulate a more nuanced understanding about how technology may engender equity in design.

Responsiveness to Devices

As the adoption of mobile phone devices allowed Internet access growth in the 2000s, both web designers and technologists required an efficient

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method to support the presentation of website content on a wide range of screen sizes. Ethan Marcotte coined the web design term "Responsive Design" in 2010 to describe a particular application of the Cascade Style Sheet (CSS) that streamlined website content presentation on both desktop and mobile devices.[2] Marcotte explained that using relative units of sizing and media queries in CSS allows a website to accommodate various screen sizes while maintaining usability and consistency. Media queries within the CSS document instruct the web browser to ping a user's screen for specific properties and return that information to the browser. If the user's configuration meets specific conditioned rules described in the CSS document, the browser is instructed to change the visual presentation of the web page according to those conditioned rules.

For example, the CSS media query would first check to determine the width of the user's browser. If the web page is being viewed at a width of 1400 pixels or more, the CSS could specify that the body text should be displayed at 18 pixels. If the webpage is being viewed at a width of less than 1400 pixels, the CSS could specify that the body text should be only 12 pixels. Along with media queries, the introduction of relative unit values within web design has allowed for proportion-based typographic control for screen widths and resolutions not explicitly declared in the CSS document. When relative units are used, a change in the base font size, triggered by an instruction, would result in all other text elements scaling proportionally to the browser and change the other text elements accordingly.[3] Fixed font sizes are not responsive to the change in base font size.[4] For example, when a media query detects that the browser window size is 1400 pixels, following the rule set by a designer, the font-size attribute in the HTML tag is set to 24 pixels. Then, the web browser sets the font-size of a header by multiplying the base font size by 3.4 rems. The explicit pixel size of the header in the document is calculated by multiplying the document root font size of 24 pixels by the specified rems unit 3.4, which would approximate 81.6 pixels. The decision of what font size to set the typography is left to this simple algorithm in the CSS document. Rather than follow an

2 MDN, "Responsive Design — Learn Web Development," accessed June 28, 2022, https://developer.mozilla.org/en-US/docs/Learn/CSS/CSS_layout/Responsive_Design.

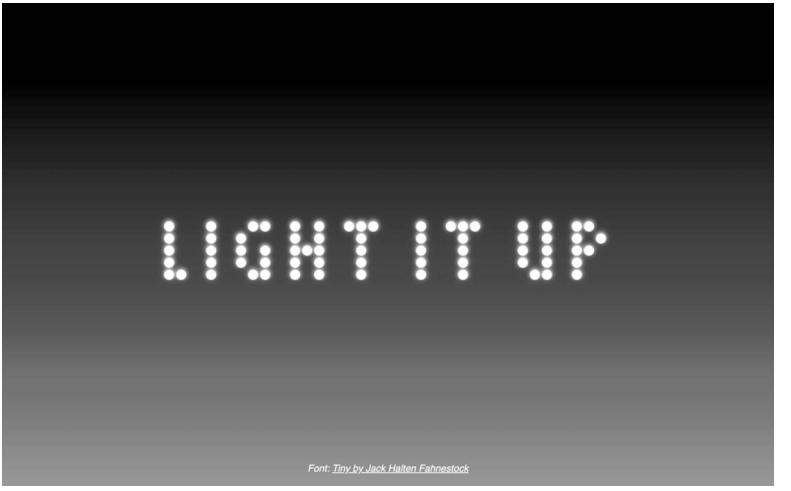
3 MDN, "Learn to Style HTML Using CSS – Learn Web Development," accessed June 28, 2022, https://developer.mozilla.org/en-US/docs/Learn/CSS.

4 MDN, "CSS Values and Units — Learn Web Development," June 28, 2022, https://developer.mozilla.org/en-US/docs/Learn/CSS/Building_blocks/Values_and_units.

explicit instruction by the designer, the font-size of the document is set by an indirect parametric provided by the designer. Such relative parameters allow for more flexible response to diverse devices and reader preference.

Responsiveness to Physical Spaces

The first treatment of responsive typography responds to the device used to access content. A second treatment of digital typography responds to data from the physical space. The legibility of typography is related to the luminosity in the environment the reader finds themselves within.



Sensor APIs allow the typography in a document to respond to the room's luminosity, 2019.[5]

5 Mandy Michael, *Light It Up*, YouTube Video, 2019, https://www.youtube.com/watch?v=ivz1hdAhJmE.

Studies as far back as 1934 confirmed the design intuition that a dim environment diminishes the legibility of text, especially at smaller font sizes.[6] Mandy Michael, a front-end developer and designer who spoke at the community-run conference *DDD Perth* in 2019, explained how sensor application programming interfaces (APIs) allow the typography in a document to respond to the room's luminosity. Light sensors come prepackaged in digital devices and detect ambient light present in the environment. Illuminance returns the current light level measured in lux units. To give a sense of the scale of lux units: a family living room would have 50 lux units, office lighting could range from 320 to 500 lux units, and direct sunlight starts at 32,000 lux units. In her conference talk, Michael provided an example of a font consisting of dots that increase in size as the brightness of the room increases and, likewise, decrease in size if the room is dim. She also suggested that such a response to lighting conditions could be applied to increasing font weight as the ambient light decreases.[7] Integrating lux values into the rule-based CSS declarations would allow typography to respond both to diverse devices as well as the environmental lighting conditions the reader finds themselves reading text.

Along with luminance, typography may be responsive to the physical distance of the reader. Reneé Steven's project, TagAR, incorporates augmented reality technology to position nametags of conference attendees above the heads of users. The tag font size responds to the distance of the smartphone user and the other persons in the room. The closer the person is to the user, the larger the font and the farther away the person is from the user, the smaller the font.[8] Gen Ramírez's thesis project at Koninklijke Academie van Beeldende Kunsten (KABK), Entorno, explores how typography can account for distance and perspective distortion. Entorno is a variable typeface family that interacts with physical and virtual spaces. Of particular interest is the subfamily Entorno Roadmark. Entorno Roadmark distorts the letterforms according to the viewer's distance from the text object on the ground, like roadway lettering. The variation 0 m is normal in appearance, whereas the other master,

6 M. A. Tinker, "Experimental Study of Reading," *Psychological Bulletin* 31, no. 2 (1934): 101, https://doi.org/10.1037/h0074040.

7 Mandy Michael, "Fun with Browser and Sensor APIs," DDD Perth Conference, Perth WA, Australia, August 2019, https://noti.st/mandy/HBCdTl.

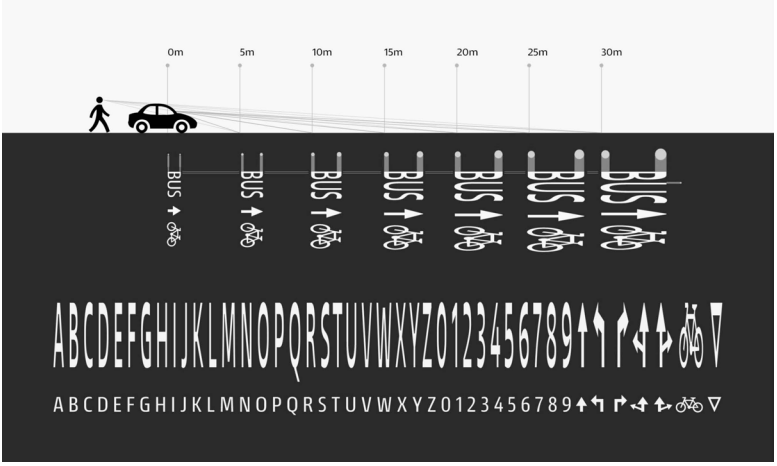
8 Renée Stevens, *Never Forget A Name Again*, TED Talk, 2019, https://www.ted.com/talks/renee_stevens_never_forget_a_name_again.

30 m, has significant vertical distortion that appears completely normal at 30 meters away.[9] When we consider both Entorno Roadmark and TagAR, digital typography has the potential to incorporate environmental distance and perspective in the rule-based CSS declarations of digital typography. Many wayfinding use cases could benefit from such a distance-based typography. The use of such distance data allows for typography that better orients the reader in the environment.

TagAR, a social app designed to provide visual name tags in an "augmented view."[10]

9 Gen Ramírez, "Entorno," TypeMedia 2018, https://www.typemedia2018.com/gen.

10 Reneé Steven, "TagAR," interactive, augmented reality, and motion design studio, 2019, http://reneestevens.design/tagar.



The typeface Entorno by Gen Ramírez, 2018.

Responsiveness to Cognition

So far, we reviewed data according to the device and the physical space of the device. Next, we explore the cognition of the reader holding these devices. For example, Word Lens allowed Google Glass users to automatically translate signage, packing, and other environmental graphics into the user's native language with the typography matching the size, width, and colors of the original language. In this example, the native language of the reader is considered to orient themselves in an environment where their native language is absent.

Development of Measurement Instruments

Researchers have explored the relationship between eye movement and reading since 1879. However, significant innovations in the measurement devices for such research to be practical were required. Initial instruments for measurement were quite intrusive, with some studies conducted with a search coil attached to the eye like a contact lens. Current methods use less invasive

and accessible means of measurement such as video-based pupil monitoring.[11] With the advent of open-source computer vision libraries, standard web cameras can detect a user's pupil position automatically.

In eye-movement research, eye-movements are divided into two broad categories; fixations and saccades. A saccade is when the pupil of a reader is in motion: fixation is when the pupil of the reader is at rest. When the saccade movement is backward rather than forward, it is called regression. Saccade distance is measured in degree units. Fixation is measured in milliseconds. Fixation time and saccade length are related to aspects of the text currently being read.

There are significant differences in eye movement measures between skilled and struggling readers. Skilled readers make shorter fixations, longer saccades, and fewer regressions than struggling readers. On the other hand, poor readers make longer fixations, shorter saccades, more fixations, and more regressions than regular readers. Likewise, bilingual readers make shorter fixations, longer saccades, and fewer regressions in their primary language.[12] A 2019 paper from Stony Brook University developed a classifier that accurately predicted reading or skimming behavior of readers. Individuals who were reading encompassed wide horizontal saccade distances with small vertical saccades, whereas persons who were skimming encompassed narrow horizontal saccade movements with large vertical saccades.[13] Eye-tracking research on reading suggests differences in kinds of readers and reading behavior is measurable. Once reading status and behavior are measured, typographic properties may change just as CSS media queries direct changes based on device viewport, lux level, or object distance. With this review of responsive digital typography and eye-tracking research, it is important to consider if the typography of diverse reading statuses and behaviors ought to be the same.

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11 Keith Rayner, "Eye Movements in Reading and Information Processing: 20 Years of Research," *Psychological Bulletin* 124, no. 3 (November 1998), 372, https://doi.org/10.1037/0033-2909.124.3.372.

12 Rayner, 392.

13 Conor Kelton, Zijun Wei, Seoyoung Ahn, Aruna Balasubramanian, Samir R. Das, Dimitris Samaras, and Gregory Zelinsky, "Reading Detection in Real-Time," in *Proceedings of the 11th ACM Symposium on Eye Tracking Research & Applications*, vol. 43 (The 11th ACM Symposium, 2019), 2, https://doi.org/10.1145/3314111.3319916.

Is One-Size-Fits-All Digital Typography Valid?

Typography within the graphic design discipline continues to live in the shadow of Modernism. A hallmark of Modernism was the search for typography stripped of variation to an essential simple form. Herbert Bayer's influential essay "Towards A Universal Type" is typical of such a viewpoint. Bayer is concerned primarily with the cultural dimension of design artifacts such as buildings, transportation, dress, and, of course, typography; he juxtaposes historical type specimens with gothic cathedrals, horseback riding, and Victorian dress against skyscrapers, automobiles, and 1920s dress. These pairings are meant to justify the need for typography that embodies the cultural moment of Modernism and breaks away from—in Bayer's words—the oppression of tradition. At the heart of Bayer's argument for a geometric sans serif design is the claim that reading is most legible when the glyph shapes of a script are uniform.[14] Even the variation between uppercase and lowercase ought to be stripped away for the sake of efficiency. Such uniform typography and script would be optimal for the diverse applications of both encoding, such as printing and handwriting, and decoding, such as reading books and signage.

Research since the time of Bayer's essay has offered a contrary account of legibility in typography. Readers who are neurodiverse, older in age, or with low vision tend to need typography set differently than typical readers. While dyslexic individuals have a phonetic processing deficit, dramatically increased spacing between character glyphs improved reading fluency for readers with dyslexia.[15] For readers with low vision, one study found the variation to their font is required, and such variation is significant among the forty elderly readers with low vision.[16] In the study, patients were permitted to adjust font attributes until the modified font met the same legibility as the control in the study. The attributes available to manipulate were spacing, stroke width, serif

14 Herbert Bayer, "Towards a Universal Type," *Industrial Arts*, 1936, 78.

15 Marco Zorzi, Chiara Barbiero, Andrea Facoetti, Isabella Lonciar, Marco Carrozzi, Marcella Montico, Laura Bravar, Florence George, Catherine ech-Georgel, and Johannes C. Ziegler, "Extra-Large Letter Spacing Improves Reading in Dyslexia," *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 28 (July 10, 2012): 11457, https://doi.org/10.1073/pnas.1205566109.

16 Aries Arditi, "Adjustable Typography: An Approach to Enhancing Low Vision Text Accessibility," *Ergonomics* 47, no. 5 (April 15, 2004): 476, https://doi.org/10.1080/00140130310000085680.

size, and x-height. The adjusted font spacing was between 5 and 70 percent relative to the cap height of the font. Likewise, x-height was adjusted between 60 and 100 percent relative to the cap height of the font. In another study, a team of researchers, including well-known typeface designer Nadine Chahine, deployed a methodology where subjects were randomly exposed to either a real word or a pseudo-word. The exposure started at a time duration of 500 milliseconds. As the subject correctly answered a prompt after each word exposure ("Was that a word?") the time duration of the next word stimulus was decreased in a 3-steps-forward-1-step-back staircase progression. This progression continued until the subject repeatedly failed to correctly answer the "Was that a word" prompt due to the time duration being too short. The more legible the font was, the more a subject could correctly answer the prompt in the shorter time duration.[17] The results of the research established that an increase in the tracking of letterforms improves response rate thresholds within subjects. The paper hypothesizes that the less-legible square sans serif could be brought up to the same legibility performance as a humanist sans serif by increasing the intra-spacing of the letterforms within the font design.

Ultimately, research shows that typography is not one-size-fits-all. While the idea of an average that works for most readers is a reasonable position when physical materials require printing and distribution, typography is responsive to data in the digital era. Now with non-intrusive eye-tracking technology, typography change for sensitive readers is as feasible as adjusting typography based on device size, lighting conditions or object distance. The technology to enable typography to respond to the individual reader is already here; we just need to shift our mental model for typography. In most studies, typography has been found to have no impact on reading performance between subjects. However, typography does impact reading performance within-subjects, especially older subjects or those with reading difficulties.[18] The belief in the uniformity of typographic properties for all readers comes from averages generated from between-subjects. The level of measurement for reading needs to shift from between-subjects to within-subject. What has prevented more use of within-subject averages is not efficacy, but technological constraints and

17 Jonathan Dobres, Nadine Chahine, Bryan Reimer, David Gould, Bruce Mehler, and Joseph F. Coughlin, "Utilising Psychophysical Techniques to Investigate the Effects of Age, Typeface Design, Size and Display Polarity on Glance Legibility," *Ergonomics* 59, no. 10 (October 2016): 1379, https://doi.org/10.1080/00140139.2015.1137637.

18 Dobres et al., 1383.

expense—collecting individualized data is expensive and time-consuming. Such limitations for individuated data are removed thanks to open-source Computer Vision (CV) libraries such as TensorFlow.

The shift to an equal fit of typography for individual readers, rather than the prior notion of the same typography for all readers, requires we consider what one means by equality. Aristotle knew the difference between the mean for the object and the subject as he wrote *The Nicomachean Ethics*. The mean for an object was the same for all persons, but the mean for an individual subject will vary. Aristotle uses the example of athletic training. The mean between 10 and 2 pounds of weight is 6 pounds. However, it does not follow that 6 pounds are fitting for different athletes. For the developed athlete, 6 pounds is too little, whereas, for the beginner, 6 pounds is too much. The trainer needs to find the intermediate, not in the weight, but for the athlete. Finding such an intermediate for the person and not in the object is the equitable.

Aristotle continued this approach with his commentary on equity. Equity, for Aristotle, is the correction of error when a universal rule is applied to a particular case.[19] In the example, he provided a flexible ruler, in contrast to a rigid linear ruler, that adapted itself to the shape of a statue. One can take this explanation as finding the ideal for the subject rather than in the universal object; The trainer who considers the right number of weights according to the athlete's ability is an equitable trainer. This is the opposite of the procrustean bed—the Greek myth of a storekeeper who allowed travelers to rest at his residence but either stretched the limbs of the traveler if they were too short for the bed or cut off their limbs if they were too tall for the bed.[20] A procrustean bed is a metaphor for removing outliers that do not fit the idealized model.

Our current method of responsive typography, in the context of the reader's cognition, is a procrustean bed. Media queries, at best, respond to different devices accessing digital content. An assumed ideal for what constitutes legible and accessible typography and what outliers may exist are either trimmed away or stretched into prepacked accessibility guidelines. Applying this notion of equity to responsive typography would mean developing a rule that can adapt to the particular reader encountering a digital document. Machine learning (ML) could provide fertile ground to develop such a rule-set. The next section

19 Aristotle, *Aristotle, XIX, Nicomachean Ethics*, trans. H. Rackham, 2nd edition (Cambridge, MA: Harvard University Press, 1934).

20 Britannica, "Procrustes: Greek Mythological Figure," accessed June 28, 2022, https://www.britannica.com/topic/Procrustes.

of this chapter provides an overview of Machine Learning and its application to responsive typography.

Applying Machine Learning to Typography

While the concept of delegating design decision-making to artificial intelligence may seem alien to designers, the historical development of typography on the web reviewed at the start of this chapter displays a trend away from explicit instruction to conditional rules in typography attributes. First, precise units of measurement such as pixels were replaced with relative proportionate units of measure like em. Then, media queries directed the typography of a document to respond differently to devices and viewports. As Tim Brown, Head of Typography at Adobe Systems, states in an *A List Apart* article, this shift from explicit visual presentation to implicit rules and instructions points to the potential for typography to fit everyone perfectly. In Brown's words, "In theory, at least, the web is universal."[21] Machine learning continues this trend of implicit rule-making as the designer's activity by permitting designers to specify conditional rules not just to viewports but also to indicators of cognition. For example, a webpage's typography or design elements could respond either to rapid scrolling actions or prolonged reading of a particular passage of text,[22] quantifying the effectiveness of such interventions according to key performance indicators and adjusting the conditional typography rules. Handing such a decision feedback loop to an algorithm introduces the need to consider the ethics of such a procedure.

Regarding benefits and risks, it is one thing to affect the presentation of text based on a user's device compared to affecting typography based on the user's cognition. While typography responding to the reader's cognition is an exciting possibility, the time at which a design algorithm should intervene in users' intentions is a living question within design ethics. Competing incentives between profit, autonomy, privacy, and authorship need to be placed

21 Tim Brown, "Typography & Web Fonts," A List Apart, accessed June 28, 2022, https://alistapart.com/blog/topic/typography-web-fonts.

22 Sian Gooding, Yevgeni Berzak, Tony Mak, and Matt Sharifi, "Predicting Text Readability from Scrolling Interactions," in *Proceedings of the 25th Conference on Computational Natural Language Learning* (CoNLL-EMNLP 2021, Online: Association for Computational Linguistics, 2021), 380–90, https://doi.org/10.18653/v1/2021.conll-1.30.

into harmony and context, acknowledging that such diverse incentives may be adverse. The next section of this chapter maps out the social ethic paradigm.

Implication for Design Ethics

While ethics are embedded in the design process, design requires an understanding of ethics different from those traditionally studied in classrooms.[23] Traditional ethics is concerned with individuals who act and cause consequences, but social ethics moves the concern of ethics to norms, trends, and policies, both explicit and implicit, that shape decision-making. Such a shift in ethics is required in design because design is a collaborative activity with many individuals contributing to the end product. These individuals come from different departments and disciplines with various incentives. Likewise, the consequences of design also affect large sections of society and individuals. One author goes as far as stating that design is a mode of social experimentation without control samples.[24] As design activities obfuscate our traditional senses of responsibility for undesirable and unseen consequences, a social ethics framework promises a better understanding of the implications of algorithm-guided design decision making.

Decision-Making in Design

The act of decision-making in design includes three major elements. The first is the requirements and criteria of success for the design.[25] The second is the potential risks and secondary effects of an act, and the last is balancing success criteria with acknowledged risks called trade-offs. Mostly, this decision process is implicit in the design process, usually guided by norms and trends within the organization and best practices of the disciplines involved in the design process. Research finds that moral problems in design are not singular and deliberate immoral choices but rather a multitude of questionable choices repeated over a long period of time. The possibility that individuals may wish

23 Richard Devon, "Design Ethics: The Social Ethics Paradigm," *International Journal of Engineering Education* 20, no. 3 (2004): 461.

24 Devon, 467.

25 Devon, 466.

to be ethical yet organizations make unethical acts is described by one writer as organizational deviance—decisions that seem fine on the inside appear deviant to outsiders looking in should give pause to the notion that decision-making should be left to the organizations which produce design artifacts.

Consequences of Algorithms in Design

In one sense, the kind of machine learning-guided responsive typography proposed throughout this essay would circumvent the traditional pitfalls of design decision-making—no individual, or even organization, is deciding the best trade-off between success and risks. Instead, the algorithm is making the decision. Such an algorithm, if given access to biomarkers that indicate cognition of the reader, would be able to find the optimal fit of typographic properties to aid that individual reader without causing a significant cost to the organization. This optimism needs to be countered against what are the criteria of success and what are the risks to be balanced is still very much a human endeavor, incentivized by priorities that may not be in the best interest of readers. The same technology that would allow text to respond to eye-fatigue or difficulty understanding a passage could be used to manipulate information in such a manner to best achieve a key performance indicator such as the purchase of products. Considering corporations—and their officers—have a legal obligation to pursue profit, such a dystopian outlook is very likely. These kinds of concerns mean informed consent for users to opt in to such advanced application of computer vision technology to track and respond to the cognition of the individual reader is necessary—but not sufficient—to address the potential ethical consequences of such a technology.

About three-in-ten U.S. adults say they are "almost constantly" online.[26] Overall, 85 percent of Americans say they go online on a daily basis. Yet, half of US adults read at a 6th-grade level or lower.[27] Considering the trend of

26 Brooke Auxier and Monica Anderson, "Social Media Use in 2021," *Pew Research Center: Internet, Science & Tech*, April 7, 2021, https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021.

27 Mary E. Hanly, "Adult Literacy and Lifeskills Survey (ALL) U.S. 2003 Restricted Use File (RUF) with Rescaled Literacy and Numeracy Scores for Trend with the Program for the International Assessment of Adult Competencies (PIAAC)," National Center for Education Statistics, January 31, 2022), https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2022007.

technology, it is inevitable that digital spaces—meditated by typography—will be the public space for commerce, discourse, and community. These digital spaces will bore the consequences of decision-making around priorities directed by AI. Will such AI-directed decision-making result in a techno-optimism where text fits transparently to the needs of each particular reader, like prescribed eyeglasses for cognition? Or will AI-directed decision-making emerge to manipulate consumer preference, information, and association for the sake of quantified metrics?

While Herbert Bayer was wrong in his legibility arguments for a singular and simplified geometric sans serif design, his argument for a kind of authenticity between technology, artifacts, and culture rings true. Typography, as a digital artifact, is placed in a new cultural and technological context with IoT powered artifacts, yet the essence of digital typography has yet to be expressed. Responsive typography for the individual reader in terms of device, environment, and cognition is both theoretically and technically possible today. The kind of typography described in this chapter could provide a more humane access to knowledge and experience previously blocked to many readers. However, such a potential requires deliberation on when and how much this capacity should be implemented. In the personal opinion of the author, rules and regulations alone cannot address the complexity and obfuscation of ML-guided design introduced into ethics. Our discipline will also need to consider normative exemplars that may direct how to use the artifacts that shape our lives. The implementation of IoT and ML into design and typography will, if only imperceptibly, nudge the outcome for our civil society in the 21st century.

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