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ISSUE 001

BIOMETRICS

DICHOTOMIES

NAVIGATING TOWARDS A BETTER FUTURE

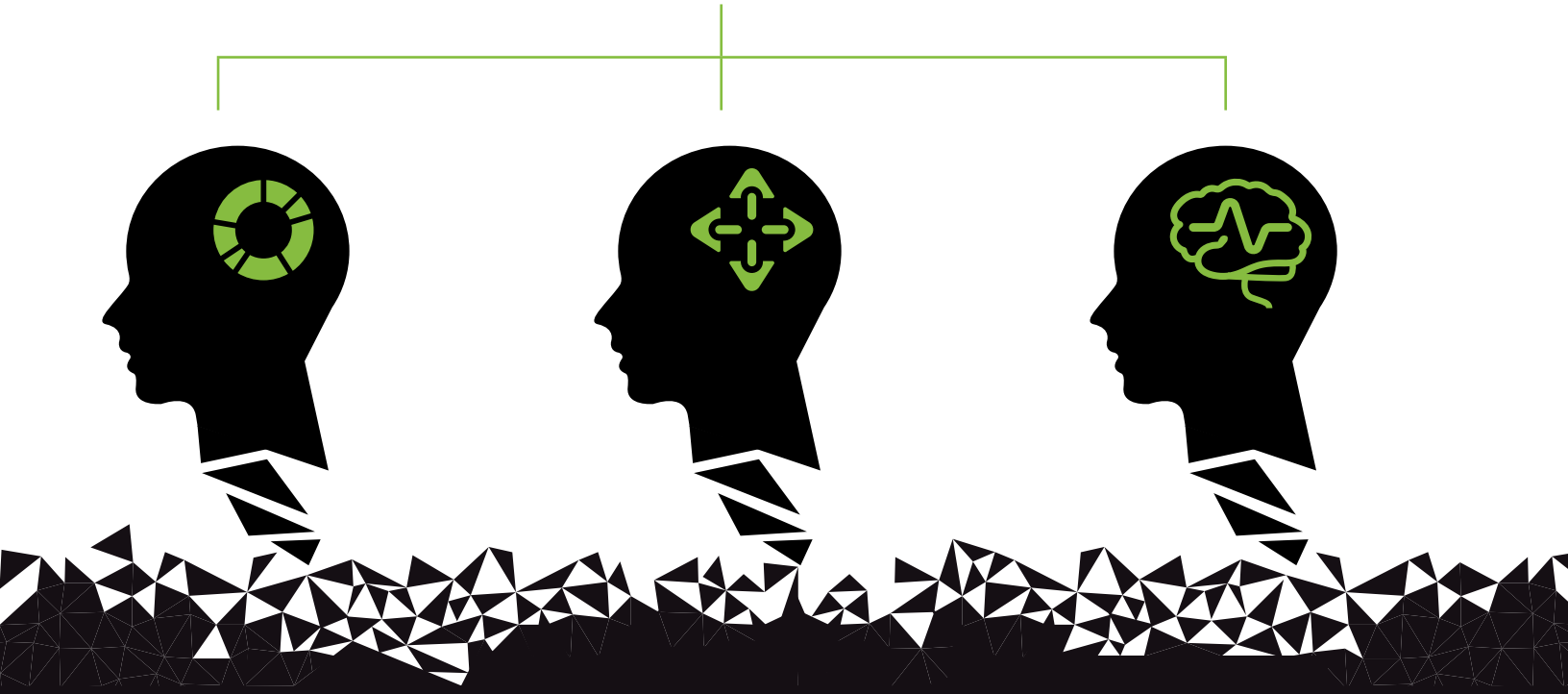
DICHOTOMIES

Dichotomies projects the possibilities of an emerging technology in two divergent scenarios. Through speculative fiction and actionable takeaways, we help leaders understand the implications and risks of the future.

BIOMETRICS

AUTOMATED RECOGNITION OF INDIVIDUALS BASED ON THEIR UNIQUE PHYSICAL, BEHAVIORAL, AND/OR NEUROLOGICAL CHARACTERISTICS.

RECOGNITION TYPES / BIOMETRIC FEATURES



PHYSIOLOGICAL

Analysis of the innate physiological characteristics of a person

- Hand geometry
- Fingerprint / palm print
- DNA
- Vascular / vein
- Eye
- Face
- Ear

BEHAVIORAL

Identification of unique and measurable patterns in human activity

- Signature
- Voice
- Keystroke
- Gait

NEUROLOGICAL

Measurement of unique neural signals transmitted from the brain

- Neuroprint
- Brain fingerprinting (electroencephalography)
- Gray / white brain matter ratios

A BRIEF **HISTORY** OF BIOMETRICS

1880

1880 | Henry Faulds publishes the first paper on forensic fingerprinting

1890

1892 | Juan Vucetich uses fingerprint evidence to identify and convict a suspect, pioneering future cases

1900

1905 | The U.S. Department of Justice institutionalizes fingerprint cards

1910

1911 | People v. Crispi is the first U.S. criminal case where a conviction is secured mainly through fingerprint evidence

1920

1930

1939 | Leonard Keeler patents the modern polygraph. His device uses biometric indicators, like galvanic skin resistance and blood pressure, to predict is a subject is lying

1940

1950

1960 | Gunnar Fant analyzes phonic sounds to create a model for acoustic speech, crucial to later developing speaker recognition

1960

1964 | Semi-automated facial recognition methods are developed

1965 | Automated signature recognition research commences

1970

1977 | Patent is awarded for dynamic signature acquisition

1980 | National Institute of Standards and Technology (NIST) Speech Group is established to study and promote speech processing techniques

1980

1985 | Iris recognition is proposed

1985 | Hand geometry identification is patented by David Sidlauskas

1985 | Patent for vascular pattern recognition is awarded to Joseph Rice

1987 | Patent is awarded for iris recognition system

1991 | Facial detection technology makes real-time recognition possible

1994 | First algorithm to automate identification of humas irises is patented by John Daugman

1990

1996 | Atlanta Olympic games uses hand geometry systems to secure access to Olympic Village

A BRIEF **FUTURE** OF BIOMETRICS

2001 | Facial recognition technology is deployed at Superbowl XXXV in Tampa, Florida

2010 | Facial recognition is used to identify individuals in social media photos and suggest tags

2013 | Built-in scanners allow users to unlock smartphones with their fingerprints

2017 | Smartphone technology advances to enable unlocking with facial recognition

2000

2010

2020

2030

Over the past 10 years, biometrics have advanced at a rapid rate. They evolved from a novel technology to an aspect of everyday life, such as fingerprint sensors on phones.

NOW | Multimodal systems combine different biometric trends to overcome the limitations of unimodal biometric systems (e.g., worn-out fingerprints, aging irises, or incomplete sensor collection)

NOW | Artificial Intelligence (AI) is being merged with biometric data to construct devices and systems that can learn and adapt to users

NOW | Biometric solutions are more widespread, with the advance of mobile solutions and technological developments. Additional biometric identification has emerged, including gait, keystroke, and electroencephalography (EEG)

ALLURE

Universal adoption of biometrics will improve security and assurance, allow faster access, and increase convenience

CONCERN

Biometrics will create greater vulnerability of our security systems, lead to false positives, and be expensive for society

Projecting future possibilities across three industries:

EDUCATION

RETAIL

HEALTH & WELLNESS

EDUCATION

Biometrics could accelerate the digitization of the classroom with more customized learning, but educators should make sure not to further exclude the students who learn differently.

ALLURE
Charlie

Charlie's running late for school again. He hasn't yet mastered his routine for the once-a-week sessions of in-person learning. He fixes his hair and orders his personal bot, Alfie, to pick out clothes for the day: Today's tests could determine his whole future.

"Maybe it's a good thing I slept in. I'll be rested," he mutters to his father as they wind into the school parking lot.

"Just... good luck," his father yells as Charlie sprints into the building.

At his 12th grade classroom door, he catches his breath while the iris recognition scanner identifies Charlie and opens the secure door to 25 staring pairs of eyes.

"You're 10 minutes late, Charlie. On Future Mind Day. You know, we can't let Central High fall behind." Mr. Fujiwara points to the clock on the main class screen.

Charlie quietly slides into his smart desk. A reminder pops up to put on his headset, which reads and records his brainwave data through EEG signals—just like it has since 1st grade.

Mr. Fujiwara explains that their school has been using the Future Mind Profile—a series of tests, puzzles and brain teasers delivered through a headset and suit. At the end of Future Mind Day, the program will analyze each student's brain activity, compare it to their preferences, and suggest the ideal job for that student.

A chat from his friend, Tamara, pops up on Charlie's smart desk.

Tamara [8:44 AM]: **Dude. I'm nervous. This is all way more than those old SATs. Wonder what it'd be like to study flash cards and practice tests, like our parents did?**

Charlie assures her they'll both do great, but secretly worries about just how much this test means—the results are shared with top companies and colleges around the world. This could be a ticket to his dream career. He doodles with his stylus, etching a skyline to calm his nerves.

After Mr. Fujiwara prepares the class, Charlie puts on the Future Mind suit and heart rate biometrics confirm his identity—he begins the grueling tests.

When Charlie returns home, his family sits around the dinner table awaiting his results. He transfers the doodle from his school desk to his tablet and continues drawing out the cityscape.

Within an hour, Tamara pings him that she received her ideal profile: Analytical Driver. Before he can congratulate her, his own results arrive.

He is a Creative Pioneer, meaning careers in architecture, metaverse design, and entertainment match his Future Mind Profile. "Yes!" Charlie screams, and jumps out of his chair to hug his folks. His dream of becoming an architect is still within reach.

Another notification pulls Charlie's attention away from daydreaming. Universities are viewing his profile and he's been offered an interview tomorrow with the local design college to major in architecture. He grabs his tablet and bounds upstairs.

"Alfie," he exclaims, "pick out interview clothes!" Tomorrow is a big day.

CONCERN
Monique

Monique and her mother sit across the table, as Mr. Fujiwara begins the usual scolding, “Thanks, Mrs. Bradley for coming in again to chat about Monique’s classroom participation. With Future Mind Day tomorrow, we must get to the bottom of this.”

He reaches into the smart desk and retrieves Monique’s digital performance folder. Displayed across the table are graphs of her classmates’ performance compared to Monique’s.

The charts indicate she’s lagging behind her 12th grade peers in several key metrics: peer engagement, eye contact, and emotional response.

Mr. Fujiwara double clicks on the peer engagement metric and a video appears of Monique with her classmates. Unlike the others in the group, she’s awkwardly bent over her desk and not contributing. “As you can see, this behavior is not standard with her classmates. It’s time we act,” he warns, as the smart desk hears the verbal que and presents a Disciplinary Action form.

Her mother sighs, knowing that the usual defense is unmatched to data expectations, “Mr. Fujiwara, please. Monique is a non-traditional learner and if you let her speak to the Chief Future Minder, she’d be *integrated* and not *excluded* from your smart desk models.”

Monique tries to look into the teacher’s eyes, like her mother taught her. But it’s these moments that make her want to slip away and be invisible. Unfortunately, introverted invisibility is not an option in the classroom; where every eyebrow raised, thought conceived and word spoken is recorded, analyzed, and judged.

So instead, she tunes out the mother-teacher feud. She looks down at her favorite sneakers—worn-out from endless games of fetch with her robodog, Max. How she wishes school could be replaced with time spent at robodog parks and playing Animal Vet on her VR headset. That’s where she feels accepted.

Unfortunately, her daydream is rudely awakened by the buzz emanating from Mrs. Bradley’s wristband.

Embarrassed by the public recognition of her rising blood pressure, Mrs. Bradley retreats from the debate. Mr. Fujiwara motions for the final victory: the parental iris signature. Mrs. Bradley lowers her gaze to the smart desk, and through iris recognition signs the Disciplinary Action form.

Just like that, Monique’s biometrics access is confined only to the classroom until her class performance increases. No more walking into the school’s virtual zoo through a simple iris wink, or playing Animal Vet through facial recognition... And no matter how hard she tries at Future Mind Day, her record is stained by this violation.

She knows no pre-veterinarian program will accept her.

TAKEAWAYS

Although Charlie and Monique are both 12th graders at Central High School, their experiences with biometrics are vastly different. Biometric systems support Charlie's learning style and affirm his passion, but they marginalize Monique when she falls outside of their standard parameters.

Ensuring students like Monique can benefit from changes in the classroom means building and implementing biometric tools that empower, not exclude.

BRINGING TEACHERS ON THE JOURNEY

Educators will need training on biometric systems before they become a part of the student experience. Take Monique's lagging metrics – instead of using them to discipline her, Mr. Fujiwara could instead be prompted to try a new approach. If educators are empowered to use biometrics to better teach their students, the new system can promote outcomes like Charlie's: tailored, efficient, and energizing.

BIOMETRICS IS BECOMING BRAINY

Biometric systems that can further transform education are coming down the innovation pipeline. For instance, Charlie's headset could track EEG trends to flag early warning signs of anxiety and depression. Biometric feedback can allow coursework to actively adapt to Monique, rather than struggle for her attention. Personalized learning environments lead to stimulating lessons and improved outcomes.

ETHICAL SYSTEMS, INCLUSIVE CLASSROOMS

Algorithmic bias, like we saw with Monique, can result in unfair exclusion. Students deserve biometric systems that are designed inclusively, built for hybrid classrooms, and capable of supporting healthy learning environments. The data that devices collect from minors will also require robust privacy regulations. Rigorously identifying and tackling these issues proactively can ensure the future of biometrics is a positive one.

Tech Projections | EEG Sensors

Electroencephalography (EEG) sensors record electric activity of the brain to study cognitive processes. During Central High School's Future Mind Day, the students wear EEG headsets that collect their cognitive data to predict career placement. In Charlie's case, his feedback was exactly what he hoped for – a positive affirmation of his career aspirations. However, for Monique, her cognitive data was unjustly compared to standardized data sets – and she was confined by disciplinary action.

A version of Future Mind Day may become a new standard for testing. EEG tests are already being explored by startups, researchers, and medical professionals to study learning effectiveness and attention control through headsets. As we learn more about how our minds grow and develop, EEG data and findings may shape education, along with work, wellness, and other disciplines.

Classrooms have long shaped students; now, they'll serve as incubators for EEG sensor technology to grow and impact other areas of society.

RETAIL

Biometric systems can power seamless payment systems and immersive fitting rooms, but they need to protect against stereotyping and mistaken identity.

ALLURE
Isabelle

Isabelle rehashes the interview prep in her mind as her self-driving car takes the exit to Bearfield Mall. Years of long hours and grueling projects have led her to her current opportunity to be Chief Marketing Officer of a quantum security startup.

She knows confidence will set her apart, so Isabelle has arrived at the mall to buy the perfect interview outfit. As she walks past stores, Isabelle's AR glasses display personalized offers integrated with her calendar. **Need a new dress for 'Second Date with Rocco' tonight? 15% off at Reformation today only!**

She ignores these alerts until she arrives at the doors of LuxWear, a store that knows her style. The store's ambient intelligence software recognizes her face and uses her measurements from past visits, along with online shopping data, to send her outfit ideas. New combinations that compliment her existing wardrobe are highlighted in her AR glasses as she browses the store. But Isabelle is here for more than just a wardrobe upgrade.

Since she has allowed LuxWear access to her eye-tracking data while in store, she receives a notification to her AR glasses: **Looking for something specific? Try our new Aimie helpdesk.**

Isabelle strolls over to a desk with multiple screens and the Aimie voice asks what she's looking for.

"An interview outfit that gives me executive presence. Comfortable, but modern. Navy for sure." Aimie prepares a collection of work suit options and instructs Isabelle to head to the virtual dressing room.

The room-height smart mirror scans her body and maps the outfit options over her reflection, so Isabelle can visualize the tailored outfit before its even stitched. She clicks on the business setting option, selects the 360° view, and her reflection appears in an interview room, turning around to display the suit from multiple angles. Isabelle scrolls through the options—pant suits, long-sleeve dresses, skirts—until she lands on a tweed pencil skirt and blazer.

The navy pinstripe pattern offers her just the executive presence she was searching for. She gestures in the dressing room as if she's interviewing and observes how the pencil skirt falls when she sits down. The store picks up on the extra time she's spent deliberating and sends a notification to her AR glasses: **10% off if you buy within the next hour.**

Isabelle selects purchase on the mirror, and an option pops up to add-on an NFT copy of the outfit for her metaverse avatar. Knowing she'll have an interview or two in VR, she accepts and equips her avatar with the new outfit. The mirror asks Isabelle to place her fingerprint in the corner to confirm payment.

By the time Isabelle reaches the mall's exit, she receives a notification of multiple positive comments on her avatar's new suit, affirming her decision to buy. *Just a matter of time*, she thinks, as she feels renewed confidence for the interview. Instead of walking out the door, she turns back around: she can spend some time on that date night dress.

CONCERN
Rayyan

Rayyan is frozen, staring intently at the tight-fitting tuxedo. The store's smart mirror scans his body shape, outlining it in sharp blue lines, and denotes his measurements and his estimated weight. He's just tried on what feels like the 50th outfit for his sister's wedding, and so far, has confirmed what he already knew: he hates shopping.

He hates having to confront the small changes in body shape and weight each time, as if he didn't worry about that enough each morning. The shop's policy is to collect such detailed data on each customer to offer style suggestions, but the process has never felt helpful for Rayyan.

The smart mirror displays a notification: **This item is often bought by buyers 2-3 sizes smaller than you; would you like me to recommend styles more suited to your physique?**

Ugh, he thinks. The smart mirror offers its unsolicited advice, as usual, on buying larger clothes. He hasn't been to this side of the Bearfield Mall before, so the system doesn't know that he prefers a slim fit. It doesn't know that Rayyan feels a surge of embarrassment as the playground jeers of his larger frame come rushing back to memory.

Feeling flustered, Rayyan exits the boutique and continues to wander the mall in his quest for an outfit. He ponders whether online shops can help avoid the humiliation he just faced, but he decides to try one more shop in the mall. The wedding is just two weeks away. Rayyan puts on AR glasses to visualize the shops in his vicinity which have his measurements, weight and preferences stored.

An ad appears in his glasses: **Shopping ever get you down? We know, we care: Come visit LuxWear.**

He double clicks on the boutique and sees a 9.9/10 rating with over 5,000 reviews praising its virtual dressing room experience. He nods his head, as the AR glasses display a 4-minute ETA and guide him down the corridor to the neon "LuxWear" sign. As he approaches the doors, they automatically lock and alarms blare around him. He panics, surveying the room for potential danger. Seconds later, two security guards approach.

Facial recognition has matched you to a recent shoplifting suspect," says the taller of the two guards. "Please follow us to undergo a full body scan."

Rayyan cannot believe it—he hasn't been to the mall in five months, as he's been stuck in the library. Even as Rayyan argues that he is not a criminal, the guards forcefully escort him to a security station beside the store and push him through two metallic beams.

On the other side, the light flashes green, to the guards' surprise.

"This is the third time this month. What is going on?" one guard mutters. "All clear!"

Rayyan questions the guards on their recognition tech, but they answer his demands with a shrug and canned apology. As the guards shuffle away on patrol, the LuxWear employees begin to point at Rayyan and whisper. He feels more like a suspect than a customer. Maybe he isn't cut out for the mall after all.

TAKEAWAYS

Rayyan and Isabelle each arrive at Bearfield Mall with a purpose—an interview outfit and a wedding guest tuxedo—yet one leaves with a shopping bag and matching NFT and the other leaves with an alienating experience.

Biometric tools should be combined with hyper-personalized considerations so they can fit each customer's need.

SALES, AT SCALE

Isabelle interacts with an immersive retail platform that transforms biometric data into a personalized promotional campaign. On the other side of the counter, LuxWear benefits from effective microtargeted discounts that convert fitting room experiences to dollars. With personalized biometric platforms, retailers and customers can find the right match in each other, the first time around.

WELL DRESSED WITH LESS STRESS

From the moment Isabelle steps foot in LuxWear, biometric tools work to optimize her experience. Aimie, the AI assistant, pairs Isabelle's preferences with existing customer data to provide the perfect products right away, even allowing Isabelle to visualize the outfit in its intended setting. Whether it's at a box store or a boutique, biometrics can cut down on excess time and resources while delivering a better customer experience.

ETHICAL, FROM STITCH TO SALE

Rayyan's experience illustrates the consequences when biometric systems don't prioritize inclusive design in their shopping recommendations or address the potential for bias within facial recognition. By incorporating ethics from the first stitch to the point of sale, biometric system design should work for customers of all identities and sizes.

Tech Projections | Unlimited Reality

Unlimited Reality encompasses the technologies that overlay digital information on top of the physical world to enhance our perspective. At Bearfield Mall, these solutions use biometric data to identify individuals in a virtual world. For Isabelle, her AR glasses integrate her biometric data to create a seamless shopping experience with personalized outfitting and promotions. But Rayyan's biometric data is mistaken for someone else, resulting in a harrowing experience and reminding us of the risks presented by poorly-trained identification technologies.

Many tech companies can achieve these ambient experiences – ones that combine multiple sensory elements – through a headset , a handheld "gateway" device, smart glasses, or even just a mobile device. However, the real path to the future is to create individual virtual identities in the metaverse for everyone. With biometrics, virtual worlds based on unique identification can create new customer experiences and enhance everyday lives beyond imagination.

HEALTH & WELLNESS

Wearable tech can unlock revolutionary insights in health and wellness, but trust will need to come first.

ALLURE
Ramy

Ramy leans back in his office chair and smiles as he takes off his AR glasses. The client presentation was well-received. He checks the time. 11:02 A.M.—enough time to fit in his daily run before a lunch meeting at 1 P.M. As he preps for the run, Ramy reaches into his shelf of personalized multivitamin bars.

The vitamin company had integrated data from his HealthAI app along with microbiome at-home tests to customize supplements for his active lifestyle and specific allergy needs. Ramy's hand comes out empty, so he checks the screen on his cabinet and sees that the replenished supply is scheduled to arrive that afternoon; he decides to run on an empty stomach instead of waiting. His half-marathon is in two weeks, and he can't skip a day of training.

As Ramy begins his usual route towards Boston Common, his watch buzzes. His socks, equipped with textile sensors, have been monitoring his heel striking and running style. The watch tells him to widen his stance and slow down a little, so Ramy adjusts as he rounds a street corner. By the time he reaches his halfway mark, where the gardens of the Common begin, he's already out of breath. Ramy pauses to check his heart rate, which his watch shows is 30% higher than usual for this point on the daily run. *Should've eaten this morning*, he thinks, as he rushes into the nearest store and devours an energy gel. Immediately, his throat starts to itch and the oximeter in his sweatband alerts him that his blood oxygen levels have dropped, even before he hears himself wheezing. Ramy knows these symptoms, but he takes out his phone to confirm with the HealthAI app. He takes a selfie in the app, which compares his flushed skin and hives to a medical database and confirms what Ramy feared: an allergic reaction.

The app automatically orders an ambulance, and the paramedic administers an epinephrine shot to stem the allergic reaction. The HealthAI app helps triage his condition and notifies the ER staff of the epinephrine injection. When he arrives at United Hospital, nurses move Ramy over to an examination room with Dr. Huang. The doctor asks Ramy to place his finger on the exam room's main screen, and his HealthAI profile appears. The doctor reviews the information and clicks into a note describing Ramy's peanut allergy. Ramy sighs. "I ate an energy gel without checking the label."

"Happens," Dr. Huang says. "Good thing you were warned before the shock set in. Let's see what else you need."

The doctor taps into Ramy's biometrics dashboard and filters for data from the past few hours. She notices that Ramy's sleeve oximeter is still showing abnormal readings, so she enters data into a prescription vendor that approves her request with iris recognition. Dr. Huang then retrieves an inhaler and antihistamines from the machine and monitors Ramy's oxygen levels on the screen before discharging him.

Back outside, Ramy looks down at the time. 12:54 P.M. He calls up the friend he's supposed to meet for lunch and asks him to triple-check the menu for peanuts, "You'll never guess what just happened."

CONCERN
Lola

Lola struggles to hold back tears as Dr. Ayodeji rotates the digital twin of Lola's body. "How was this missed?" she cries. Her vibrating watch screen warns of increased heart rate and provides her with suggestions for mindfulness activities. She swipes away the notifications and focuses in on the model in front of her: a small brown mass across her upper back.

"Well, sometimes these things can happen..." Dr.Ayodeji begins. His words retreat into a distant mumble and the United Hospital exam room falls silent. Lola was just informed she had a form of skin cancer that could spread to other organs.

Lola reflects on the skincare subscription she signed up for, TrueSkin, that monitored skin conditions and integrated HealthAI data to offer personalized products from acne cream to cosmetics. TrueSkin promised to work on all skin types, and Lola was eager to finally use an app that would customize to her own darker complexion.

Now she wonders how with all that data on her skin, *how could TrueSkin miss her cancer?*

Alert: High Heart Rate

The notification from Lola's smart watch transports her back to the moment.

"Ms. Warren, I advise you to take some deep breaths. Your heart rate is going through the roof."

Dr. Ayodeji sighs as he looks at the exam room screen. "I know this is difficult news to take in." But just as Lola attempts to lock her device, an email from her workplace catches her attention.

Dear Ms. Warren, we are sorry to hear of your diagnoses. Your legal work as senior attorney has provided incredible value to the development of our law firm. Please let us know how we can support you through this difficult time...

Lola's heart sinks. Before she can process the news herself, her office has been alerted by HealthAI. She would have preferred to tell them in her own time and avoid anyone feeling sorry for her. Despite how hard she had worked to earn the senior attorney position, it could all be gone in a second.
Dr. Ayodeji fidgets uncomfortably with his white coat as he battles to hide his disdain at the sophisticated technology missing a cancer diagnosis. After all his years of training, he cannot help but feel a sense of denial that such an oversight had occurred with one of his patients.

He taps on the exam screen to display a dashboard of Lola's general health and vitals collected from her smart clothing and biometric sensors. He assures Lola that, given her otherwise healthy lifestyle and body, she would be a great candidate for a new gene therapy treatment.

But as he displays statistics about her chances of tumor reduction with and without gene therapy, his own mind wanders. *Can he even trust the technology in front of him?*

TAKEAWAYS

While Ramy and Lola both have life-changing interactions with biometrics, Ramy experiences a life-saving intervention and Lola is left wondering what more could've gone wrong.

Bringing biometric improvements to health and wellness requires balancing data-driven insights with provider expertise and privacy.

AN APP A DAY KEEPS THE DOCTOR AWAY

The biometric data that feeds Ramy and Lola's HealthAI app would've required a visit to a doctor's office just five years ago. However, this in-depth collection – from glucose levels to gait analysis – isn't sufficient on its own. AI programs that leverage biometric data can be combined with advances in diagnostics and physician review to create interventions that save lives.

ONE SIZE FITS ONE

Ramy's personalized multi-vitamin bars use biometric data from blood tests and microbiome collection to build a diet just for him – keeping him healthier now and in the future. With customized healthcare powered by a central app like HealthAI, overburdened healthcare professionals will have valuable new tools at their fingertips, and patients will be empowered to take stock and take ownership of their health.

ETHICS AND EQUITY AT THE HEART

For Lola, an inadequately trained biometric system leads to a catastrophic health outcome, while a lack of data protection causes a breach of trust. If biometric systems and AI programs are trained on biased data, they'll perpetuate any inequities that currently affect the healthcare system. Building ethical biometric systems means rooting out bias from historical data to create a future where equity is prioritized.

Tech Projections | Next-Gen Wearables

Next-gen wearables are driving healthcare innovation and discovery by providing granular, real-time health indicators to patients and providers. In these stories, Ramy's watch saves his life by detecting abnormal biometric patterns. Unfortunately for Lola, smart clothing and sensors that she relied on for health information were not trained well enough to detect her skin condition.

Wearables such as smartwatches, necklaces and glasses can track our steps, our heart rate, and our eye movement. The data collected is continuous and measured over a lifetime. From predictive analysis of COVID-19 diagnoses to improving nutrition for mental wellbeing, the possibilities provided by long-term constant monitoring are endless.

As wearables and biometric sensors continue to permeate our daily lives, the quantity of data collected and the resulting quality of insights is set to increase exponentially.

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