American Teenage Vision and the Value of Cool

by

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A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of Master of Fine Art in Industrial Design

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November 2, 2017

Abstract

One quarter of American youth have a vision problem that, left untreated, can impact personality and academic achievement. The vast majority of these cases could be remediated with a pair of eyeglasses. However, even when kids and teenagers are prescribed glasses, many do not wear them. This thesis questions why this problem - which has a seemingly straightforward solution and clear benefit - has not been resolved. First, it discusses current literature and qualitative research on the prevalence of eye correction issues. This paper also focuses on how American teenagers specifically are impacted by this problem. Finally, it suggests a categorical redesign of eyeglasses for this demographic to address many of the issues with glasses on the market today and discusses potential systems-level changes to improve youth health in the United States.

Keywords

Introduction

Increased vision care may be the most cost-effective way to improve child welfare and correcting vision has a greater impact on academic success than any other health related intervention.[1] Untreated vision problems can not only cause headaches, blurred or double vision, work avoidance, tripping, and decreased academic success, but can also lead to worsening eyesight and permanently altered perceptions of the world.[2] Although the vast majority of vision problems can be remedied with corrective lenses, 239 million youth globally do not get the eye care they need.[3] In the United States, up to 85% of American youth aged 8-18 who are at risk academically or behaviorally have an undetected or untreated vision problem.[4] This is related to many factors, from confusion surrounding the healthcare industry and distrust of the system, to affordability and accessibility of resources, to the desirability of vision correction devices themselves. While many organizations are attempting to solve this, none have been successful. Addressing one particular aspect of this problem, namely the allure of eyeglasses specifically for American teenagers, might increase the use of glasses among this demographic and reduce the number of people in need.

Supplementary Research

Enabling kids to see by prescribing them appropriate glasses has a greater impact on academic success than any other health-related intervention;[5] improving children's vision can have the same effect as gaining up to half a year of schooling.[6] Not only is 80% of learning is visual,[7] but people with untreated vision problems frequently suffer physiologyical consequences as well. Treatment is especially

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1   Madeleine K. Albright, et al., "Eyeglasses for Global Development: Bridging the Visual Divide," June 2016. United States Agency on International Development, World Economic Forum: 16. Danna Ethan and Charles E. Basch, "Promoting Healthy Vision in Students: Progress and Challenges in Policy, Programs, and Research, *Journal of School Health* 78, no. 8 (2008): 411.

2   Ethan and Basch, 412.

3   Katherine White, interview with author, Rochester, NY, September 30, 2016. Bob Olsen, interview with author, Rochester, NY, September 16, 2016. Albright et al., 4, 7.

4   Albright et al., 18.

5   Albright et al., 16. Ethan and Basch, 411.

6   Albright et al., 8.

7   "School-aged Vision: 6 to 18 Years of Age." American Optometric Association. 2015.

crucial for kids and teens as vision can deteriorate faster when left unadressed.[8] Moreover, because vision is developed through interrelated systems inovolving both the eyes and brain, children whose vision problems go uncorrected develop different cognitive perceptions of the world.[9] The most common vision problem for youth - over 90% of issues among 12-19 year olds - is refractive error, the vast majority of which can by remedied with corrective lenses.[10] In spite of this, innumerable youth still do not get the eye care they need.[11]

More than 20% of American youth have a vision problem, a statistic significantly higher among certain demographics.[12] Not only are youth in poor, urban areas twice as likely to have vision problems, they are also less likely to receive follow-up services and care even when they are free.[13] Incarcerated youth and children in foster care also have disproportionately high rates.[14] Additionally, up to 85% of American youth (8-18) who are academically and behaviorally at risk also have an undetected or untreated vision problems, and kids with undetected vision issues are more likely to be misdiagnosed with ADHD.[15]

Myopia - near-sightedness - is the most common vision affliction among youth. In more affluent schools many kids can slide by without addressing their myopia because being near-sighted enables them to read text close-up, such as a book on their desk. In schools with smaller budgets, larger classes, and fewer books, however, not only does myopia go unnoticed more frequently, but it is likely to have a greater impact on these students since the majority of teaching is done on a screen or board. To understand why so many American youth are not receiving the vision care they need, we must understand

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8   Charles E. Basch, *Healthier Students Are Better Learners: A Missing Link in School Reforms to Close the Achievement Gap,* publication, Research Review No. 6, Teachers College, Columbia University, Campaign for Educational Equity. 2010. 1-104. Ethan and Basch, 411-16. Kimel, L. S. "Lack of Follow-up Exams After Failed School Vision Screenings: An Investigation of Contributing Factors." *The Journal of School Nursing* 22 no. 3 (2006): 156-62.

9   Ethan and Basch, 411-16.

10   Basch, *Healthier Students...*, publication, 12. White, 2016. Olsen, 2016.

11   White, 2016. Olsen, 2016.

12   Basch, 588. Ethan and Basch, 411-16. Kimel, 156-62.

13   Ibid.

14   Ethan and Basch, 411-16. Roger P. Harrie and Paul Christopher Harrie, "The Prevalence of Uncorrected Refractive Errors in Adolescents Incarcerated in a Youth Detention Center," *Child and Adolescent Social Work Journal*, (2015): 1-5.

15   Albright et al., 18. "School-aged Vision: 6 to 18 Years of Age," *American Optometric Association* (2015), http://www.aoa.org/patients-and-public/good-vision-throughout-life/childrens-vision/school-aged-vision-6-to-18-years-of-age?sso=y.

the system surrounding this particular modality of the health care system in the U.S. This system can be broken down into three main areas: identification of a problem, follow up with a healthcare professional, and - if glasses are determined to be the appropriate treatment of the condition - wearing the glasses.

Identification

The first step to obtaining vision correction is recognizing potential problems. Children or teenagers might be identified by parents, teachers, pediatricians, or may self-identify.[16] The American Academy of Pediatrics (AAP) recommends that all kids be tested by a pediatrician shortly after birth and then again via age-appropriate methods at every well-child visit.[17] However, many pediatricians do not follow this recommendation and do not test.[18] Pediatricians are frequently limited for time and resources during these routine visits, and because it is common for schools to test vision, many assume that it will be addressed there.[19] However, because testing is left up to the discretion of states, only 71% offer free testing.[20] While numerous charitable organizations have attempted to accommodate for this gap: nationally, InfantSEE provides free exams for babies, the Lion's Club screens older children, and other regional groups operate on a smaller scale, there is a lack of communication between all parties that results in kids falling through the cracks.[21]

Undiagnosed vision problems can also create communication issues downstream between parents and schools. Many parents leave their child's pediatrician with the impression that vision screening was completed and are subsequently caught off-guard when notified by a school nurse or other screener that their child needs an evaluation by an optometrist.[22] This can foster skepticism and distrust between parents and schools. Identifying this as a potential catch in the system, however, is not intended to lay blame on pediatricians. Vision screening can be a frustrating, time-consuming endeavor without the proper training or tools, and it is logical that doctors might prioritize their efforts on issues they know

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16   White, 2016.

17   "Eye Examination in Infants, Children, and Young Adults by Pediatricians," *Pediatrics* 111, no. 4 (2003): 903.

18   Colleen Clandenning et al., interview with author, Brighton, NY, September 21, 2016. Kimberly Lawrence, interview with the author, Rochester, NY, September 30, 2016.

19   Lawrence, 2016.

20   Barbara P. Yawn et al. "Barriers to Seeking Care Following School Vision Screening in Rochester, Minnesota." *Journal of School Health* 68 no. 8 (1998): 319-24.

21   Yawn et al., 319-24. Clandenning et al., 2016. Lawrence, 2016.

22   Ibid.

will not be tested redundantly in schools.[23] While using appropriate equipment, such as the Welch Allyn Spot Vision Screener, testing for referral to an eye care specialist can be done in seconds,[24] devices such as these are prohibitively expensive for many clinics unless covered by insurance.[25] A few phone applications boast the ability to screen vision with a smart phone camera, but may also be cost prohibitive unless reimbursed by an insurer.

<div align="center">Follow Up</div>

Of the kids who are initially diagnosed with a correctable vision issue, only 40% receive follow up care.[26] While this is due to a number of reasons, a significant factor is communication breakdowns. For instance, school nurses and teachers frequently do not discuss vision screening results, which inhibits follow up and perpetuates confusion.[27] Parents of children in lower socio-economic groups - particularly those with unstable housing or unreliable phone access - are especially difficult to contact. Many parents in strained financial situations are also reticent to receive yet another phone call from someone telling them what to do.[28] There is also a pervasive lack of trust. Up to 59% of kids don't receive necessary follow up because their parents doubt the initial test result.[29]

Two of the most universal concerns of parents relating to follow-up are the cost of eye care and glasses, and the inconvenience of scheduling appointments.[30] The Affordable Care Act (ACA) mandates that all plans cover pediatric vision care, including one appointment per year, glasses frames and lenses, and replacement if they break.[31] However, most people are unaware of this benefit.[32] Scheduling can be especially difficult for low income families. Parental literacy, English comprehension, and a general opinion that downplays the importance of eye care, as well as a lack of necessary resources - such as

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23   White, 2016.

24   Mae Millicent W. Peterseim et al., "The Effectiveness of the Spot Vision Screener in Detecting Amblyopia Risk Factors," *Journal of American Association for Pediatric Ophthalmology and Strabismus* 18 no. 6 (2014): 539.

25   Lawrence, 2016

26   Childhood Vision: What the Research Tells Us. *George Washington University* (2004). Brad Finnegan and Peter Shin. "Access to Comprehensive Vision Care Services Under SCHIP." *National Commission on Vision & Health* (2008).

27   Yawn et al., 319-24.

28   Lawrence, 2016.

29   Kimel, 157-160.

30   Kimel, 157-160. Yawn et al., 319-24.

31   Lawrence, 2016.

32   Kimel, 157-160.

consistent access to phones and transportation - all complicate scheduling.[33] Additionally, families on Medicaid can be forced to wait months before they are able to obtain an optometric appointment.[34]

Glasses Use

The final step in glasses adoption is convincing youth to wear their glasses. While the stigmas around glasses are changing for adults, the culture for young people - especially teenagers - has been slower to come around. Teenagers frequently refuse to wear eyeglasses because they don't want to be teased or don't believe they do anything. This perceived lack of need or benefit, as well as the impression that glasses might worsen vision, is pervasive.[35]

One alternative to glasses is contact lenses. However, contacts are not typically the best choice for youth for several reasons including cost, the need for a continuous supply of solutions, and threat of infection.[36] Another option is lasik surgery, but because teens' eyes are still developing, surgery is not an option until they are older.[37]

A survey of more than 80 high school students attempted to identify why teenagers do not wear their glasses. Students noted that they do not like the way their glasses look (30.4%) or that they are uncomfortable (28.3%). Many commented that they do not like their glasses because they had received them when their personal style was different. While more than 75% of respondents noted that the coolness of glasses depends on the particular type, a few students commented that they do not wear their glasses because their choices were limited to those covered by insurance and they did not like them. Overwhelmingly, students indicated that cooler glasses need to be more affordable, comfortable, and personalized.[38]

Surveys and interviews indicated that the majority of glasses available in the United States - especially plastic glasses (which are most popular among American teenagers) are made to fit prominent Caucasian nose bridges.[39] As a result, teenagers of non-European lineage are limited to glasses that either

33   Kimel, 160.

34   Kimel, 157-160. Yawn et al., 319-24.

35   Albright et al., 18. Lawrence, 2016. White, 2016.

36   "Healthy Contact Lens Wear and Care." *Centers for Disease Control and Prevention.* (2015). Lisa A. Jones-Jordan et al., "A Comparison of Spectacle and Contact Lens Wearing times in the ACHIEVE Study." *Clinical and Experimental Optometry* (2010): 157-63. Marjorie Rah et al., "Vision Specific Quality of Life of Pediatric Contact Lens Wearers." *Optometry and Vision Science* (2010): 560-66.

37   Olsen, 2016.

38   Pullman High School, survey by author, internet survey, Pullman, WA, fall 2016.

39   Wendy Micca, Interview with author, October 10, 2016. Logan Newman, Interview with author, October

do not fit or are less popular. While a few companies - such as Oakley and Warby Parker - have addressed this by creating frames specifically for faces with low nose bridges and high cheekbones, options are still severely limited and typically expensive.

Many students acknowledged that they frequently forget their glasses. One way to potentially combat this might be through habit formation.[40] Marketers frequently utilize habits to obtain customers. For instance, although recent research has indicated that devices like FitBit are less helpful for weight loss than paper trackers, dieters continue to habitually wear FitBits.[41] Designing eyeglasses as a status symbol in this way might entice teenagers to wear them. Gamification also might encourage glasses use. Studies have shown that an important contributing factor to the success of gamification is peer to peer connection.[42] As exemplified by the recent success of Pokémon GO, this may be especially relevant when considering marketing to teenagers.[43]

One of the most popular apps among teens is Snapchat, which utilizes facial recognition software to augment or alter face structures.[44] This experience is incomparable to the clunky UX of eyeglass websites such as Zenni Optical. American teenagers are accustomed to smooth graphics and a seamless interface; anything less sophisticated will not be adopted.

Benchmarking

A primary reason many glasses are expensive is that 70% of the market (everything from designers, to manufacturers, to distributors, to insurance providers) is owned by one company: Luxottica.[45] Luxottica has changed perceptions of glasses from a medical necessity to a high fashion object, and in doing so artificially inflated the cost. A typical pair of glasses can be manufactured and

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21, 2016.

40   Charles Duhigg, *The Power of Habit: Why We Do What We Do in Life and Business*, (New York: Random House, 2012): 35-36.

41   Erin, "Weight Loss On Your Wrist? Fitness Trackers May Not Help," NPR. September 20, 2016, http://www.npr.org/sections/health-shots/2016/09/20/494631423/weight-loss-on-your-wrist-fitness-trackers-may-not-help.

42   Naini Gomes et al., "Steptacular: An Incentive Mechanism for Promoting Wellness." *2012 Fourth International Conference on Communication Systems and Networks* (COMSNETS 2012), 2012.

43   Gal Rimon, "How Pokémon GO Relates To Gamification In The Workplace," ELearning Industry, July 31, 2016, https://elearningindustry.com/pokemon-go-gamification-in-the-workplace.

44   "A Look at How Snapchat's Powerful Facial Recognition Tech Works," *PetaPixel*, June 30, 2016, http://petapixel.com/2016/06/30/snapchats-powerful-facial-recognition-technology-works/.

45   "Sticker Shock: Why Are Glasses so Expensive?" CBS News, June 15, 2014, http://www.cbsnews.com/news/luxottica-eyewear-why-are-glasses-expensive/.

delivered to the user for $11.28.[46] Charging hundreds of dollars for these objects emphasizes the class difference between people who can afford high-end eyeglasses and those limited to either the charity of not-for-profits or the Medicare limit of around $60.00 reimbursement.[47] A few companies, such as Zenni Optical, Eye Buy Direct, and Warby Parker, are attempting to disrupt Luxottica's near-monopoly. New technologies - 3D printing and wearable electronics - are also influencing the evolution of glasses.

A look into the current market also reveals an interesting absence. While most eyeglasses are designed for adults, and a few cater to children, there does not appear to be anyone making glasses specifically for teenagers. Teenagers have different activity schedules, aesthetic tastes, and priorities than adults. While teenagers can typically wear adult glasses, they may choose not to because they do not suit their needs.

While no one solution can eliminate this problem, there is potential to change perceptions of eyeglasses within the demographic of American teenagers. In doing so this might further the overall trend of viewing glasses as a medical device to a desirable object.

Solution Development

I began ideation by exploring the system surrounding eye care, which includes three main sections: the problem origin, the process of getting eye care, and eyeglasses themselves. Tracing backward and questioning why this problem exists illuminated how the cyclical nature of systemic poverty and factors surrounding education and the availability of healthcare perpetuates this issue (fig. 1).

Investigating glasses themselves I found the most potential to make a positive impact. While glasses have become less stigmatized among adults, they are still an undesirable object for many teenagers. Seemingly contradictory trends, such as the popularity of lensless glasses among teens nonetheless reticent to wear prescription lenses demonstrates that glasses themselves are not undesirable; glasses as an assistive device are undesirable. Additionally, as noted by numerous teenagers, although some glasses are cool, insurance frequently only covers less cool, decidedly medical varieties. There appears to be an opportunity here for glasses more specifically designed for teenagers. I distilled my

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46   David A. Wilson et al., "Real Cost of Recycled Spectacles," *Optometry and Vision Science* 89, no. 3 (2012): 304-09.

47   Lawrence, 2016. Micca, 2016.

ADDRESSING MISCONCEPTIONS

GLASSES MIGHT NOT IMPROVE VISION STRABISMUS → BUT STILL WORK

SUN

SCREENS

GLASSES DON'T MAKE YOUR VISION WORSE

EDUCATING + COMMUNICATING WITH PARENTS IS CRUCIAL

WHAT OTHER INFO NEEDS TO BE COMMUNICATED?

WHAT TO DO AND HOW TO DO IT.

AVENUES OF COMMUNICATION

SCHOOLS

FAMILIES

CHURCHES

* HOW DOES VISIT/HEALTH BASED ON LOW INCOME?
* HOW HAVE SEES WIN?
* THE CARTER FOUNDATION AND WIN/GLOW COMMUNITY?

METHODS OF COMMUNICATION

WHAT DOES A FORM LETTER HOME LOOK LIKE?

WHAT TYPE OF COMMUNICATION IS MOST EFFECTIVE W/ PARENTS?

WHAT ALSO BE COST EFFECTIVE AND TIME SENSITIVE FOR PARENTS + THE PPL DELIVERING THE INFO.

PEDIATRICIANS

SOME CHECK VISION SOME DON'T

CAN'T TELL ALL AN OPTOMETRIST CAN

NO TIME

NO EXPERTISE

NO TOOLS

GENERALIST

APP GOCHECK KIDS

CHILD PEDS COME TO SCHOOLS

WHO WOULD PAY?

PROBLEMS W/ PULLING KIDS FROM CLASS

KIDS GET PULLED FROM CLASS ANYWAY

SCHOOL DISTRICT OPTOMETRISTS AND DENTIST

SHOULD SCHOOLS HAVE APED ON STAFF

DO PARENTS CARE IF THEY AREN'T PRESENT

LEARNING DISABILITY

CAN'T SEE

HEALTH

IT WASN'T VALUED BY THE FAMILY

OTHER THINGS ARE MORE IMPORTANT

WHY?

SCHOOL WASN'T IMPORTANT

IT WAS BORING

IT WAS TIMECONSUMING

IT WAS HARD

IT DOESN'T MAKE MONEY

IT FELT POINTLESS

DROPPED OUT

WHY?

WHY?

YOUNG, UNEDUCATED

NO MONEY/RESOURCES/EDUCATION

WHY?

LACK OF NUTRITION/ PRENATAL CARE

WHO IS THE MOTHER?

WHY ARE THERE SO MANY PREEMIES?

PREMATURE BABIES HAVE UNDERDEVELOPED EYES + BRAINS

WHY?

RATE OF VISION PROBLEMS IN URBAN POOR SCHOOLS IS 2X THAT OF AFFLUENT SCHOOLS

OPTOMETRIST OR OPHTHALMOLOGIST?

SCHEDULING

HOW DO YOU GET TO APPTS?

HOW FAR AHEAD DO YOU NEED TO PLAN?

CAN YOU GET TIME OFF WORK?

WHAT TOOLS WOULD A DOC NEED TO BRING THE CLINIC TO THE SCHOOLS?

IF SCHOOLS AREN'T DIAGNOSING, WHAT IS THE BARE MIN THEY CAN TEST?

IN-NETWORK?

DO YOU HAVE INSURANCE?

DO YOU HAVE A WAY TO MAKE APPTS?

▷▷▷▷▷▷▷▷ START HERE

FIG. 1 Initial ideation of eye care in the United States.

research into three key qualities of eyeglasses that would contribute to solving this problem (fig. 2). Glasses for teenagers must be (1) cool, (2) comfortable, and (3) accessible. Once these elements were identified, I continued to further define what each of these requirements means in this context.
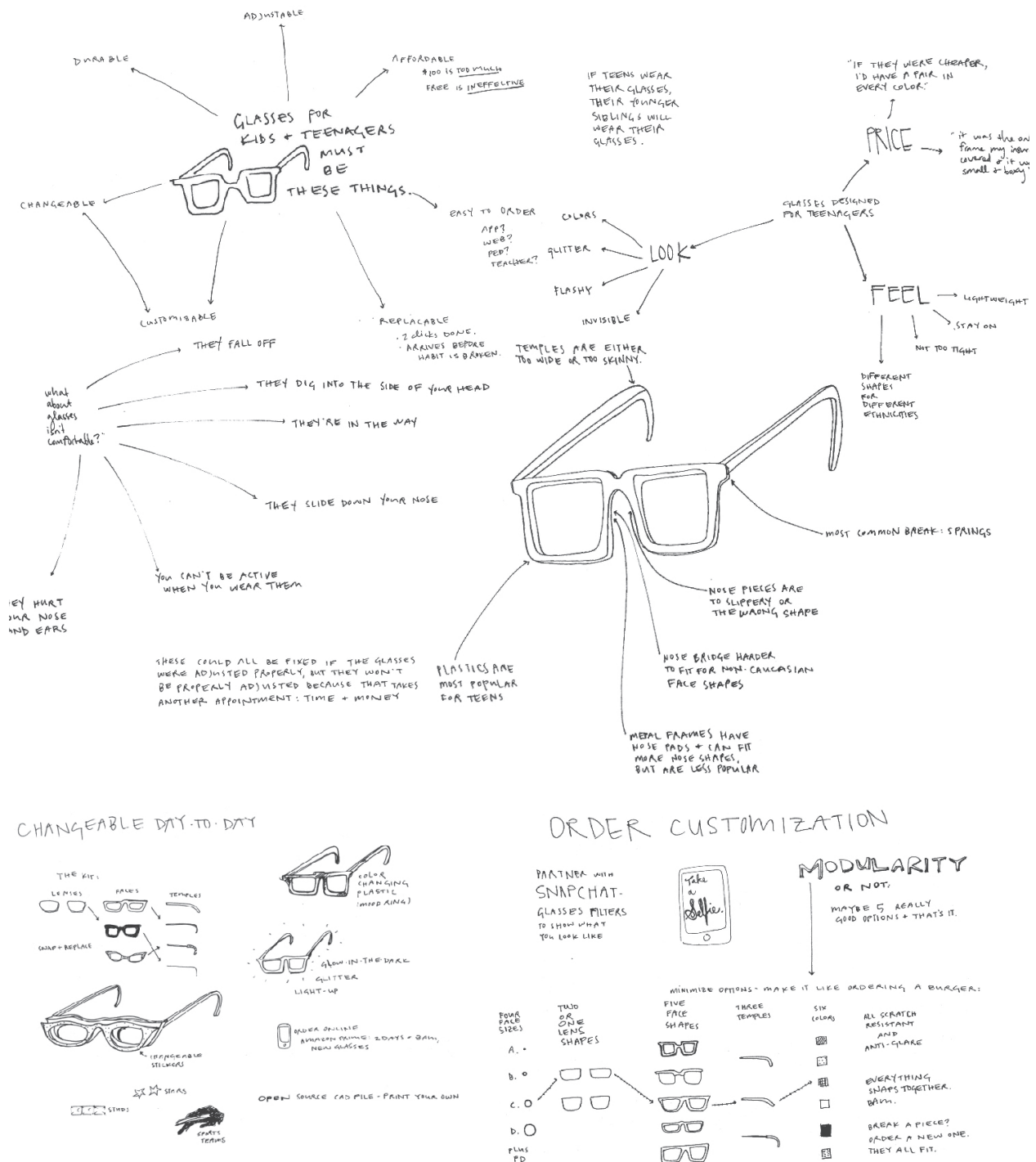
FIG. 2 Sketches of crucial qualities for a successful redesign of glasses.

Concept Development

Coolness

Changing teenagers' perceptions of glasses from a medical device to a fashion object starts first and foremost with making them cool. Coolness, however, is not objective; nothing - except perhaps Beyoncé - is universally cool. In an attempt to identify what is cool to American teenagers, I conducted a survey of more than 80 teens in rural Washington state, polled teens in urban Denver, CO, and Phoenix, AZ, and urban and suburban Rochester, NY. I also investigated phone applications, games, celebrity culture, and fashion. This information allowed me to narrow in on a few necessities that must be included in a "cool" glasses design.

Personalization

Expressing individuality within a socially accepted framework is a critical component of coolness. A successful solution must enable personalization while keeping the brand recognizable so that no one sticks out too much (fig. 3). Coolness also incorporates exclusivity, as exemplified by the clothing company Brandy Melville. Catering almost exclusively to thin, tall, white, teenage girls, Brandy Melville creates exclusivity by selling only one tiny size. Through this and their expert utilization of their customers as brand evangelists on Instagram, Brandy Melville has leveraged peer-led aspirational marketing to cultivate an incredibly dedicated following.

Cool is not necessarily expensive. Many of the most popular activities undertaken by bored teenagers today - posting videos online or using apps such as Snapchat - are free and social. However, they include an expensive barrier to entry: a smartphone. Most teens, even in low-income brackets, have

FIG. 3 Examples of objects that allow expressions of individuality but maintain brand identity.

smartphones.[48] In contradiction to this, many teens interviewed noted that although some glasses are cool, those ones are prohibitively expensive. Glasses (which cost less than smartphones) are not viewed as necessary as smartphones - both for activities enabled and social recognition. With all this in mind I began prototyping to find a balance between unique and generic and allow for personalization. After testing I determined that the simplicity of modular personalization was most effective. I also explored various materials, eventually settling on plastic (fig. 4).

FIG. 4 Prototypes exploring materiality (fabric, paper, wire) and personalization (facades, stickers, modularity). Photos by the author.

48   "73% of Teens Have Access to a Smartphone; 15% Have Only a Basic Phone," Pew Research Center, April 8, 2015, http://www.pewinternet.org/2015/04/09/teens-social-media-technology-2015/pi_2015-04-09_ teensandtech_06/.

Comfort

As noted by most of the teenagers surveyed, many glasses are uncomfortable, the most common complaints being that they pinch, fall off, or hit the user's cheeks. I identified specific aspects of existing glasses that contribute to these problems - sizing, temples, and nose pads (fig. 5 and fig. 6).
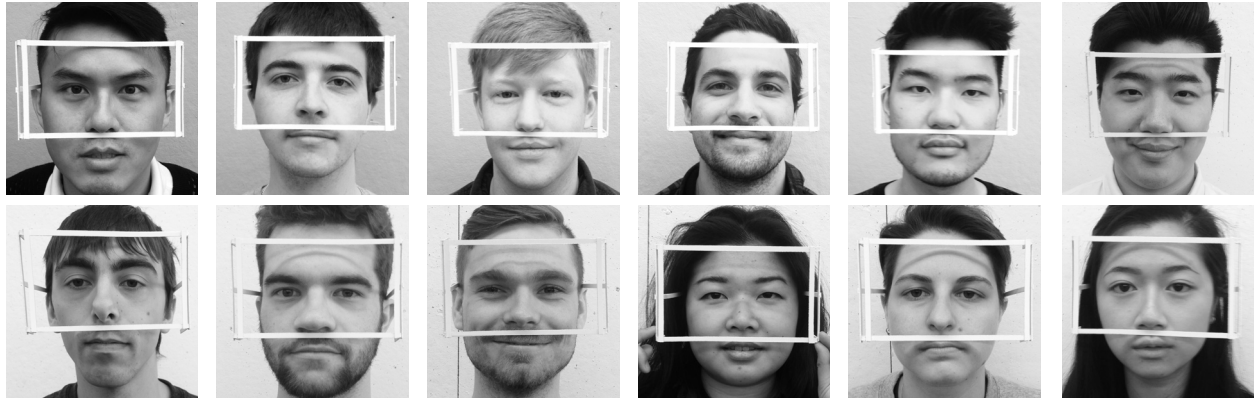
FIG. 5 To address how to fit various faces more comfortably, I began by superimposing a grid over a variety of faces and determining commonalities and differences. Photos by the author.
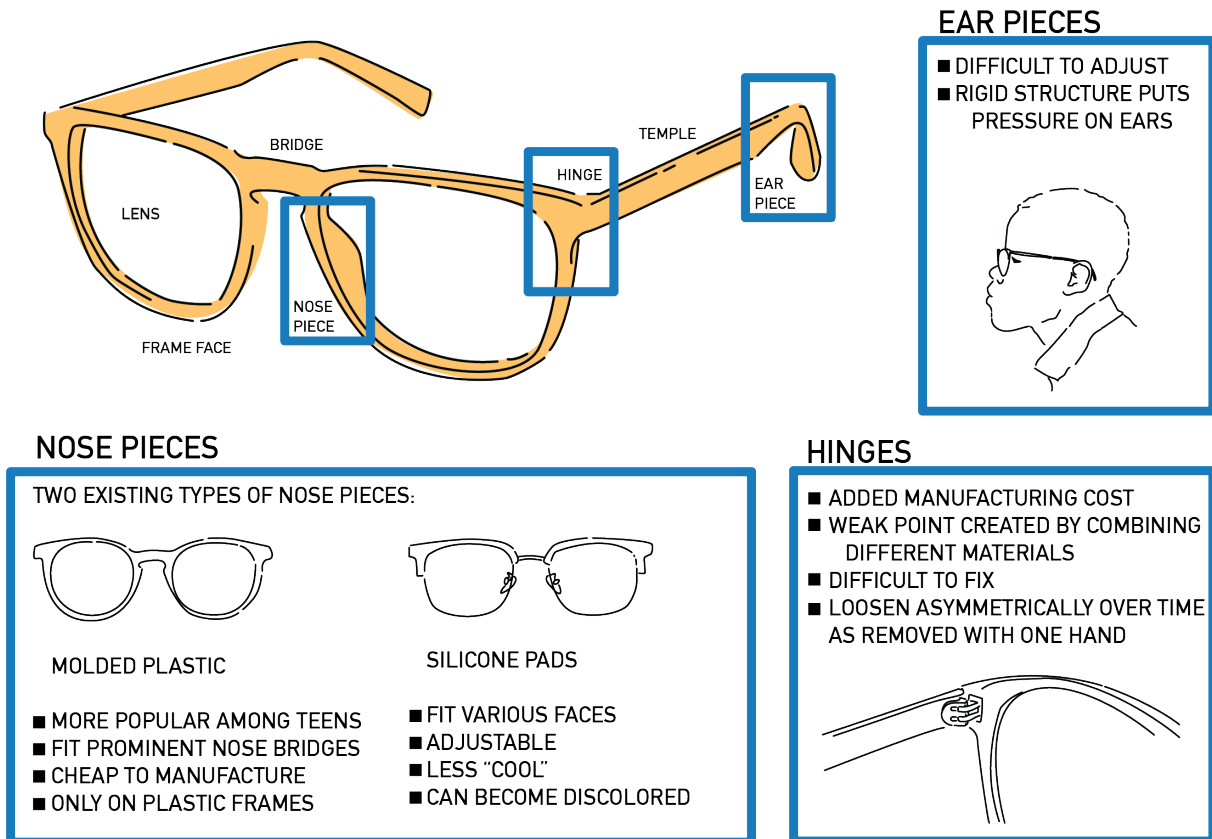
FIG. 6 Pros and cons of existing glasses design.

Temples

To combat issues with existing hinges, I explored alternate mechanisms. Fig. 7 shows tests of magnets, thermoplastics, wires, and living hinges, which helped me isolate weak points: connecting multiple materials and attachment methods that are not fully integrated into the form. To address these issues I referenced furniture joinery, developing an integrated hinge made of only one material.

FIG. 7 Prototypes of fabric and thermoplastic nose pieces, and wire, magnetic, and thermoplastic hinging mechanisms. Photos by the author.

The resulting mechanism also enables personalization through modularity; users can snap temples in and out based on both comfort and style. The first hinge I developed could be easily 3D printed, but would have been expensive to manufacture. A survey of production methods indicated that injection molded plastic would be optimal. To angle the design for this I changed the bottom half of the hinge from a pin to a hemisphere.
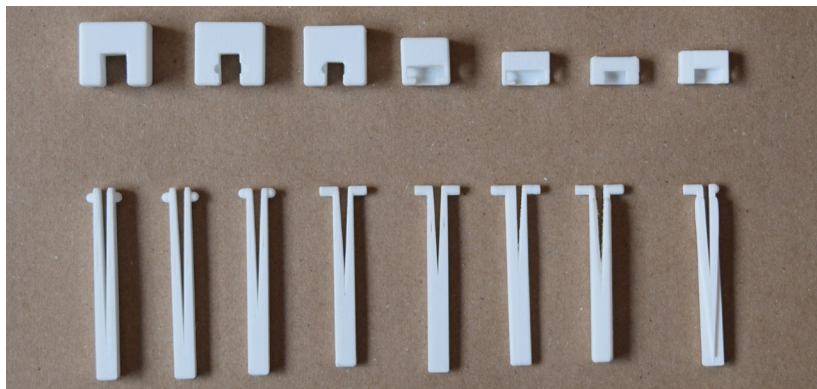
FIG. 8 Iterations of 3D printed hinges. Extensive testing of various combinations of pins and hemispheres illuminated the balancing point: one pin and one hemisphere. Photos by the author.

The angle at which temples meet the front of the frame is critical for comfortable fit. Testing indicated that adjusting the angle one to two degrees accommodated many different faces. People with prominent nose bridges typically fit better in glasses with temples at a ninety degree angle. People with lower nose bridges, however, often need the front canted out slightly so that the glasses do not rest on their cheeks.
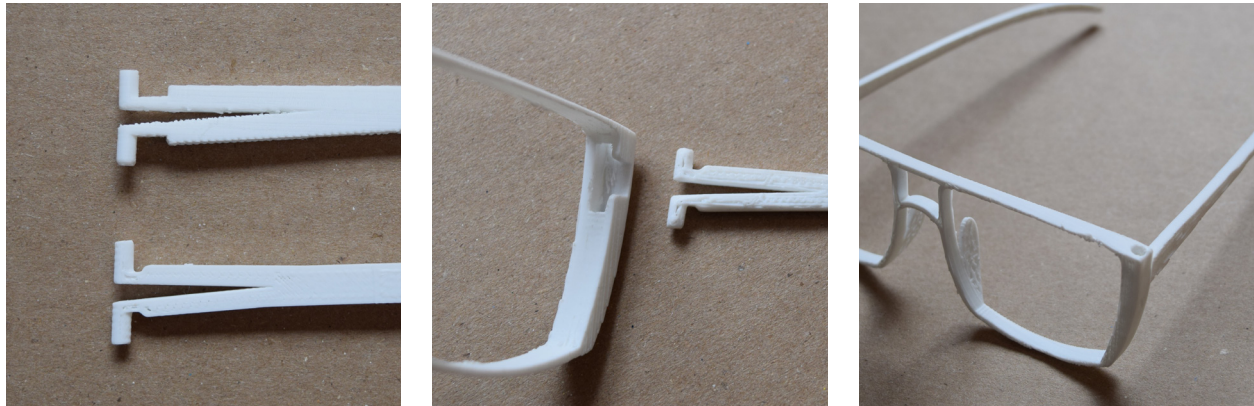
FIG. 9 Pins at a 90 degree angle to the temple (top left) and pins at an 89 degree angle to the temple (bottom left). Above middle and right: a hinge integrated into the frame of a pair of glasses. Photos by the author.

Existing glasses earpieces are typically stiff structures that cannot be easily adjusted to fit different ears. Some rigidity is necessary to stay properly placed on the user's face, but there is opportunity for increased adjustability. To increase flexibility I perforated the temple end into a living hinge that curves slightly around the user's head (fig. 10).
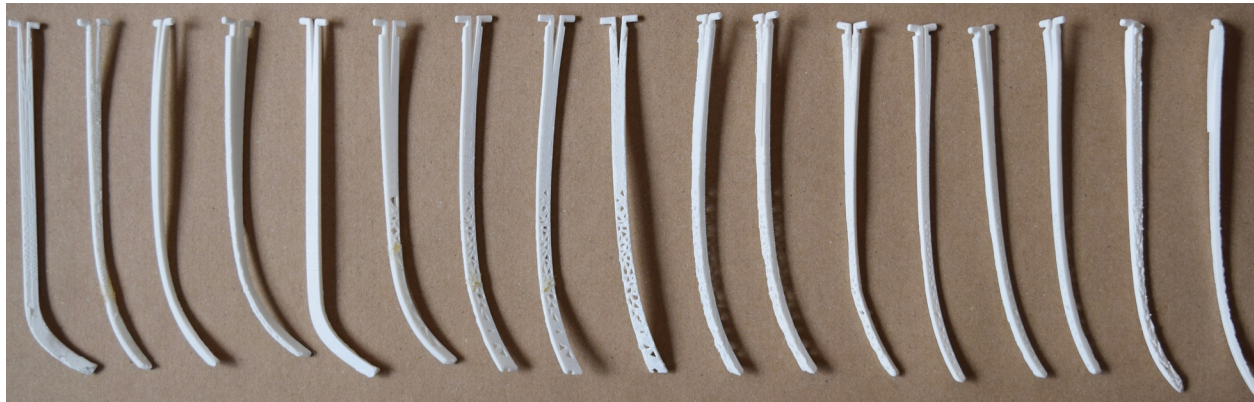
FIG. 10 Iterations of temples with various curves, hinges, and perforations. Photos by the author.

Nose Pieces

As noted in fig. 5, there are problems with the two types of nose pieces currently on the market. To address the issue of where nose pieces rest, I 3D printed curves out of thermoplastic PLA and tested them on a variety of noses. I developed snap-fit ball joints at the ends of the curves that allow enough

rotational movement for the plastic pads to rest on various different geometries of faces (fig. 11).

Once I identified effective contact points on a diverse set of faces, I began to explore perforated structures. These shapes derive both strength and flexibility through their pattern to rest comfortably on many faces. However, testing revealed that more customization was necessary. To enable this I created a modular nosepiece out of a thermoplastic that can be molded similar to a mouthguard (fig. 13).
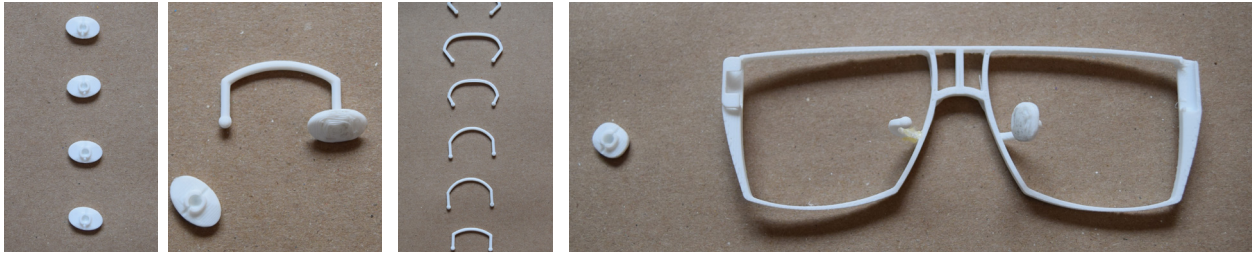

FIG. 11 Prototypes of ball joint nose pieces.
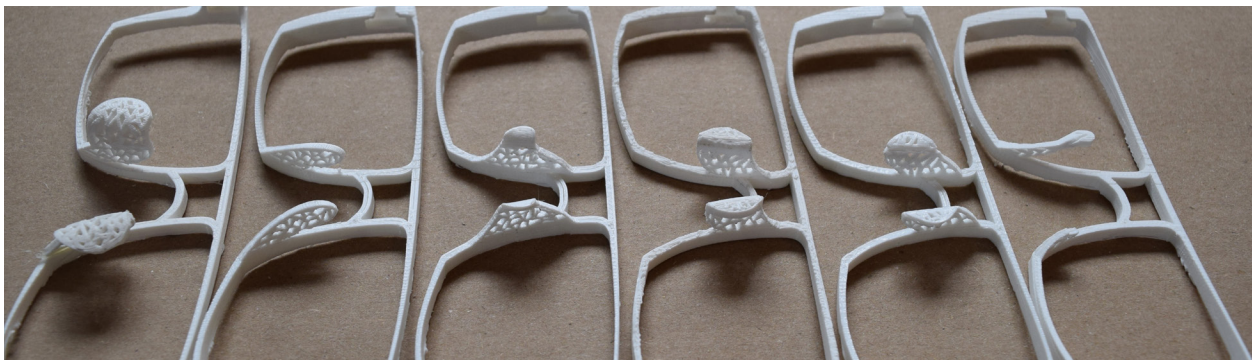
FIG. 12 Prototypes of perforated structures integrated into frames.
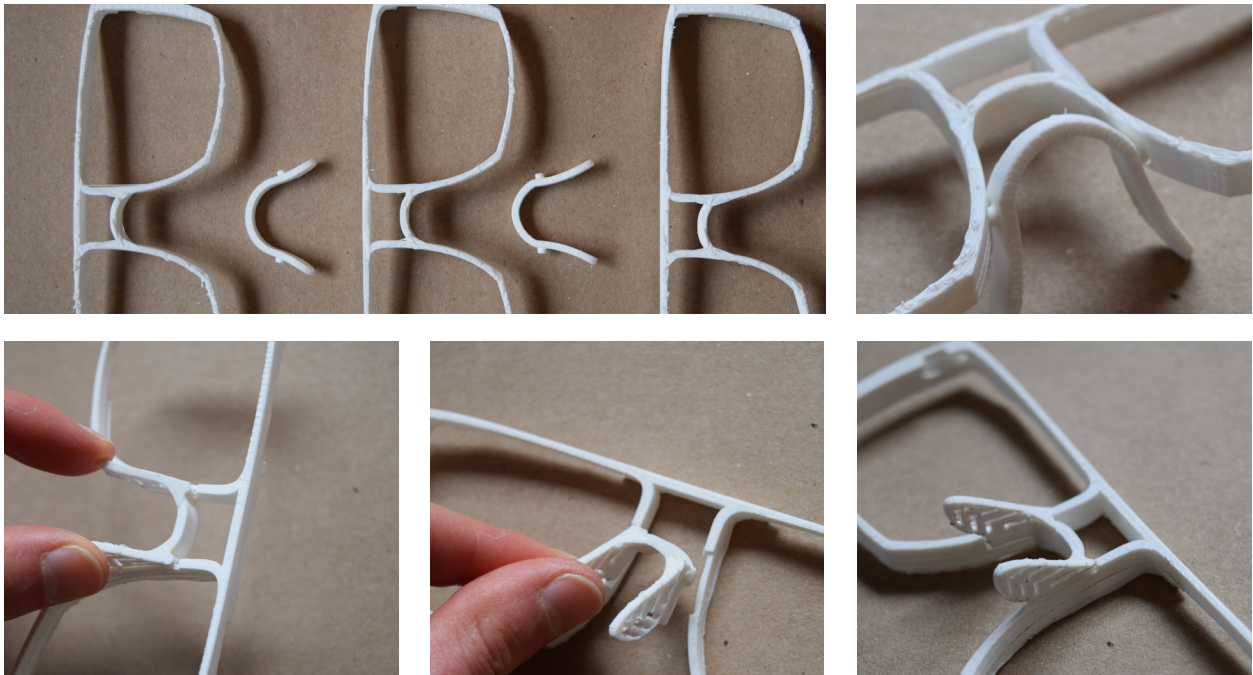
FIG. 13 Prototypes of perforated nose pieces that click into the frame. Photos by the author.

Sizing

To accurately fit different faces, the trend until now has been to offer seemingly infinite options. Companies size eyeglasses as a series of three numbers, which refer to temple, bridge, and lens lengths. However, because these numbers do not correlate to a specific fit, they are unhelpful to most users. Many opticians do not use them.[49] In contrast to this, sunglasses are more simply sized. Ray Ban sunglasses, for instance - some of the best selling sunglasses ever - come in only four sizes and 90% sold are one size.[50] There appears to be an opportunity to reduce size options and subsequently decrease complication with ordering and fitting glasses. If these limited frame options could be easily adjusted by the user this would also negate the need for an extra trip to an optician. In an effort to simplify this process I reduced size options for frames and temples, enabling the user to snap parts together and eliminating the need for an appointment. The slightly oversized aesthetic referencing sunglasses makes precision fit more about comfort than look.

Accessibility

The third component of a solution to this problem is accessibility, which can be broken into three parts: cost, acquisition, and repair. It is irrelevant that a pair of glasses is cool and comfortable if they are inaccessible. In order to keep cost affordable I considered manufacturing processes throughout the redesign, reducing the number of components and different materials involved in construction and limiting size options. I also looked at distribution methods, eventually settling on two pathways: via the internet (which is both cheaper than brick and mortar and also angled toward techno-savvy teens) or via a mobile shop. By integrating technology and utilizing a completely modular design, people could walk out with a pair of fully functional, customized glasses in one hour.

Finally, one of the most common reasons teenagers do not wear glasses even if they own them is that they are broken. To enable people to fix their own glasses, common break points need to be strengthened and users should be able to easily fix or replace a broken part. Filtering my design decisions through this lens led me to integrating the hinge into the frame and eliminating screws.

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49   Micca, 2016.

50   "Size Guide," Ray-Ban Size Guide, Sunglasses & Eyeglasses Sizes, accessed April 29, 2017, http://www.ray-ban.com/usa/size-guide?pid=IP01_G-DSA_DSA_Eyeglasses.

Final Design: Specs Modular Glasses

A redesign of glasses must comfortably fit multiple faces, be adjustable, fixable, and customizable by the user, and be easily accessed. This design accomplishes these goals through alteration of traditional glasses design. Modularity encourages personalization and enables a more customized fit with fewer components, which lowers manufacturing cost. Furthermore, eliminating metal and integrating new hinges and nose pieces into the frame strengthens the overall structure and renders the entire pair of glasses recyclable.

Three crucial measurements for comfortable fit are indicated in fig. 15. Modular design enables users to snap different parts in and out of the frame, while limiting temples and face pieces to four sizes simultaneously enables more specific customization and reduces the number of different sized pieces necessary. Furthermore, Specs accommodate for asymmetrical heads by allowing users to choose different left or right temples, as well as fitting specifically to individual noses.

To facilitate appropriate fit for different types of noses, the nose piece can be injection molded (either via co-molding or over-molding) out of two different thermoplastic elastomers (TPEs). By molding the bridge in a TPE with a higher melting temperature than the wings, users can fit nose pieces to their noses in the same way they would with a mouthguard (fig. 18). If the nose piece is 3D printed, the user can choose from two different options that snap into the frame. One has a slight curve at the end, lending itself to lower bridges, while the other has wings that rest on the sides of prominent bridges. Perforations render all nose pieces breathable and flexible and spreads out pressure.

Modularity also enables users to adjust, fix, and customize their glasses at home. Because pieces are inexpensive and can be replaced without tools, broken components are easily swapped out. This also encourages personalization. Temples can be snapped in and out in seconds, creating an opportunity for people to match their glasses to an outfit, sports team, holiday, or swap parts with a friend.

The overall design lends itself to two means of manufacturing. First, it is entirely 3D-printable. This enables anyone with a 3D printer to make their own glasses, customize a new component, or quickly replace a broken piece. Second, as a more viable option for large scale production, the design can be inexpensively injection molded.

One way to keep cost down and capitalize on the technical inclinations of teenagers is to bypass brick and mortar stores and limit distribution to the internet. An online store could utilize facial

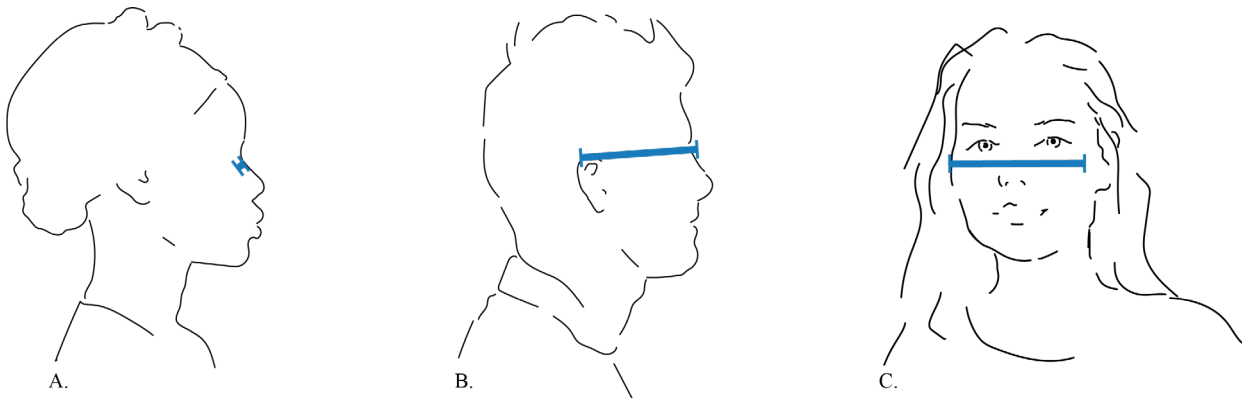FIG. 14 Final design for Specs Modular Glasses. Photo by E. Torgerson-Lamark.

FIG. 15 For a pair of glasses to fit comfortably it must fit different face widths (C), depths (B), and noses (A).
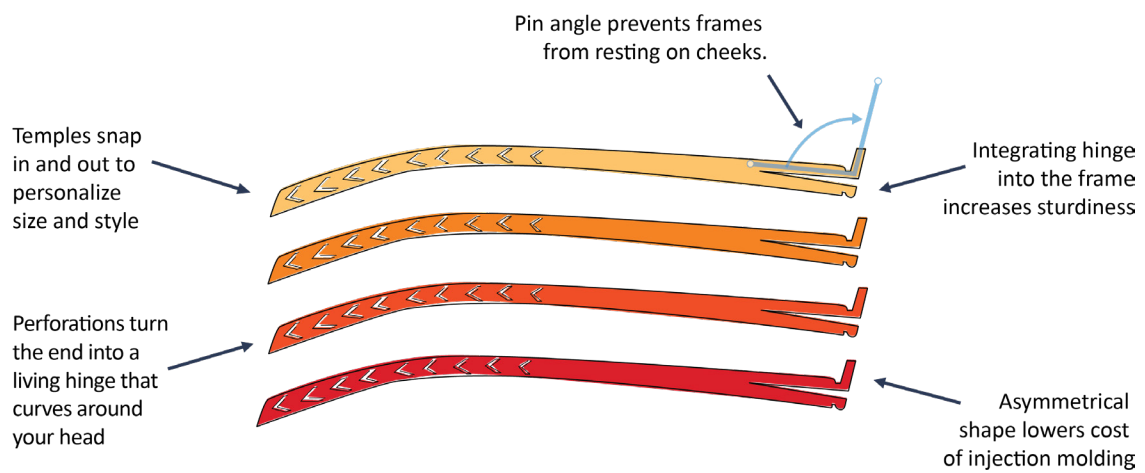

FIG. 16 Temple re-design addresses specific issues present in existing eyeglasses.
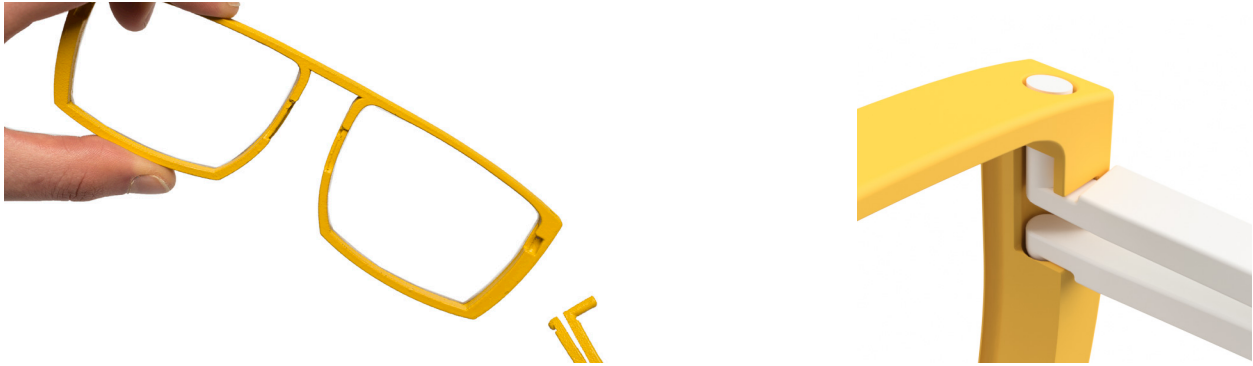
FIG. 17 Modular temple design enables micro-level customization. Photo by E. Torgerson-Lamark.

recognition software to determine Pupillary Distance and the appropriate frame size just by having a customer take a selfie. Anyone who knows their prescription could then order a pair in seconds. The glasses would cost under the amount allowable by Medicaid, but would have the option of adding cheap personalized temples.

Another way to get the glasses to kids would be through a mobile shop. This roaming vision center would offer vision screening with immediate results. Kids could create their own pair of glasses on site, pick different parts based on their individual style, snap them together, and then add prescription lenses if necessary or unaltered lenses if not. Gamifying the experience could further reduce the stigma of glasses as a medical device.

While the final design does not solve all the higher level problems surrounding youth and vision,

1 Snap the nose piece out of the frame.
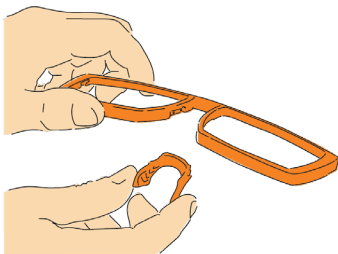
2 Drop it into hot water and wait until the wings soften. The bridge has a higher melting point so it will stay rigid.
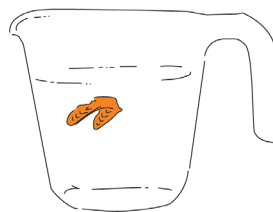
3 Snap it back into the frame and put your glasses on. It will form to your nose as it cools.
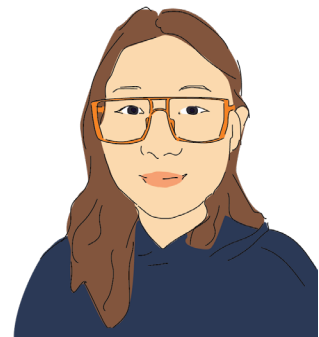

FIG. 18 Nose piece design.

by considering the system as a whole and making specific design decisions in response, it decreases the impact of the systemic factors. For instance, redesigning eyeglasses does not eliminate confusion regarding healthcare. However, creating glasses that are inexpensive and can be accessed without any additional appointments or insurance hurdles decreases opportunities for confusion. Making the process easy, quick, and transparent also increases trust among those involved.

Systemic poverty is another factor that influenced design decisions. Youth with uncorrected vision issues frequently suffer academically. A consequence of making eyeglasses more affordable, accessible, and desirable, is that more kids may get the vision care they need which helps them succeed in school. This is a definite step toward disrupting cycles of poverty. Additionally, kids in impoverished areas of the United States frequently do not have access to the necessary resources (such as reliable transportation) to get eye care. Because of this, the final design can be ordered via an app. According to the Pew Research Center, the majority of teenagers have a smartphone - even those in low income households where access to other resources may be unreliable.

Offering glasses via an app also relates to problems of communication and distrust. Parental literacy and hesitance with English contribute to miscommunications between parents, healthcare professionals, and educators. Including visual aides and translation options in an app could help.

The final design also addresses systemic issues of affordability and accessibility. Because the redesigned glasses components are inexpensive and can be easily snapped together, teenagers are able to customize their glasses on a daily basis. This relates to both affordability and accessibility. For glasses to be accessible, users must be able to adjust and fix them themselves. The integrated hinge renders the frames sturdier than traditional models and the modularity enables users to quickly replace broken pieces.

This modularity also allows better fit for a wide variety of faces and nose bridges currently underserved by the market (especially in low income areas). Ill-fitting frames are particularly uncomfortable and inconvenient for active kids and teens; glasses that stay in place both in class and while shooting a basketball further destigmatizes the object. This design also confronts societal biases against glasses by furthering the trend of viewing glasses as a fashion object instead of a medical device. Encouraging affordable personalization, offering non-prescription lenses, and decreasing necessary interactions with insurance companies and healthcare professionals normalizes the experience of purchasing and wearing glasses. All these design decisions were made in response to specific, systems-level factors.

Discussion

Although this redesign solves many of the issues of glasses currently on the market, no product solution exists in a vacuum. In the United States, eyeglasses and eye care for youth are not only wrapped up in the healthcare and public school systems, they are also inseparable from from social stigmas and societal perceptions. Any successful solution must also consider all these aspects.

Researching the system as a whole illuminated the difficulties parents face when getting their children health services. Navigating appointments, transportation, and insurance, is not only time consuming and expensive, but is also unnecessarily complicated. Integrating pediatric healthcare into the American public school system might make life easier for parents and set more kids up for success. Huge communication breakdowns currently result in general distrust between parents, schools, and healthcare providers. If school districts had pediatricians, optometrists, and dentists on staff, parents could come to their child's school for appointments. Scheduling with the school would be less difficult, parents would be able to make one trip to the school instead of picking up their child, taking them to a doctor, and then returning them. The child would also miss less school and the parent miss less work.

Social stigmas and societal misconceptions must also be addressed to create a comprehensive solution to this problem. Educating parents on the importance of wearing glasses - especially regarding common misconceptions, such as the incorrect beliefs that glasses do not do anything or might worsen vision - is crucial. These sentiments were expressed throughout my research, from those of all education levels and backgrounds. This must be corrected before any solution will stick.

Lack of youth vision care is not limited to the United States and is especially prevalent in impoverished countries.[51] Numerous organizations are attempting to address this through a variety of approaches with variable success. While they are not directed at American teens, a common thread can be found in the reasons none have succeeded on a universal scale; the cost is too high and perceived value too low.[52] By addressing many of the reasons people generally do not value glasses as an object, this redesign may be applicable in contexts outside the U.S. Fitting more faces and enabling greater personalization might encourage more regional customization of glasses both within the U.S. and

51   Albright et. al., 8.

52   Aneel G. Karnani, Bernard Garrette, Jordan S. Kassalow, and Moses Lee, "Better Vision for the Poor,"
        Stanford Social Innovation Review, Spring 2011.

elsewhere. Additionally, by decreasing the cost of glasses this design could potentially lower the price of each pair beneath the threshold people are willing to pay.[53]

Globally, 2.5 billion people live with untreated but correctable vision problems, resulting in a loss of $227 billion dollars from the global economy per year. Two hundred thirty-nine million of these people are children.[54] While a redesign of eyeglasses alone will not solve this problem, addressing many of the issues in existing glasses that decrease their desirability and adoption may encourage more people to wear the eyeglasses they need.

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[53]   Karnani, Garrette, Kassalow, and Lee, "Better Vision for the Poor."

[54]   Albright et. al., 8.

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