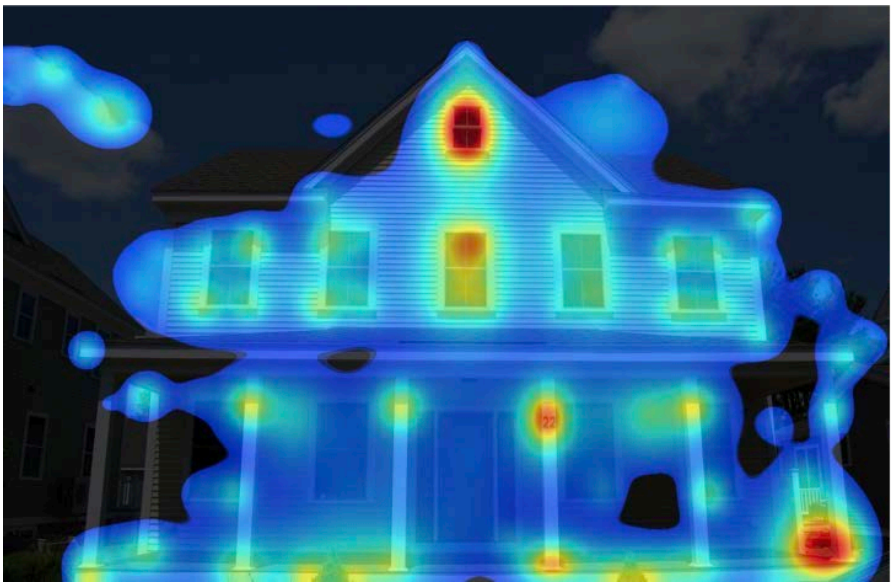
Seeing the 'Unseen' in Devens, MA

A Biometric Pilot-Study to Better Understand How 'Unconscious' Behaviors Govern Our Experience in the Built Environment

By Justin B. Hollander, PhD, Ann Sussman, AIA, Hanna Carr, Peter Lowitt, Neil Angus



ABSTRACT

New research in brain and cognitive science is changing our understanding of how people perceive and experience their surroundings. These scientific advances provide planners and architects with powerful new tools to design and evaluate their work and better understand its impact. In this study, we used a new biometric tool, 3M's Visual Attention Software (VAS), to assess the visual responses people have to buildings and streetscapes in a redeveloped former army base in central Massachusetts. The VAS software creates *heat maps*, *regions*, and *visual sequence* reports, to predict where people will look in *pre-attentive processing*, the first 3-to-5 seconds they take in a scene, before their conscious brain can get into the act. Applied to analyze 70 images of a recently-built neighborhood, the VAS study demonstrated how significantly these *hidden* behaviors impact our experience of place. Results indicate that specific architectural elements, including punched windows and red doors, consistently attract the eye while blank facades do not. More broadly the research suggests new parameters for quantifying a development's effectiveness and outlines how biometric tools, including the VAS eye-tracking emulation software, provide new kinds of data for forecasting a proposed plan's success.

INTRODUCTION

Today we live in a new 'Age of Biology' where new findings in cognitive science coupled with new biometric tools can help us better understand human behavior (Sussman and Hollander 2015). Technologies such as EEG, which measures brain waves, facial expression analysis software which follows our changing expressions, and eye-tracking software that allows us to record 'unconscious' eye movements, provide game-changing information about how our brain takes in our surroundings and directs our behavior (Hollander and Foster 2016). These technologies, widely used to create ads, packaging, computers, cars, and many other products today, remain relatively unknown and untested in the fields of architecture, planning and real estate development. In this pilot-study, we begin to explore their usefulness in assessing a new residential development built to encourage sustainability, walkability and public health.

While the environmental psychology literature is rich with evidence about ideal street widths, signage, lighting, signaling, and landscaping, this study is one of the first to show how biometric tools can increase understanding of how people actually respond to the places around them. It provides new kinds of data on hidden, 'unseen' experiences that determine our behavior. This information turns out to be germane in helping us better understand remarkably specific and significant things, such as how difficult it might be to find the front door of a new house, how confusing someone might find signage on an unfamiliar street or how likely it would be for a visitor to go for a walk in a new neighborhood.

Devens is a 4,400 acre former military base located approximately 35 miles west of Boston that is undergoing redevelopment (see Figure 1). Guided by the principles of sustainability, Devens' redevelopment to date has attracted over 100 businesses, created over 5,000 jobs, and permanently protected over 1,400 acres of open space. What sets Devens apart from other military base redevelopments is its' eco-industrial park approach, having firms collaborate and work together to share information and resources to maximize efficiencies and minimize waste, mimicking a natural ecosystem. To create a truly sustainable community, Devens realized it needed to also create opportunities for people to live, as well as work, play and learn.

Figure 1. A map of eastern Massachusetts, showing the location of Devens relative to Boston and Worcester.

To facilitate sustainable approaches to residential development, in 2013 the Devens Enterprise Commission, the permitting and regulatory authority overseeing redevelopment, drafted and adopted new residential regulations designed to promote healthy, energy-efficient, complete, connected and accessible neighborhoods, that put people first and foremost. Since the passage of these regulations, a 124-unit residential development (Emerson Green) was approved with a mix of single family, two-family, townhomes, and apartment buildings. Emerson Green combines cluster subdivision concepts with new urbanist principles where highly energy-efficient homes frame the street, creating a pedestrian-scale and socially-engaging streetscape. Phase 1 of Emerson Green, completed in early 2017, consists of 17 units of single and two-family homes along a narrow, tree-lined street with sidewalks on both sides (see Figure 2).

Figure 2. Looking down Chance Street, part of a new residential development in Devens, MA.

This new development provided an ideal setting to explore how biometric tools can be used to better understand how design decisions impact human behavior.

For this study, we used an off-the-shelf biometric tool, 3M's Visual Attention Software (VAS), introduced in 2011, to measure the 'unconscious' visual responses people have to the built environment. The results suggest new parameters for quantifying a development's effectiveness and more broadly outline how biometric tools, including eye-tracking emulation software, provide a viable means for both assessing and predicting the human experience of place. Letting us see the 'unseen', these tools can help us build more successful neighborhoods because they show us how to appropriately respond to intrinsic, yet often overlooked, human behaviors.

LITERATURE REVIEW

Eye tracking records 'fixations', or visual resting points, and saccades, the rapid movements between them, and can give insight into what features of an image

immediately draw attention. The technology is widely used today to measure the effectiveness of video and print advertising. Companies including Microsoft, IBM, and Kraft Foods have used it in product and packaging design (Wedel and Pieters 2008). Employed as a diagnostic tool in medicine, eye tracking can also assess eating, autism-spectrum, and anxiety disorders including PTSD (Bauer et al. 2017, Guillon et al. 2014, Kimble et al. 2010). Eye-tracking has also lent insight into the way people observe their surroundings and how they perceive landscapes (Dupont et al. 2013; Lucio et al. 1996; Potocka 2013.)

- **Eye-tracking Emulation Software**

3M's Visual Attention Software, or VAS, (solutions.3M.com) was developed in 2011, primarily as a marketing tool. The software employs an algorithm consolidating 30 years of eye-tracking data to predict the human response to visual stimuli within the first 3 to 5 seconds, or during *pre-attentive processing* (before the conscious brain can get into the act). While traditional eye-tracking studies require a lab set-up and a physical eye-tracker sending out infrared light beams that bounce off a viewer's eyes and tracks the reflections, VAS does not. Though not as a robust as the lab set-up, which also requires 30 or more test-takers per study, VAS, which starts at $49 per month for unlimited access, can be easier, cheaper, and much more efficient for pilot-studies (Auffrey and Hildebrandt 2017; Cottrell 2016).

Companies including Clorox, Unilever, and Anheuser-Busch have used the software to design commercial products ("VAS in your workflow"). VAS has also been employed to assess packaging designs (Cottrell 2016), the effectiveness of roadside signage placement for drivers (Auffrey and Hildebrandt 2017), and optimize the placement of ads on a page (Carr 2011) or website.

VAS works by assessing images for five "visual elements" known to attract the human eye: "edges," "faces", color "intensity," "red/green color contrast" and "blue/yellow color contrast" (3M Corporation, 2017). The data the software creates for each image appear as compelling graphics, which are typical eye-tracking output. These are: *heat maps,* which glow reddest and brightest where people look most, *sequence* reports, which track the path eyes will take looking at a scene, and *regions* reports, which with simple enclosed lines, delineate areas that draw the most attention in comparison with those that draw less or none. VAS produces results quickly, in under a minute, once an image is uploaded to its dedicated 3M site.

No published research to date has applied VAS to better understand the human experience and effectiveness of architecture, neighborhood design or place-making. So, we set out to do so.

STUDY PROTOCOL

● Photo Inventory

We created a photo inventory for the Emerson Green neighborhood under investigation to use with the VAS software. Traveling to Devens on a sunny day, we took pictures of the houses in the new development as well as older restored and unrestored buildings in the area. This visit gave us the opportunity to experience the setting firsthand and make note of where we felt comfortable and welcome as well as where we did not.

In total, we collected 70 site-specific, color images to study with VAS, receiving additional photographs and renderings from the Emerson Green project architect Union Studio Architecture & Community Design of Providence, R.I.

FINDINGS

● Regions Reports

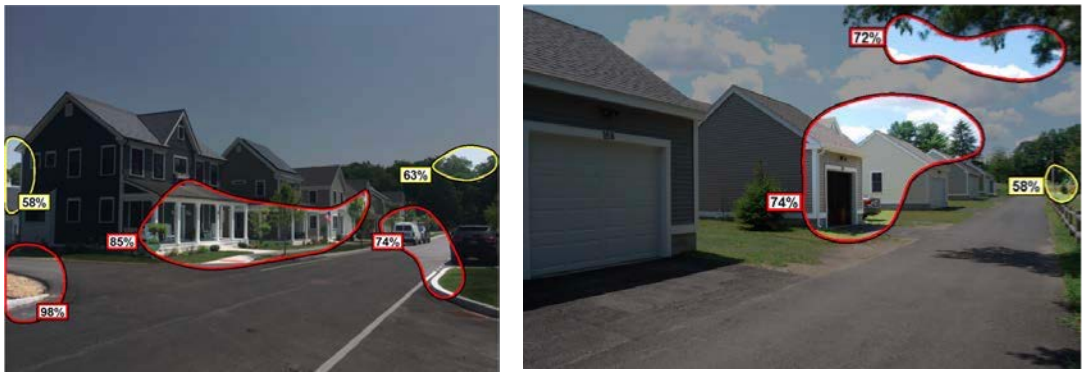


Figure 3. Regions report for Chance Street houses as well as garages on private alley behind.

The *regions* diagrams VAS created for the new development suggest how effectively specific design elements in the project work, particularly how the white columns on the porches of the new homes draw the eye (see Figure 3). Conversely, the lack of detail and simpler design of the garages in the rear private alley do not draw attention, which may fit the developer's intent to encourage privacy in this area. Note how the red outlined areas will likely receive the most views (74% to 98%), with the areas outlined in yellow receiving moderate attention (58% to 63%). Uncalled-out regions, such as building roofs and areas of blank roadway will most likely be ignored in the first 3-to-5 seconds.

● **Heat Maps**

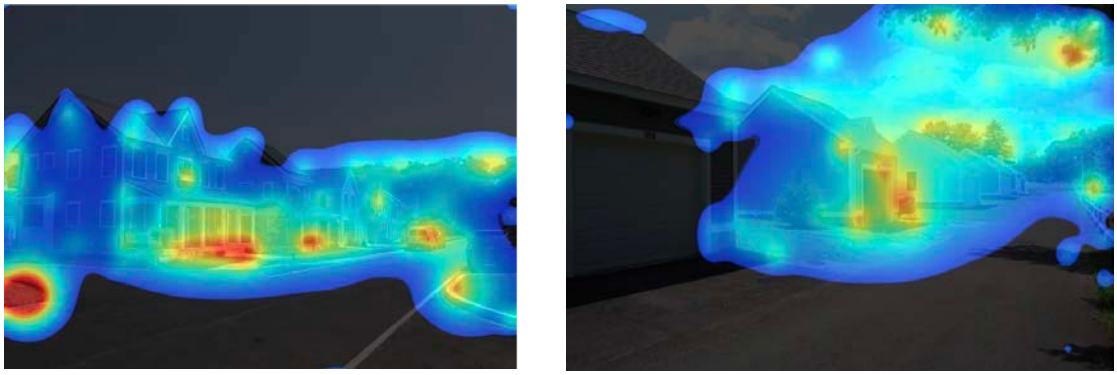


Figure 4. Heat map of Chance Street houses as well as garages on private alley behind.

The *heat maps* of the same streetscapes present the VAS information in a different form, glowing bright red where people look most, fading to orange and yellow where they look less, and moving to green, light blue, and darker blue where people are least likely to look. Areas most likely to be ignored appear dark grey or black. Results suggest that both the layout of the new houses on Chance Street and their design encourages viewers to cast views along and down the street, however in the private alleys attention likely will shift sky-ward to the tree canopy (see Figure 4).

● **Visual Sequence Reports**

Figure 5. Sequence report for Chance Street houses as well as garages on private alley behind.

The VAS *sequence reports* forecast the path the eye will likely follow as it 'fixates' or rests (for several hundred milliseconds) on different elements in a scene. This turns out to be quite significant since our conscious behavior is always rooted in unconscious activity. In Figure 5, we see how 'fixations' *we don't realize we're making* provide the hidden structure for us to look at something, and then move into our brain's consciousness. Cognitive scientists say that 'fixations drive exploration,' a mantra that

advertisers know, too. When people don't 'fixate' on an image in an ad, for instance, it can't direct the consumers' attention as intended. Similarly, if visitors' brains can't unconsciously easily find fixations on a street, they're less likely to amble along it.

Visiting this new development for the first time, we took note of how much easier it was for us to walk down the street lined with houses – it simply beckoned. This was not the case with the private alleys behind the homes; we felt unwanted there. 'Seeing' the fixation paths above can help us understand why these feelings and behaviors occurred.

- **Viewers Avoid Blank Facades**

Figure 6. Regions report for a Chance Street garage.

Eye-tracking data also reveals other hidden human habits that are critical for the design of successful habitat, such as being hardwired to avoid focusing on blank spaces and places. Our brain is on continuous lookout for areas of high contrast, a consequence of having a central nervous system that's an artifact of 3.6 billion years of evolution.

We saw the impact of this evolutionary design play out in the way the emulation software predicted people would ignore blank facades of the garages (see Figure 6), particularly their doors, and instead focus on building elevations, both old and new, that offered consistent pairs of punched windows.

- **Fixation Drives Exploration**

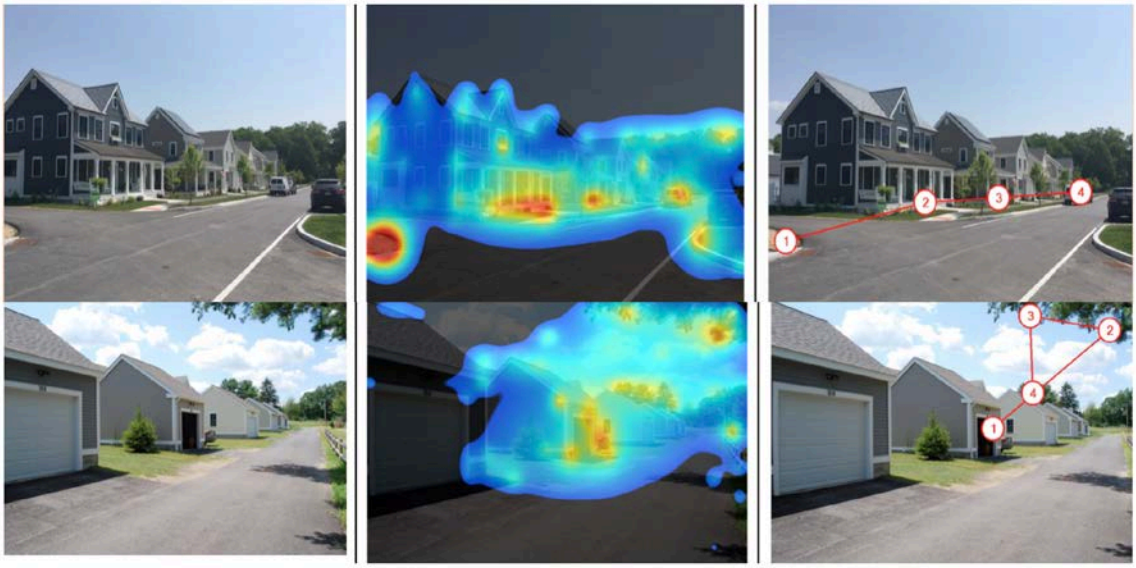


Figure 7. Original images, heat maps, and sequence reports for a view of Chance Street and a view of the Chance Street garages.

The data can also help us understand why some areas are easier to walk in than others and predict ease of walkability. Figure 7 helps illustrate how unconscious fixations underlie simple behaviors, like strolling down a street and making the conscious decision to do so. The view down Chance Street evokes an eye-tracking sequence that naturally travels down the street, while the view down the row of garages does not exhibit as natural of a pattern.

- **Architecture Has Power**

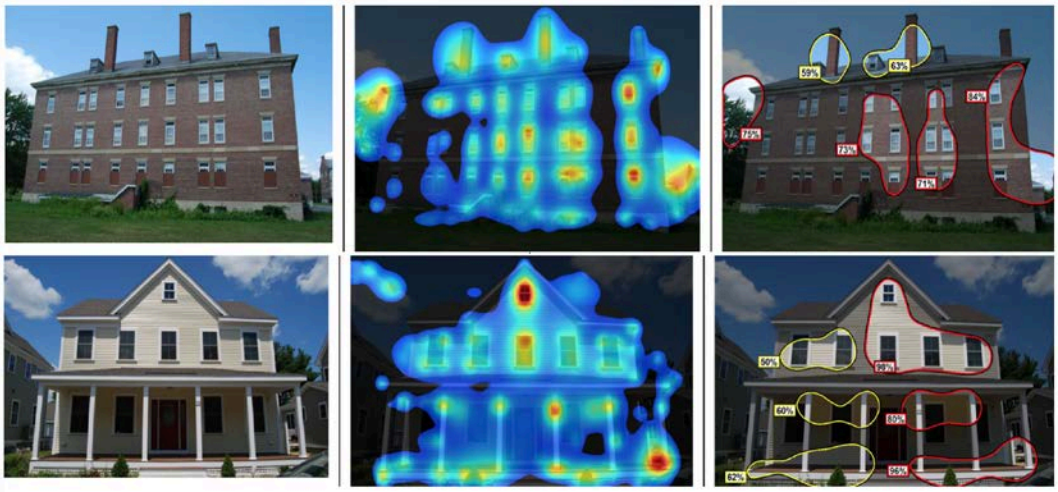


Figure 8. Original images, VAS heat maps, and VAS sequence report for a historic building at Devens and a house at 22 Chance Street in Devens.

Figure 8 shows how architecture has power. Facades with punched windows and columns consistently catch the eye, as humans are innately drawn to discrete areas of high contrast. This can be seen in the VAS reports of both a historic Devens building and the recently constructed house at 22 Chance Street.

- **Red Doors Attract Attention**

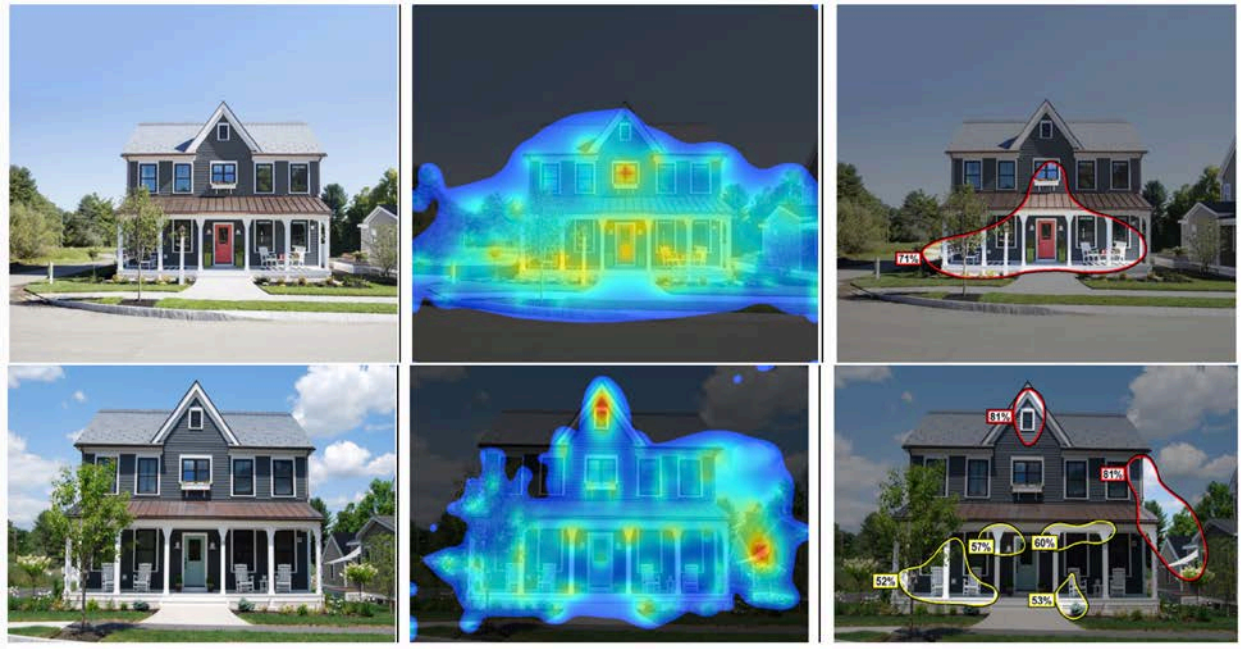


Figure 9. Original, heat map and regions reports of 28 Chance Street, with and without a red door.

Eye tracking emulation also suggests how much color matters in the built-environment, particularly red. The reports in Figure 9 illustrate a red door grabbing viewer attention, showing the same house, 28 Chance St., with and without one. The regions reports illustrate the difference well. When the house has a red door, the probability that it will be looked at within the first 3-5 seconds is 71%, but with a light blue door, that probability drops to less than 60%. The contrast between the red door and the dark background likely causes this measurable change in pre-attentive focus. Color has a measurable effect on our attraction to visual stimuli, and red doors happen to be remarkably, and measurably, effective.

● **Flags and Banners Captivate, Too**

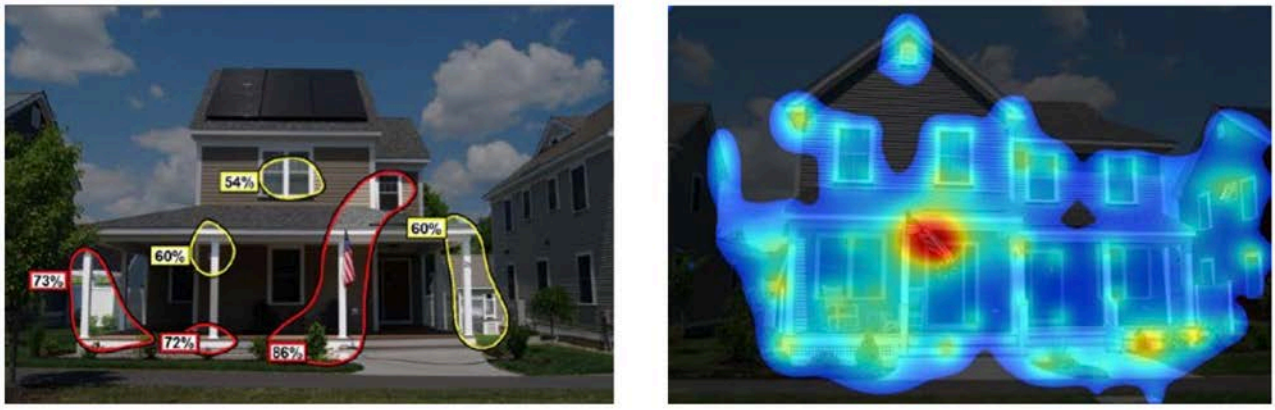


Figure 10. Flags, glowing reddest in heat map, at right; attracting the most interest, in the regions report, at left.

In Figure 10, we see why flags are popular and always will be: they draw the eye. The bright red spot on the heat map (at left) and the area of 86% probability of pre-attentive focus on the regions diagram, (at right), indicate the intensity of the flags' appeal. These diagrams suggest that of all of the buildings' design elements, the flags are most likely to consistently capture attention first and foremost in the pre-attentive phase.

● **What Eye-Tracking Emulation Software Can't Tell Us**

While VAS successfully estimates where we'll look in pre-attentive processing, the software can't tell us about the emotional character of the person's response, or how buildings or streetscape make people feel. Eye-tracking tools record how long a person spends looking at an element, not their positive or negative emotional responses. For that critical information, researchers combine eye tracking with other biometrics, including EEG, which measures brain waves and approach avoidance tendencies, facial expression analysis, which actively tracks facial muscle movements, and heart rate monitoring, which can indicate levels of arousal and interest, among other metrics. Researchers also use 'self-report', or simply asking volunteers how they feel taking in a stimulus and systematically recording their responses.

Eye-tracking and emulation tools nevertheless remain powerful because they help us 'see' how much of our response to our surroundings is determined unconsciously, or 'pre-attentively.' By letting us 'see the unseen' these tools may help us even forecast the success of a neighborhood before it's built. They give us important insights into hidden human behaviors that are critical to understand to make healthier, walkable places for everyone. Understanding ourselves better, promotes building healthier, happier places moving forward.

● Implications for Urban Planning and Design

We believe the potential for eye-tracking emulation software in urban planning is vast (no pun intended). With new biometric technologies such as VAS, urban planners can run renderings of their building or street-view designs to quickly learn where fixation points lie. They can get hard data on human behavior that was previously inaccessible or rarely discussed. The biometric tools can also be used to identify areas which attract attention versus those that don't, from front doors to signage in parking lots to whether a proposed streetscape will encourage exploration or privacy, all key factors that play into the success of a new community. Human behavior matters and biometric software, such as VAS, new metrics for tracking it to promote successful, evidence-based design in the future.

CONCLUSIONS

This pilot-study, using emulation software to assess the impact of a new residential development, showed us how:

- House design and layout influence walkability on new streets;
- Consistently aligned residences close to the street/sidewalk with punched windows and porch columns on facades attract the eye;
- People ignore blank facades;
- 'Fixations drive exploration,' or our unconscious eye movements direct our conscious behavior everywhere, whether in advertising or urban planning;
- 'Seeing the unseen,' gives new insight into what makes developments successful, also suggesting ways to fix neighborhoods that are less so;
- And finally, it suggests biometric tools have a future role in the creation of design guidelines and assessment metrics for existing and proposed developments.

SOURCES

3M Corporation. 2017. “How VAS Works.” 3M Visual Attention Software (VAS). http://solutions.3m.com/wps/portal/3M/en_US/V AS_NA/Home/How2/.

Auffrey, Chris, and Hank Hildebrandt. 2014. Utilizing 3M’s Visual Attention Service software to assess on-premise signage conspicuity in complex signage environments found in urban neighborhood and suburban strip business districts: Lessons learned from a graduate seminar. University of Cincinnati College of Design, Architecture, Art, and Planning. Accessed October 13, 2017. http://www.signresearch.org/wp-content/uploads/New- Tools-for-Looking-at-the-Importance-of-Signage.pdf.

Auffrey, Chris, and Henry Hildebrandt. 2017. "Do Motorists See Business Signs? Maybe. Maybe Not. A Study of the Probability that Motorists View On-Premise Signs." *Interdisciplinary Journal of Signage and Wayfinding* 1, no. 2: 100. doi:10.15763/issn.2470- 9670.2017.v1.i2.a8.

Bauer, Anika, Silvia Schneider, Manuel Waldorf, Karsten Braks, Thomas J. Huber, Dirk Adolph, and Silja Vocks. 2017. "Selective Visual Attention Towards Oneself and Associated State Body Satisfaction: an Eye-Tracking Study in Adolescents with Different Types of Eating Disorders." Journal of Abnormal Child Psychology 45, no. 8: 1647-661. doi:10.1007/s10802-017-0263-z.

Carr, Austin. 2011. "3M's Visual Impact Scanner Knows What Your Eyes Want." Fast Company. Accessed October 13, 2017. https://www.fastcompany.com/1758454/3ms- visual-impact-scanner-knows-what-your-eyes-want.

Cottrell, David Bradford. 2016. *Comparing multiple methods of eye tracking for packaging*. Master's thesis, Clemson University. ProQuest Dissertations Publishing.

Dupont, Lien, Marc Antrop, and Veerle Van Eetvelde. "Eye-tracking Analysis in Landscape Perception Research: Influence of Photograph Properties and Landscape Characteristics." *Landscape Research* 39, no. 4 (2013): 417-32. doi:10.1080/01426397.2013.773966.

Guillon, Quentin, Nouchine Hadjikhani, Sophie Baduel, and Bernadette Rogé. 2014. "Visual social attention in autism spectrum disorder: Insights from eye tracking studies." *Neuroscience & Biobehavioral Reviews* 42: 279-97. doi:10.1016/j.neubiorev.2014.03.013.

Hollander, Justin B. and Veronica Foster. 2016. Brain responses to architecture and planning: A neuro-assessment of the pedestrian experience in Boston, Massachusetts. *Architectural Science Review* 59, 6:474-481.

Kandel, Eric. R., The Age of Insight: The Quest to Understand the Unconscious in Art, Mind and Brain. Random House, 2012.

Kimble, Matthew O., Kevin Fleming, Carole Bandy, Julia Kim, and Andrea Zambetti. "Eye tracking and visual attention to threating stimuli in veterans of the Iraq war." *Journal of Anxiety Disorders* 24, no. 3 (2010): 293-99. doi:10.1016/j.janxdis.2009.12.006.

Klein, Thomas Michael, Thomas Drobnik, and Adrienne Grêt-Regamey. 2016. "Shedding light

on the usability of ecosystem services–based decision support systems: An eye-tracking study linked to the cognitive probing approach." *Ecosystem Services* 19: 6586. doi: 10.1016 /j.ecoser. 2016.04.002.

Lucio, J.V. De, M. Mohamadian, J.P. Ruiz, J. Banayas, and F.G. Bernaldez. 1996. "Visual landscape exploration as revealed by eye movement tracking." *Landscape and Urban Planning* 34, no. 2: 135-42. doi:10.1016/0169-2046(95)00208-1.

Moore, Richard J. 2011. “Improving Sign Effectiveness with Visual Attention Modeling Software.” http://www.signresearch.org/wp-content/uploads/Improving-Sign- Effectiveness-with-3Ms-Visual-Attention-Modeling-Software.pdf

Noland, Robert B., Marc D. Weiner, Dong Gao, Michael P. Cook, and Anton Nelessen. 2016. "Eye-tracking technology, visual preference surveys, and urban design: preliminary evidence of an effective methodology." *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 10, no. 1: 98-110. doi:10.1080/17549175.2016.1187197.

O’Shea, Michael. The Brain, A Very Short Introduction. Oxford University Press. 2005.
Potocka, Ilona. 2013. "The Lakescape in the Eyes of a Tourist." *Quaestiones Geographicae* 32, no. 3. doi:10.2478/quageo-2013-0018.

Sheliga, B.M., L. Riggio, and G. Rizzolatti. 1995. "Spatial attention and eye movements." Experimental Brain Research 105, no. 2. doi:10.1007/bf00240962.

Sussman, Ann and Justin B. Hollander. 2015. *Cognitive architecture: Designing for how we respond to the built environment.* London / New York: Routledge.

"VAS in your workflow." 3M Visual Attention Software (VAS). Accessed October 29, 2017. http://solutions.3m.com/wps/portal/3M/en_US/V AS_NA/Home/workflow/.